Risques à la santé et maladies professionnelles

dans les industries alimentaires

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Introduction

Le secteur de l'alimentation confronte les intervenants en santé au travail à de nouvelles difficultés : l'évaluation environnementale et le suivi médical se font maintenant pour des risques avec lesquels ils sont moins familiers parce que peu ou pas rencontrés dans les secteurs d'activité traditionnels : ce sont les risques biologiques et par certains aspects les risques ergonomiques. De plus, en ce qui concerne les médecins responsables, leurs liens sont peu établis avec les médecins traitants alors que ce sont ces derniers qui suivent les travailleurs atteints d'infections, de dermatoses ou de problèmes musculo-squelettiques. Il n'y a pas non plus de guide de surveillance standardisé. La prévention des maladies professionnelles exigera un suivi régulier, une recherche des causes et des interventions aussi bien en hygiène qu'en ergonomie.

Par ailleurs, nous avons dû aborder dans nos documents des risques à la santé qui sont communs à d'autres secteurs. Par exemple, les risques biologiques et les zoonoses se retrouvent surtout dans l'agriculture, mais par continuité se rencontrent souvent dans l'alimentation. D'autres problèmes de santé comme le travail de nuit se retrouvent dans l'alimentation, mais sont plus fréquents dans la fonction publique.

Compte tenu de la variété des risques présents dans le secteur Aliments et Boissons, le document de référence que nous vous présentons ici se compose principalement d'un ensemble de textes de référence associés à chacun des principaux risques. Un texte les accompagne et se limite à des définitions et explications visant à orienter les activités. Nous espérons que ce recueil pourra inspirer les intervenants dans leur travail auprès des travailleurs et employeurs de ce secteur d'activités.

Suraité

Noise-Induced Hearing Loss: A Possible Marker for High Blood Pressure in Older Noise-Exposed Populations

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The present study assessed the relationships among occupational noise exposure, noise-induced hearing loss, and high blood pressure. The study population consisted of 245 retired metal assembly workers from Pittsburgh aged 56 to 68 with chronic noise exposure of 30 or more years at ≥89 dBA. Results of the audiometric testing indicated 52% of the younger workers (ages 56 to 63) have severe noise-induced hearing loss (≥65 dBA loss at 3, 4, or 6 kHz) and 67% of older workers (ages 64 to 68). Body mass index and alcohol intake were significantly related to systolic and diastolic blood pressure.

Among older men, there was a marginally significant increased prevalence of high blood pressure (≥90 mm diastolic or taking blood pressure medicine) among those with severe noise-induced hearing loss ($P = .05$). Moreover, another measure of hearing loss at high frequencies, speech discrimination score in noise (measured in the better ear), referred to as the W-22 MAX score, was also found to be related to the prevalence of high blood pressure in the older (64 to 68) age group ($P < .05$). Multiple regression analysis revealed W-22 MAX and severe noise-induced hearing loss were independent predictors of hypertension in the older, but not in the younger group of retired workers.

Noise-induced hearing loss is a major cause of disability. It is estimated that 10 million people in the United States and many more worldwide have hearing loss that may be related to noise exposure.[1] Whereas the auditory effects of noise exposure are well known, the cardiovascular effects of chronic noise exposure are less clear.[2-4] There have been two general approaches used in the investigation of this subject. The first involves the determination of noise exposure, both intensity and duration, and the assessment of blood pressure status in noise exposed and comparison populations.[5-7]

The second group of studies utilized varying definitions of noise-induced hearing loss as a marker for noise exposure. The blood pressure status of occupationally noise exposed workers was then compared by hearing loss categories.[8-10] These studies have been reviewed in detail.[11]

A study conducted in 1981 to 1982 of the epidemiology of high blood pressure (HBP) in metal assembly workers in Pittsburgh, PA, and a comparison population revealed a strong relationship between noise-induced hearing loss (≥65 dBA loss at 3, 4, or 6 kHz) and high blood pressure particularly among older men after adjusting for important HBP risk factors (alcohol intake, family history, body mass index).[11, 12] Although the effect was stronger in the noisier plant (≥89 dBA), a relationship between noise-induced hearing loss and high blood pressure was seen in the less noisy plant (≤81 dBA) as well.

The previous study[13] did not explore the potential effect of interference with speech discrimination and recruitment to loud sounds that may occur in noise exposed populations. The observed relationship may be confounded with another variable, that of social isolation from communication handicap and interference with lifestyle. This phenomenon may affect older men in the group in which we observed our greatest blood pressure difference. Therefore, the present cross-sectional investigation focused on an in-depth study of a noise-exposed

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population to characterize more finely their audiological profile and to assess further the relationship of noise-induced hearing loss as a marker for increased risk of hypertension.

The plant that employed these men was divided into six major sections: Press Room, Tool and Die, Metal Assembly, Blank and Sheer, Steel Storage, and Small Press. These are not partitioned by walls of any kind.

The workers in the plant are engaged in the fabrication and partial assembly of large metal parts. A sound survey was conducted using both a Gen Rad 1565A sound level meter as well as a Metro Logger dB-301 dosimeter. The average noise level within the plant was 89 dBA. The noise has been described as continuous and severe in all areas of the plant. A normal conversation is considered impossible.

Since 1978 there has been a mandatory hearing conservation program in effect. When men who participated in the study were queried concerning their current use of hearing protection, 39% reported wearing protection always or almost always. However, before 1978, very few of the men used hearing protection of any kind.

Study Design

There were 616 men who were members of the union retirement organization as of April 1, 1984. The study population consisted of men aged 56 to 68 with 20+ years of employment at the plant and living within a 50-mile radius. A total of 137 workers were ineligible because they had moved out of the state or lived beyond the 50-mile radius of our study area. Of the 479 remaining, 110 were ineligible because they were over or under age or currently working. Sixty-eight was chosen as the cutoff because the small numbers available at older ages may unduly confound the effects of noise exposure. Fifteen people from the original sample were deceased, 67 refused and 245 were screened. An additional 42 were unable to be contacted. The overall response rate was 78.6%. Clinical examination included measures of height, weight, pulse, and blood pressure, as well as a detailed medical and personal habit history, alcohol consumption, and smoking patterns. There was also a detailed questionnaire on occupational and military history and noisy hobbies. The examination and interview were administered at the union hall. An audiometric evaluation was also conducted. This consisted of air and bone conduction, audiometry, speech reception threshold, word discrimination testing, and an index of social interaction and communication.

Multiple blood pressure measurements using standard procedures were implemented in this investigation.[14] Blood pressure was determined by a nurse three times within 5 minutes after a 10-minute rest and then repeated by a second nurse 15 minutes later.

The following standardized procedures were utilized. All blood pressure measurements were taken using the participant's right arm in a sitting position. A standard mercury sphygmomanometer and random zero device were used for all measurements. The first measurements of each set of three were taken with the standard device followed by two readings of the zero muddler. The systolic and diastolic blood pressures of each worker were determined by the overall mean of four zero muddler measurements at one time.

The first and fifth Korotkoff sounds were recorded as the systolic and diastolic blood pressure, respectively. In addition, a history of cardiovascular disease and history of treatment for high blood pressure were obtained. The use of antihypertensive therapy was also ascertained including both current and previous use.

Standardized audiometric testing procedures were used. The testing was conducted by a certified audiologist. The procedure used for conducting the pure-tone audiogram includes the basic features of the Hughson Westlake technique for determining the pure-tone hearing threshold.[15] All audiometric testing was performed in testing booths that conform to the American National Standards criteria for background noise in audiometric rooms.[16] All thresholds were measured with a single TDH headphone. The audiometers were initially calibrated and periodically checked thereafter. The sound pressure output of the audiometer was calibrated monthly. A noise exposure questionnaire, which outlined information on employment, hobbies, military service, hearing disorders, was administered to each worker.

The revised Hearing Performance Inventory (HPI) developed by Lamb et al[21] to assess the communicative difficulty of hearing-impaired persons in a variety of everyday listening situations was administered to this population.

The Interpersonal Support Evaluation has been employed in a total of 12 studies as a measure of support functions. For psychometric properties, correlation, and scale validity refer to Cohen et al.[22] Responses to 36 items on the Interpersonal Support Evaluation and six questions designed to measure anxiety were administered. Responses to the 40 questions were categorized into six choices: I agree very much, I agree pretty much, I agree a little, I disagree a little, I disagree pretty much, and I disagree very much.

Results

Cohort Description

The age distribution of the total group is shown in Table 1. The mean age was 63 years (SD = 3.2). The present study utilized two age strata consisting of 56 to 63 years and 64 to 68 years. Diastolic blood pressure did not vary markedly with age. However, there was an age-related systolic blood pressure increase ($P < .01$). The average number of years of work at this plant was 29.9 (SD = 4.2). No consistent pattern in blood pressure by total years of employment was noted. The initial date of hire ranged from 1946 to 1970 with 90% of the mean reporting a 1950 to 1953 entry into the plant. The average date of retirement was 1981 (SD = 4.0). Therefore, this cohort had been removed from daily exposure to noise for approximately 4 years.

TABLE 1
Distribution of Age among Retired Assembly Workers in Pittsburgh, Pa 1986–1987

Age Group, y*	No.	%	Blood Pressure			
			Diastolic		Systolic	
			Mean	SD	Mean	SD
56–59	39	15.9	83.6	9.62	135.6	13.3
60–63	93	38.0	82.5	9.32	138.7	17.3
64–68	113	46.1	83.4	11.01	143.4	19.4
Total	245	100.0	83.5	10.24	140.3	17.9

* Mean age (SD) 62.9 (3.2).

The majority of workers attained a high school diploma. Ninety percent were currently married. Neither education or marital status was related to blood pressure in this sample. Eighty-nine percent had served in the military, especially World War II and the Korean conflict. In addition, 61% of the participants reported participation in hobbies, the majority of which would be construed as noisy, such as woodworking, hunting, and target shooting. These noise insults might produce a cumulative effect on the acoustic mechanism and might affect our exposure marker, noise-related hearing loss. The majority (80%) of the men worked in areas measured as noisy (steel stores, press, machine shop, press pit, or metal assembly).

Hypertension Risk Factors

The prevalence of hypertension is defined as ≥ 90 mm Hg diastolic or currently taking blood pressure medications. Workers who reported currently taking blood pressure medications exhibited higher systolic and diastolic blood pressure than those not reporting such usage (mean BP 85.9 mm Hg diastolic, 146.4 mm Hg systolic and 81.8 mm Hg diastolic, 137.1 mm Hg systolic, respectively). This may reflect poor compliance or poor hypertension control in this population. In contrast, those workers reporting a history of heart disease had slightly lower diastolic blood pressures than workers reporting no history of hypertension (mean BP 81.6 mm Hg diastolic and 146.4 mm Hg systolic, *v* 83.5 mm Hg diastolic and 140.0 mm Hg diastolic, respectively). A history of hypertension in the immediate family was noted for 35.1% of the participants. Those reporting a family history of hypertension also exhibited higher systolic and diastolic blood pressure.

Body mass index was directly related to blood pressure. For both 56 to 63-year-old and the 64 to 68-year-old groups, systolic and diastolic blood pressures significantly increased as body mass increased ($P < .01$). Alcohol consumption patterns were detailed by a self-report of the type, quantity, frequency, and variability of alcohol use.[16–19] There was a significant relationship between alcohol intake and systolic and diastolic blood pressure in the younger ($P < .05$), but not in the older age group. Although 75.9% of the participants reported ever smoking cigarettes, only 26.5% reported being current cigarette smokers.

Hearing Levels

Mean hearing levels across various frequencies are shown in Figs. 1 and 2 for both the right and the left ear for all ages combined. It can be seen that there is significant hearing loss in this population, particularly in the high frequencies, with average decibel loss at 53.7, 60.3, and 60.5 dBA at 3, 4, and 6 kHz, respectively. There is some mild recovery evidenced at 6000 and 8000 Hz. The mean threshold levels for the right and left ears of all 245 participants indicate differences between ears no greater than 2.5 dBA at all frequencies from 0.25 kHz to 6.0 kHz. The combined results of our subjects demonstrate hearing within normal limits through 1.0 kHz, followed by a progression of hearing loss that begins with a decline of 12 dBA between 1.0 kHz and 2.0 kHz, a much steeper decline (30 dBA/octave) between 2.0 and 3.0 kHz, a rather uniform loss between 3.0 and 6.0 kHz, and, finally, a mild recovery at 8000 kHz. The audiogram was consistent with noise-induced hearing loss (Figs. 1 and 2).

Severe noise-induced hearing loss was defined as a threshold greater than or equal to 65 decibels, at 3, 4, or 6 kHz within 20 dBA in the contralateral ear. Fifty-six percent of the men aged 56 to 63 years and 68.1% of the older men (64 to 68 years) had severe noise-induced hearing loss. Average speech reception threshold scores (an index of hearing impairment at lower speech frequencies), monosyllabic word discrimination test scores (a measure of speech distortion), and mean hearing thresholds for the two age groups according to severe noise-induced hearing loss categories were also determined (Table 2). There were clear differences between the high frequency ranges 3, 4, and 6 kHz according to severe noise-induced hearing loss cate-

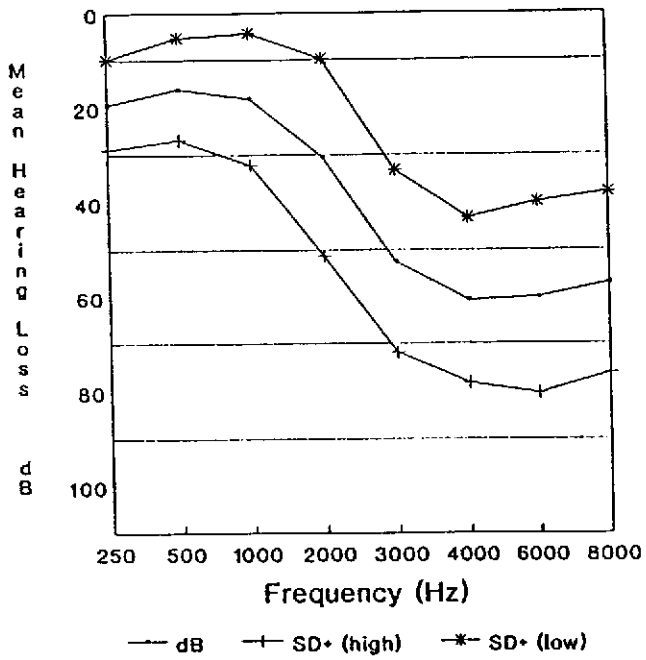

Fig. 1. Mean hearing loss levels in the right ear for workers in the noisy plant (exposed workers).

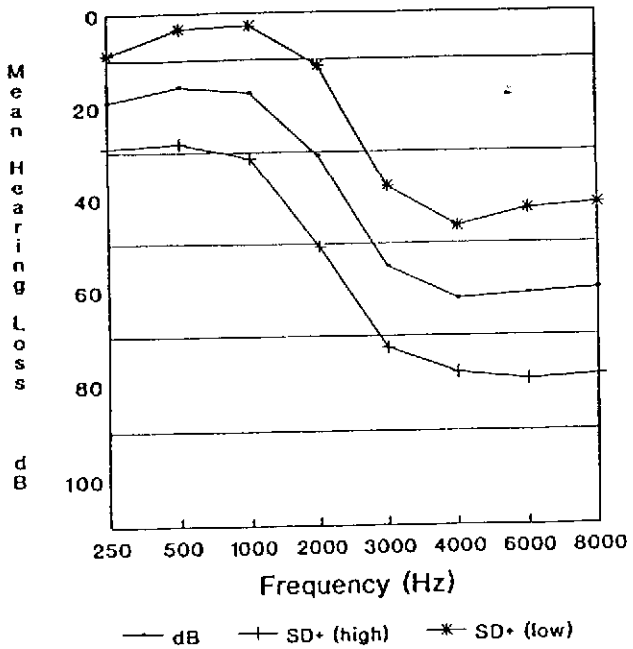

Fig. 2. Mean hearing levels in the left ear for workers in the noisy plant (exposed workers).

TABLE 2
Comparison of Puretone and Speech Discrimination Test Scores in Men by Age and Degree of Noise-Induced Hearing Loss*

	Severe Noise-Induced* Hearing Loss (n = 74)		Nonsevere Noise-Induced Hearing Loss (n = 58)	
	Mean	(SD)	Mean	(SD)
Age 56–63 y				
Average speech reception threshold	19.1	(10.1)	17.2	(15.6)
Average speech discrimination score (in noise)	42.2	(19.6)	62.0	(20.5)†
Average hearing thresholds				
3000 dB	60.7	(12.2)	39.1	(19.9)
4000 dB	68.0	(11.9)	49.1	(18.1)
6000 dB	66.4	(16.6)	48.4	(19.5)
Age 64–68 y				
Average speech reception threshold	23.2	(12.9)	16.1	(9.8)
Average speech discrimination score (in noise)	41.3	(20.4)	60.8	(21.6)‡
Average hearing thresholds				
3000 dB	63.0	(12.2)	37.7	(19.8)
4000 dB	69.6	(12.5)	48.2	(17.3)
6000 dB	70.7	(15.7)	44.8	(18.2)

* ≥65 dB loss at 3, 4, or 6 kHz.
† *t* test, $t = 5.6$, $df = 130$, $P < .0001$.
‡ *t* test, $t = 4.6$, $df = 111$, $P < .001$.

gories in both age groups. The monosyllabic discrimination tests administered in quiet areas yield scores very close to 100% in normal listeners. However, when the same test materials are administered with a competing noise of 6 simultaneous speakers at a signal-to-noise ratio of 0 dBA, normal listeners score was between 80% and 90%. Speech reception threshold and speech discrimination scores did not differ according to noise-induced hearing loss in the 56 to 63-year-old group.[13] Among the older group, a difference was noted in the speech discrimination score between noise-induced hearing loss workers compared with the nonnoise-induced hearing loss workers (83.2% [SD 11.5] *v* 91.1% [SD 7.1]. $P < .01$).

W-22 MAX represents the maximum speech discrimination score for the better ear when words are presented in combination with competing noise. It was usually more difficult to process speech in noise than in quiet conditions. In the noise presentation conditions, subjects with a lesser degree of noise-induced hearing loss scored almost 20 percentage points higher in discriminating word lists in noise than their age counterparts ($P < .001$). In the case of the two older age groups, subjects with less noise-induced hearing loss scored 7.7 percentage points higher in quiet ($t = 3.9$, $df = 111$, $P < .001$) and 19.5 percentage points higher in noise conditions relative to subjects with more noise-induced hearing loss ($t = 4.6$, $df = 111$, $P < .001$). Thus, differences in degree of higher frequency hearing loss appear related to ability to discriminate speech stimuli, particularly in the presence of competing noise.

Hypertension and Its Risk Factors According to Hearing Levels

The mean ages of the younger group with and without noise-induced loss were similar (60.5 and 60.8, respectively) (Table 3). Body mass index was higher in the nonsevere noise loss group ($P < .05$). Their average years of employment were 30.2 and 30.1, respectively. For older men with or without severe noise-induced hearing loss, the mean age was 65.9 and 65.4 years, respectively. Body mass index was similar (28.1 *v* 27.1), as was average length of employment (29.0 years) (Table 2).

A greater proportion of severe noise-induced hearing loss workers aged 64 to 68 years were currently taking blood pressure medications (39.2% *v* 20.5%, $P < .05$). The mean unadjusted blood pressures for these two groups were 144.1 mm Hg and 141.9 mm Hg systolic, respectively, and mean diastolic 84.0 mm Hg and 82.2 mm Hg, respectively (*P* value not significant).

There were no significant differences between the mean systolic or diastolic blood pressure for either age group dichotomized by hearing loss category (Table 3). Among men 64 to 68 years of age, there was a trend toward increased prevalence of high blood pressure in those with severe noise-induced hearing loss compared with those not meeting this criteria (39 of 77 [50.6%] *v* 11 of 36 [30.5%]. $P = .07$). No evidence of a relationship was seen among men aged 56 to 63 years.

The overall distribution of speech discrimination scores by hypertension status is shown in Fig. 3. There is a relationship between poor speech discrimination scores in noise (≤60%) and HBP ($P < .05$). Similar to the noise-induced hearing loss category, when these variables were further categorized by age, older hypertensive men were twice as likely to exhibit poorer speech

TABLE 3

Comparison of Salient Factors among Retired Metal Assembly Workers with and without Noise-Induced Hearing Loss*, Pittsburgh Plant

	Age 56–63 y				Age 64–68 y			
	Severe Noise-Induced Hearing Loss		Nonsevere Noise-Induced Hearing Loss		Severe Noise-Induced Hearing Loss		Nonsevere Noise-Induced Hearing Loss	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
n	74		58		77		36	
Mean age, y	60.5	(2.2)	60.8	(1.75)	65.9	(1.5)	65.4	(1.5)
Body mass index	27.6	(5.0)	29.4	(5.3)	28.1	(4.6)	27.1	(3.6)
Mean years employment	30.2	(3.8)	30.1	(3.9)	29.3	(4.5)	29.0	(5.0)
Family history of HBP	35.6%		42.4%		33.8%		35.9%	
History of hypertension	37.1%		37.3%		39.2%		20.5%	
Currently taking BP medication	34.8%		35.6%		38.3%		23.1%	
Currently smoking	31.5%		22.0%		25.7%		25.6%	
Exsmoker	17.8%		18.6%		13.5%		20.5%	
Total mean systolic blood pressure†, mm Hg	132.9	(13.2)	135.0	(15.2)	142.5	(16.3)	138.2	(16.3)
Total mean diastolic blood pressure†, mm Hg	81.8	(9.8)	81.3	(7.8)	83.5	(12.6)	79.9	(8.6)

* ≥65 dB loss at 3, 4 or 6 kHz (bilateral ± 20).

† Persons taking blood pressure medication excluded.

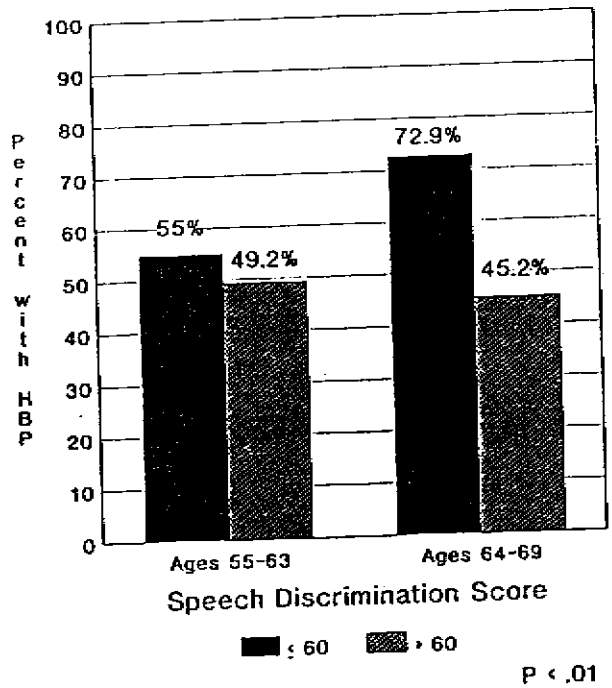

Fig. 3. Prevalence of high blood pressure (≥90 mm Hg diastolic, or taking blood pressure medication) by age and speech discrimination score in the better ear (in noise) for retired metal workers.

discrimination scores compared with nonhypertensive men (55% *v* 27.6%, $P < .01$).

Hearing Performance Inventory

The overall HPI scores in this particular study were in the lower range, indicating that the workers had little difficulty in everyday listening situations compared with a clinical sample of hearing-impaired persons. There was a nonsignificant correlation between puretone thresholds and the HPI inventory scores. The puretone threshold average correlates with the 47 listening items. However, there was only an 8% common variance. A thorough discussion of the reliability and validity of the HPI and its relationship to audiometric thresholds and hearing handicap is reported elsewhere.[35] Of the 75 items, 38 purport to measure the ability to understand speech and thus constitute the "understanding speech" section. Nine items dealt with the detectability (not the understandability) of communication and other environmental signals, making up the "intensity" section. Twenty items, composing the "response to auditory failure" section, relate to the subject's compensatory behaviors related to a communicative impairment, and eight items concern adjustment to a hearing loss in the personal section. The distribution of HPI subscores related to the specific areas were then recorded into one of three tertiles (high, medium, and low). χ^2 tests of the distribution between HPI score and HBP were conducted. No relationship between HPI and our outcome variable, HBP, was noted.

Social Support

Table 4 presents the distribution of social support scores according to noise-induced hearing loss groups for five subscores of social support. Among younger men, there was no statistically significant difference in test scores between the two hearing loss groups. In the older category, the older men with noise-induced hearing impairment did exhibit more social anxiety than younger men. Analysis of variance using blood pressure as the outcome and social support scores were dichotomized by above and below the mean; no significant relationships were observed.

Multiple Regression Analyses

Logistic multiple regression model fitting techniques, together with a step-wise procedure, were used to determine the predictors of hypertension status. Because

of the number of independent variables to be tested, only main effects were initially fitted; relevant interaction items were subsequently entered into the resulting equation to obtain a final model. Independent variables tested for inclusion in the model were (1) noise-induced hearing loss (yes = 1, no = 0), (2) W-22 MAX (speech discrimination in noise) (≤60 = 1, >60 = 0), (3) family history of hypertension (yes = 1, no = 0), (4) alcohol consumption (grams of ethanol), (5) body mass index (kg/m^2), (6) noisy hobbies (yes = 1, no = 0), (7) age in years, and (8) cigarette consumption (number of packs per day). The final model (see Table 5) included three independent variables—body mass index, family history of hypertension, and W-22 MAX—which together explained approximately 7% of the variance in the data.

The data set was subsequently stratified into the two age groups. When the procedure was applied to these data, it was found that body mass index was the only variable in the final model for the younger (55 to 63 years) age group, whereas the final model for the older (age 64+ years) age group included family history of hypertension, W-22 MAX, and body mass index. The latter model, when compared with the former, explained about three times the variance in the data (*ie*, 4% *v* 13%), indicating that we were more successful in predicting hypertension status among the older subjects.

Finally, the above analysis repeated the logistic regression only, without the W-22 MAX variable. This was done to determine whether or not noise-induced hearing loss would enter into the final model in the absence of W-22 MAX. When the logistic model was fit for all subjects (see Table 5), noise-induced hearing loss did not enter the final equation, which consisted of only two variables—body mass index and family history of hypertension. When the data were stratified according to age group, noise-induced hearing loss did enter the equation for the older (age 64+ years) age group. The resulting equation for the older age group contained two independent variables, family history of hypertension and noise-induced hearing loss, which together explained about 9% of the variance.

TABLE 4
Distribution of Social Support Scores* for Noise-Induced and Non-Noise-Induced Hearing Loss Groups

	Age 56–63 y, Noise-Induced Hearing Loss		Age 64–69 y, Non-Noise-Induced Hearing Loss	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Appraisal support	24.93 (6.3)	25.9 (7.1)	27.1 (7.5)	25.8 (8.3)
Belongingness	22.4 (6.6)	22.9 (7.8)	23.5 (7.4)	21.5 (6.2)
Self-esteem	24.7 (5.8)	24.7 (7.0)	24.5 (7.3)	23.7 (6.7)
Tangible support	18.8 (6.5)	18.6 (8.2)	18.9 (7.3)	16.9 (5.6)
Low social anxiety	22.2 (6.4)	20.9 (6.8)	21.4 (5.9)	24.1 (7.0)

* Social support: low score = high social support; high score = low social support. Social anxiety: low score = high anxiety.

Discussion

The aims of the present study were to characterize more finely the audiometric profile of a group of highly noise-exposed workers at a metal assembly plant and to determine whether severe noise-induced hearing loss was related to the prevalence of hypertension in this group of workers. The definition of severe noise-induced hearing loss was a puretone threshold of ≥65 dBA at 3, 4, or 6 kHz in either ear (within 20 dBA of each other) and is considered to be a biologic marker of noise damage. In addition to using this definition of noise-induced hearing loss, an additional index of communicative difficulty, Hearing Performance Inventory scores, was also utilized. This inventory measures five areas of hearing performance and was used as an indicator of interference with lifestyle or interpersonal communication abilities. A marginally significant relationship was noted between severe noise-induced hearing loss and the prevalence of hypertension among older men. There were nonsignificant correlations between the HPI and the more objective puretone audiometric measures of hearing loss. No relationship was found between the total hearing performance inventory scores or HPI subscores and high blood pressure.

Another measure of noise-induced hearing loss and communication in everyday life was the speech discrimination score in noise (W-22 MAX). This is an indicator of both the psychosocial impairment and biologic damage to the hearing mechanism. Referred to in this

TABLE 5
Multiple Logistic Regression of the Presence of Hypertension in Retired Male Workers and Significant Risk Factors with and without W-22 MAX*

Group	Variable	β		SE		χ^2		P	
		With W-22 MAX	Without W-22 MAX	With W-22 MAX	Without W-22 MAX	With W-22 MAX	Without W-22 MAX	With W-22 MAX	Without W-22 MAX
All subjects (n = 245)	BMI	0.12338	0.11438	0.0375	0.0364	10.82	9.90	.001	.002
	FHX	0.94741	0.85124	0.2944	0.2846	10.36	8.94	.001	.003
	W-22 MAX	0.58225		0.2852		4.17		.041	
Age group 55–63 (n = 132)	BMI	0.12123		0.0487		6.19		.013	
Age group 64+ (n = 113)	FHX	1.58481	1.57904	0.4639	0.4408	11.67	12.83	.001	.000
	W-22 MAX	1.14020		0.4580		6.20		.013	
	BMI	0.11138		0.0580		3.68		.055	
	NIHL†		0.90994		0.4681		3.78		.052

* Speech discrimination in noise/better ear.
† NIHL, noise-induced hearing loss; ≥65 dB loss at 3.0, 4.0, or 6.0 kHz.

investigation as W-22 MAX, it represents the ability to differentiate a word list presented on an audiotape with a background of noise for both the left and right ear. The score or percent of a word list correctly identified in the better ear is then taken as the W-22 MAX score for speech discrimination. The W-22 MAX measure of speech discrimination ($\leq 60\%$ v $>60\%$) was a predictor of increased prevalence of hypertension in both age groups. This indicates that W-22 MAX may be a more sensitive index of both the psychosocial and biologic components of noise-induced hearing loss. The hallmark of loss in the speech range was found in the frequencies of 1000 to 2000 kHz. Clinically, a person who is above a 35-dBA threshold for these frequencies may be adversely affected with regard to his or her speech discrimination score. He or she may also be at risk for the hypertensive effects of chronic noise exposure.

Our previous noise and blood pressure study also noted a significant relationship between noise-induced hearing loss and blood pressure, with the effect in older men being more pronounced.[11] The sample population drawn from the plant for the present study were older retired men who had not participated in the earlier investigation. They represent, therefore, a cohort that in the earlier study were aged 56 to 63 years, but were now part of the 63 to 68-year-old group. It is interesting to note that once again this group may represent the most noise-exposed cohort. These results suggest that there may be a threshold of occupational noise exposure that must be reached before the relationship between noise-induced hearing loss and hypertension is exhibited. W-22 MAX appears to be a unique measure of both noise-related damage to the cochlea as well as a determinant of communication handicap. Further work with speech discrimination testing in other noise exposed populations is needed.

A variable not addressed by the current study is the effect of lipoprotein levels and noise exposure on hearing. Noise-induced hearing loss is a well-documented effect of prolonged exposure in a noisy environment.[25] Several investigators, however, have reported a correlation between hearing loss, particularly at high frequencies, and high serum cholesterol levels.[25-31] Epidemiologic studies have suggested that elevated blood lipids, which are known to lead to atherosclerosis, may cause damage to the vascular system of the inner ear. This may result in an increased susceptibility to noise-induced hearing loss.[32] Animal experimentation involving exposure to both an atherogenic diet and high levels of noise has yielded similar results.[33,34] Although the pathogenesis of the relationship between abnormal blood lipids and noise-induced hearing loss is not fully understood, a model for the mode of interaction has been proposed by Axelsson and Lindgren.[26] Future work in the area of noise-induced hearing loss and blood pressure should include lipid measurements as well as better measures of speech discrimination.

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Agenda for Afternoon of Life

We might compare masculinity and feminity and their psychic components to a definite store of substances of which, in the first half of life, unequal use is made. A man consumes his large supply of masculine substance and has left over only the smaller amount of feminine substance, which must now be put to use. Conversely, the woman allows her hitherto unused supply of masculinity to become active.

This change is even more noticeable in the psychic realm than in the physical. How often it happens that a man of forty-five or fifty winds up his business, and the wife then dons the trousers and opens a little shop where he perhaps performs the duties of a handyman. There are many women who only awaken to social responsibility and to social consciousness after their fortieth year . . . .

The worst of all is that intelligent and cultivated people live their lives without even knowing of the possibility of such transformations. Wholly unprepared, they embark upon the second half of life. Or are there perhaps colleges for forty-year-olds which prepare them for their coming life and its demands as the ordinary colleges introduce our young people to a knowledge of the world? No, thoroughly unprepared we take this step with the false assumption that our truths and ideals will serve as hitherto. But we cannot live the afternoon of life according to the program of life's morning; for what was great in the morning will be little at evening, and what in the morning was true will at evening have become a lie. I have given psychological treatment to too many people of advancing years, and have looked too often into the secret chambers of their souls, not to be moved by this fundamental truth.

—From Jung CG. *Aspects of the Masculine.*
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1 - SURDITÉ ET AUTRES EFFETS DU BRUIT

Le bruit est présent dans de nombreuses entreprises alimentaires. Comme la plupart des intervenants en santé au travail ont déjà une expérience valable dans ce domaine nous n'élaborerons pas sur ce sujet : l'évaluation et la surveillance médico-environnementales s'appliquent de la même manière. Les sources de bruit peuvent cependant être différentes. On n'a qu'à songer à la chaîne mécanique de l'embouteillage. Il faudra se familiariser avec les solutions technologiques spécifiques aux différents procédés. Etant donné l'avancement du dossier sur le bruit, d'autres aspects comme le stress dû au bruit pourraient être évalués.

Surdité et autres effets du bruit

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* Article joint

Contraintes
thermiques

+ inconfort

2 - CONTRAINTES THERMIQUES ET SANTÉ

2.1 - Chaleur

La chaleur peut devenir une contrainte dans certaines circonstances ou tâches précises. Par exemple les fours à pains dans les boulangeries. Comme pour le bruit, l'évaluation, la surveillance et les mesures de prévention sont similaires à celles appliquées dans d'autres genres d'entreprises.

2.2 - Froid

Dans le contexte de l'industrie, l'exposition au froid dans l'entreprise se situe le plus souvent entre 0°C et 10°C et ponctuellement jusqu'à - 20°C. Il s'agit d'une contrainte thermique bien différente de celle des travailleurs de l'extérieur exposés à des températures extrêmement basses qui peuvent causer des engelures et des hypothermies sévères. On pourrait qualifier l'exposition du travailleur alimentaire de "froid intermédiaire" : il s'agit d'un stress thermique dont les effets sur la santé sont souvent mal définis et mal connus, mais qui contribue à des inconforts sérieux et à la perte de dextérité manuelle. Les lieux de travail les plus souvent impliqués sont :

- chambres froides laitières (+ 4°C)
- unité de coupe (+ 10°C)
- empaquetage de la viande (+ 10°C)
- entreposage : poisson (0°C à 2°C)
  produits laitiers (0°C à 10°C)
  produits congelés (- 18° à - 20°C)

Il est bon de reviser brièvement comment se font les échanges thermiques de l'homme avec son milieu, comment ils s'appliquent aux travailleurs des entrepôts frigorifiques, jusqu'à quel point les travailleurs s'adaptent et enfin comment à la lumière de ces données scientifiques, ils peuvent se protéger.

Les quatre processus d'échange de chaleur sont la conduction, la convection, l'évaporation et le rayonnement. Entre les corps matériels inertes, les échanges se font jusqu'à égalisation des températures. Entre le milieu

adaptation corporelle totale
Soin vêtement ≠ adaptation corporelle
adaptation des extrémités peut se faire mais peut avoir baisse de dextérité

ambiant et le corps humain, les échanges se font vers l'égalisation, mais l'organisme tendant à maintenir une température constante, compense ses pertes par la production accrue d'énergie. Advenant une incapacité à maintenir une température constante, le corps humain peut développer toutes les pathologies bien connues de l'exposition au froid. La thermogénèse se fait par des mécanismes cardiovasculaires hormonaux, neurologiques ou hypothalamiques. Dans une ambiance froide, la perte de chaleur se produit par l'émission d'ondes électromagnétiques longues qui sont absorbées par les matières froides environnantes. Près d'un mur froid, un individu peut perdre beaucoup de son énergie calorifique. Cette perte est proportionnelle à la différence de température entre sa peau et la surface froide avoisinante. Cette perte est énorme. Le rayonnement compte pour 40 à 60% de la totalité des pertes calorifiques et se chiffre à environ 1000 à 1500 Kcal. Viennent ensuite les pertes par convection qui sont de l'ordre de 25 à 30%. Les pertes par conduction sont habituellement moins fréquentes car elles nécessitent le contact direct avec l'objet froid. L'évaporation de la sueur ne cause habituellement pas de refroidissement, mais si l'activité physique s'intensifie et que les vêtements s'humidifient au contact de la sueur, un refroidissement plus marqué s'ensuit.

L'adaptation au froid, à toutes fins pratiques, se divise en adaptation corporelle totale et en adaptation des extrémités. Les Inuit par exemple ont une adaptation des mains et du visage au froid, par contre ils sont aussi sensibles que les autres races à l'exposition corporelle totale vu qu'ils portent des vêtements protecteurs adéquats.

Lors de l'immersion d'une main dans l'eau froide la température des doigts chute à 0°C; après quelques minutes, elle s'élève à 5-6°C et fluctue ensuite entre 0 et 5°C. Il y a vasoconstriction initiale suivie d'une vasodilatation observable, due à un "shunt" artério-veineux. La douleur survient en baisse de température et s'atténue lors de la pseudovasodilatation. La douleur apparaît le plus souvent en vasoconstriction mais existe parfois en vasodilatation. Ce phénomène se répète de façon intermittente. Les Inuit, les pêcheurs et bien d'autres ne ressentent pas de douleur, ils sont adaptés.

En ce qui concerne l'adaptation corporelle totale seulement quelques peuplades s'acclimatent vraiment au froid. Paradoxalement, ils vivent dans des climats chauds. Les arborigènes d'Australie Centrale, les hommes des bois de Kalahari, les Indiens de Tierra Fuego et quelques autres s'adaptent.

Ils peuvent dormir nus à 0°C ou plus bas en hiver sans abri entre deux petits feux. Ils ne frisonnent pas, leur température rectale ou cutanée continue à baisser toute la nuit et ils dorment. Ils survivent en hypothermie dans un confort relatif. Dans les mêmes conditions un individu non adapté perd sa chaleur, frissonne, présente une légère baisse de température rectale et bien entendu ne réussit pas à dormir.

A la lumière de ces connaissances on peut se rendre compte que dans les entrepôts frigorifiques les travailleurs exposés à des températures de 0° à 10°C ne passent pas à un stade d'adaptation même après des années d'exposition. Des études récentes en Suède tendent à confirmer ces faits. On a constaté un inconfort marqué au niveau des extrémités s'approchant parfois du seuil de la douleur à des températures de 10°C. Une baisse de dextérité manuelle se manifeste à ces niveaux. Par contre, on a noté une adaptation psychologique à ces inconforts ou douleurs. L'explication de la non adaptation vient du fait que les conditions de températures ne sont pas assez basses pour permettre une adaptation des travailleurs.

Cette absence d'adaptation doit être retenue lors de la recherche de moyens de protection de mains. Le port de gants en coton est efficace temporairement, mais perd de sa valeur quand le gant se mouille. La dextérité ou le rendement est souvent moindre avec des gants.

En général, des travailleurs dans les chambres frigorifiques auraient tendance à sous-estimer le besoin de protection contre le froid et porteraient des vêtements d'isolation insuffisante. Cette perception du froid est probablement reliée à la variation d'intensité des activités.

En l'absence d'adaptation physiologique à des conditions de températures froides limitrophes, il ne reste que la protection personnelle pour rendre le travail confortable. Comme les activités varient en intensité et que les températures ambiantes changent d'une pièce à l'autre, il faudra user de beaucoup d'ingéniosité pour arriver à une solution pratiquement acceptable.

Seuil : 23 à 24°C sur le dos de la peau de la main
serait le mieux

2.3 - Prévention, contrôle et surveillance

En ce qui a trait aux moyens de prévention générale nous vous référons au texte ci-joint de l'INRS sur le froid artificiel dans l'industrie alimentaire. Quant à la surveillance médicale nous procédons en déterminant la population cible selon le risque et la présence des atteintes à la santé, et non par des examens généraux obligatoires tels que décrits en référence. Nous croyons qu'il est important de tenir compte des symptômes rapportés par les travailleurs, de vérifier les cas individuels et de proposer des solutions à la lumière des connaissances dans le milieu de travail. On pourra surveiller certaines pathologies spécifiques comme la maladie de Raynaud. Les méthodes de surveillance et les solutions aux problèmes rencontrés ne sont pas nécessairement connues aussi faudra-t-il agir selon les besoins et circonstances des milieux de travail et suivre les recherches en cours. A titre d'exemple, même si on préconise la mesure de la température cutanée du dos de la main comme moyen d'évaluation, peu d'intervenants ont développé cette expertise et cette méthode reste à évaluer.

Contraintes thermiques et santé

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INRS

ND 1637-128-87

Baisse de la dextérité des salariés travaillant au froid

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L'exposition au froid entraîne une diminution de la dextérité. L'objectif de la présente étude est de rechercher celle-ci chez les salariés exposés au froid dans des locaux dont la température est comprise entre −30 °C et +10 °C.

Cinquante-sept salariés ont subi deux fois le test du boulon sans aucun entraînement préalable; une fois à leur poste de travail au froid, une autre fois dans un local dont la température est normale (autour de 20 °C). Le seuil de température cutanée du dos de la main ($t_{sk,m}$) en deçà duquel la dextérité des salariés est modifiée se situe entre 23 et 24 °C. Ce résultat est obtenu grâce à une analyse de variance particulière. La $t_{sk,m}$ de près de la moitié des salariés étudiés est inférieure au seuil de 24 °C. La baisse de la dextérité chez les salariés exposés au froid est donc une réalité.

Le fait que l'étude se déroule uniquement dans les entreprises amène une situation expérimentale spécifique car certains facteurs ne peuvent pas être contrôlés directement. Aussi, la validité du test du boulon, l'intérêt de $t_{sk,m}$ en tant qu'indicateur de refroidissement, ainsi que la validité de la relation en forme de courbe à seuil liant le refroidissement corporel à la performance, sont discutés par rapport à la littérature.

Impairment of worker's dexterity working in cold environments.

Cold environments affect finger dexterity. The purpose of this study was to evidence any decrease in dexterity among people occupationally exposed to cold in stores with temperatures between −30 °C and +10 °C. As the results of the studies carried out in this field are difficult to analyse, it appears necessary to previously assess the relationships between body cooling and dexterity by reviewing the literature. The concept of critical hand skin temperature, which is used now, allows us to choose the adequate statistical tool in order to analyse the results of this study.

Fifty seven workers were twice subjected to the screw-test without any previous training : one time at the workplace in a cold environment, another time in a room at normal temperature (around 20 °C). The threshold of hand skin temperature below which the dexterity is affected is 23-24 °C. This result is obtained by an ANOVA. In fifty percent of the subjects studied, the hand skin temperature measured was below 24 °C during the working days. The results of this study show that the impairment of worker's dexterity could be a real problem. It must be taken into account by the persons organizing the work of people occupationally exposed to cold.

Le refroidissement des mains entraîne une baisse de la dextérité (Fox, 1967; Enander, 1984). Or, chez les salariés exposés au froid, le refroidissement affecte surtout les extrémités corporelles, donc les mains (Enander et coll., 1979; Williamson et coll., 1984). Par ailleurs, il faut considérer la baisse de la dextérité comme une des causes possibles d'accident du travail chez ces salariés. *L'objectif de la présente étude est de mettre en évidence, si elle existe, cette baisse de la dextérité chez les salariés exposés au froid dans l'industrie alimentaire.* Il s'agit donc d'une étude sur le terrain qui impose des contraintes spécifiques (en particulier, absence de maîtrise du refroidissement des mains des salariés) à l'origine de difficultés pour mettre en évidence une liaison entre la performance et le refroidissement des mains. En conséquence, c'est l'analyse des documents bibliographiques qui nous conduit à choisir le test du boulon, car il nécessite des mouvements fins des doigts, la température cutanée du dos de la main comme indicateur de refroidissement (Fox, 1967) et une relation en forme de courbe à seuil pour relier le refroidissement de la main à la performance (Fox, 1967; Enander, 1984). Tous ces choix seront justifiés dans la discussion.

(1) Service de physiologie environnementale.

1. MÉTHODE

La présente étude s'est entièrement déroulée au poste de travail des salariés sans que l'organisation de leur tâche soit modifiée. Parmi les 57 salariés qui ont participé à l'étude, 21 travaillent dans un local dont la température est inférieure à 0 °C (chambre froide) et 36 travaillent dans un local dont la température est comprise entre 0 °C et +10 °C (chambre climatisée). Quinze femmes travaillent dans une chambre climatisée alors qu'aucune ne travaille dans une chambre froide.

1.1. Origine et déroulement du test du boulon

1.1.1. Origine

Le test du boulon fait partie de la batterie des tests de dextérité et de rapidité de Bonnardel. La présentation du test aux salariés est rapide car visser des boulons est un geste connu par tous. Enfin, le matériel est solide, peu encombrant et facile à transporter. C'est pourquoi, ce test a été retenu pour la présente étude.

1.1.2. Déroulement

Le salarié est assis à une table. Devant lui, 3 casiers sont disposés côte à côte. Les casiers de droite et de gauche contiennent soit les vis, soit les écrous, le salarié choisissant leur emplacement relatif. Au signal donné par l'expérimentateur, il prend une vis et un écrou, visse un tour et dépose le boulon dans le casier central. La consigne est de visser le maximum de boulons pendant 2 minutes. Les vis ou les écrous qui tombent des mains ne doivent pas être ramassés. Avant et pendant le test, aucun encouragement n'est adressé au salarié pour le motiver.

Le test du boulon est subi mains nues, sans aucun apprentissage préalable. Il est subi deux fois, une fois dans des conditions de référence (Réf.), une fois au froid (F). Pour le test au froid, la température d'air est toujours inférieure à +10 °C. Pour le test de référence, la température d'air est comprise entre 18 et 26 °C. Avant le test au froid, les boulons et les casiers sont conservés dans un chariot isotherme (température supérieure à 15 °C), si bien qu'ils ne se refroidissent pas suffisamment pendant ce test pour en biaiser les résultats. Le test au froid est subi sur le lieu du travail. S'il porte des gants, le salarié les retire. Étant donné que le salarié subit deux fois le test, l'apprentissage peut interférer avec l'effet du froid. C'est pourquoi, la population des salariés étudiés est divisée en deux groupes. Un groupe subit d'abord le test de Réf., puis le test F (sens de passation « Réf. → F »). L'autre groupe subit le test F, puis le test de Réf. (sens de passation « F → Réf. »). Le sens de passation est pré-établi pour chaque entreprise de manière à équilibrer, a priori, les effectifs des deux groupes. Cinquante-sept salariés ont subi les deux tests, soit 29 dans le sens « F → Réf. » et 28 dans le sens « Réf. → F ».

1.1.3. Mesure de la température cutanée du dos de la main gauche ($t_{sk,m}$)

La température cutanée du milieu du dos de la main gauche ($t_{sk,m}$) est relevée avant chacun des 2 tests. Le capteur de température est une thermistance de type CRAFTEMP, enveloppée dans un ruban de cuivre adhésif. Ce capteur est fixé à la peau, dégraissée au préalable avec de l'éther, au moyen d'un ruban adhésif de type BLENDERM.

2. RÉSULTATS

Le test au froid est subi après une durée continue de travail au froid très variable d'un salarié à l'autre. En moyenne, cette durée est de 95 min avec un écart-type de 54 min. La dispersion est importante; elle est due à la grande variabilité de la durée continue d'exposition au froid des salariés et, dans une moindre mesure, à l'instant choisi pour subir le test. Le test de référence est réalisé dans le local où le salarié est préparé. Lorsque le salarié subit le test de référence, il est dans ce local depuis au moins 10 à 15 minutes.

Les résultats sont présentés en deux parties. La première concerne la présentation des résultats bruts, la seconde partie présente la méthode statistique utilisée pour déterminer le seuil.

2.1. Résultats bruts

Le nombre de boulons vissés par un salarié pendant un test représente la performance. Les valeurs qui figurent dans le tableau I sont les moyennes

TABLEAU I

Moyenne et écart-type des performances réalisées par les salariés aux tests du boulon

	Effectif		Sens			2 sens confondus		Apprentissage	
			1 Réf. →	2 F →	3 Réf.	4 Réf.	5 Froid	6 1er	7 2e
Échantillon complet	57	$\bar{x}$				29,1	27,6	27,2	29,5
(ligne A)		σ				5,5	5,9	5,3	5,5
Groupe Réf. → F	28	$\bar{x}$	28,9	29,7					
(ligne B)		σ	5,6	5,6					
Groupe F → Réf.	29	$\bar{x}$		25,6	29,3				
(ligne C)		σ		5,4	5,6				

$\bar{x}$: moyenne.
σ : écart type.

interindividuelles des performances aux tests pour chaque groupe de salariés suivant : l'échantillon complet, le groupe « Réf. → F », le groupe « F → Réf. ».

Dans le tableau II, figurent les résultats des tests de Student pour échantillons appariés réalisés sur les résultats bruts tels qu'ils sont présentés dans le tableau I.

Pour l'ensemble de l'échantillon, les performances au test au froid sont significativement inférieures à celles obtenues au test dans les conditions de référence (A4–A5, tableau II).

Dans le groupe « Réf. → F », les performances au test dans les conditions de référence sont inférieures à celles obtenues au test au froid sans que cette différence soit significative (B1–B2, tableau II).

Dans le groupe « F → Réf. », les performances au test au froid sont significativement inférieures à celles obtenues au test dans les conditions de référence (C2–C3, tableau II).

TABLEAU II

Tests de Student

Moyennes comparées	« t »	Degré de liberté (ddl)	Signification
A4 - A5	2,26	56	$p < 0,05$
B1 - B2	0,37	27	NS
C2 - C3	4,56	28	$p < 0,01$
A6 - A7	3,62	56	$p < 0,01$

NS : non significatif.
$p < 0,05$: seuil de significativité.
A, B, C, 1, 2, 3, 4, 5, 6, 7 sont les numéros des lignes et des colonnes du tableau I.

D'autre part, pour l'ensemble de l'échantillon, lorsque le sens de passation est pris en compte indépendamment de la température du local où le test est subi, les performances au premier test sont significativement inférieures à celles obtenues au second test (A6–A7, tableau II).

Les résultats bruts des tests ne sont pas suffisants pour mettre en évidence l'effet du froid. Mais ils indiquent que le sens de passation doit être pris en compte dans l'analyse des données.

2.2. Recherche du seuil

L'analyse bibliographique montre l'importance de $t_{sk,m}$ en tant qu'indicateur physiologique permettant de représenter au mieux l'influence du froid dans le cadre de la relation en forme de courbe à seuil. La recherche du seuil est donc indispensable.

Afin d'éliminer l'influence des variations interindividuelles de performance, les boulons vissés au froid sont exprimés en pour cent de ceux vissés dans les conditions de référence. La figure 1 présente l'évolution de la performance en fonction de $t_{sk,m}$ mesurée avant le test au froid de chacun des 57 salariés.

Le seuil où commence à apparaître l'influence du froid est recherché par répétition d'une analyse de variance à deux facteurs avec prédétermination des deux classes établies par rapport à une valeur de $t_{sk,m}$ progressivement incrémentée de 1 °C.

Les deux facteurs sont les suivants :

- $t_{sk,m}$ mesurée avant le test au froid,
- sens de passation.

Chaque $t_{sk,m}$ est appariée au résultat du test exprimé en pour cent. L'analyse de variance se déroule alors comme suit. Pour chaque valeur de $t_{sk,m}$ choisie entre 20 et 29 °C, deux classes de salariés sont constituées, l'une dont $t_{sk,m}$ est inférieure à $t_{sk,m}$ choisie et l'autre dont $t_{sk,m}$ est supérieure. Entre 20 et 29 °C, 12 valeurs de $t_{sk,m}$ sont choisies et, par conséquent, 12 analyses de variances sont effectuées. La figure 2 représente l'évolution des 3 valeurs de « F » de Fischer correspondant aux 2 effets et à leur

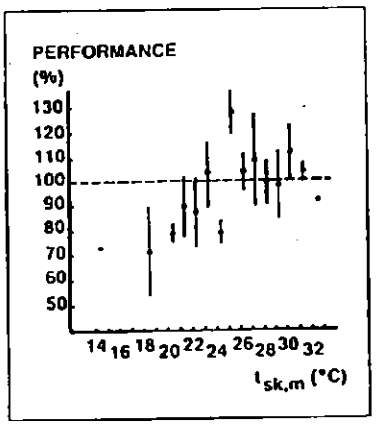

Fig. 1. Performance, exprimée en %, au test du boulon en fonction de $t_{sk,m}$.

•: moyenne des performances des salariés dont $t_{sk,m}$ est dans l'intervalle $[(t_{sk,m}), (t_{sk,m} + 1)[$.
|: écart-type centré sur la moyenne.
N : nombre de salariés pour lesquels $t_{sk,m}$ est compris dans l'intervalle défini précédemment.

$[(t_{sk,m}), (t_{sk,m} + 1)[$	14, 15	15, 16	16, 17	17, 18	18, 19	19, 20	20, 21	21, 22	22, 23	23, 24
N	1	3	2	3	5	6	7	3	2	5

24, 25	25, 26	26, 27	27, 28	28, 29	29, 30	30, 31	31, 32	32, 33
3	2	5	3	7	4	3	2	1

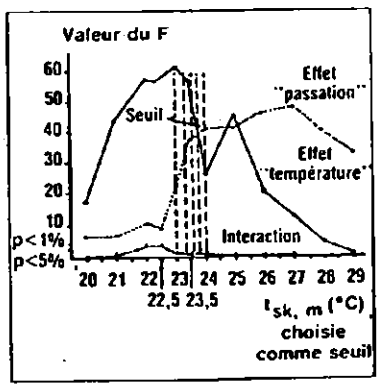

Fig. 2. Recherche du seuil; valeurs des F pour chacune des 12 analyses de variance (cf. paragraphe 2.2).

$t_{sk,m}$ (°C) choisie comme seuil	20	21	22	22,5	23
Effectifs dans les 2 classes	6-51	9-48	14-43	17-40	20-37

23,5	24	25	26	27	28	29
25-32	27-30	30-27	32-25	37-20	40-17	47-10

interaction, en fonction de $t_{sk,m}$ choisi comme seuil. Chaque analyse de variance est réalisée avec des classes à effectifs variables mais dont le total des effectifs des deux classes est toujours égal à 57.

« L'effet température » est toujours significatif car, quelle que soit $t_{sk,m}$ choisie, tous les salariés sont contenus dans les 2 classes. C'est pourquoi, l'analyse des 2 courbes de la figure 2 tient compte uniquement des variations des valeurs de « F », surtout dans l'intervalle 23-27 °C. Entre 23 et 27 °C, les valeurs de « F » de « l'effet température » sont les plus élevées et plus précisément entre 23 et 23,5 °C. Autrement dit, l'influence de $t_{sk,m}$ sur la baisse de la performance est maximum pour ces valeurs de $t_{sk,m}$.

L'effet « sens de passation » n'est pas significatif en dessous de 22,5 °C. Puis la courbe s'élève brutalement entre 22,5 et 24 °C et l'effet devient significatif. Au-delà, la courbe reste parallèle à l'axe des $t_{sk,m}$. Ainsi, lorsque $t_{sk,m}$ est inférieure à 23 °C environ, l'influence du sens de passation sur la performance est faible parce que l'effet température prédomine. En revanche, lorsque $t_{sk,m}$ est supérieure à 23 °C, « l'effet passation » est important, la répétition du test entraînant une amélioration des résultats. Autrement dit, le salarié bénéficie alors de bonnes conditions d'apprentissage parce que l'influence de « l'effet température » n'existe plus. Ainsi, au-delà de 24 °C de $t_{sk,m}$, la dextérité n'est pas modifiée par le froid.

Si le seuil de $t_{sk,m}$, en deçà duquel la dextérité est diminuée, est fixé entre 23 et 24 °C, aucune corrélation ne doit alors exister entre $t_{sk,m}$ et la performance pour tous les salariés dont $t_{sk,m}$ est supérieure à ce seuil.

Ce test de corrélation a donc été réalisé. Cependant, du fait que le seuil ne peut être fixé avec précision puisque c'est un intervalle qui est proposé, 3 valeurs seuils ont été choisies, soit respectivement : 23, 23,5 et 24 °C. Le tableau III présente ces corrélations; pour chaque valeur du seuil, 2 corrélations sont calculées : l'une entre les $t_{sk,m}$ supérieures au seuil et la performance correspondante, l'autre entre les $t_{sk,m}$ inférieures au seuil et la performance correspondante.

L'examen de ce tableau montre que, quel que soit le seuil, aucune corrélation n'existe entre les $t_{sk,m}$ supérieures à ce seuil et la performance. En revanche, la corrélation entre les $t_{sk,m}$ inférieures à ce seuil et la performance est significative pour les valeurs de seuil de 23,5 et 24 °C.

Ces résultats confirment donc que le seuil peut être fixé entre 23 et 24 °C.

TABLEAU III

Tests de corrélation entre les $t_{sk,m}$ supérieures au seuil ou inférieures au seuil et la performance correspondante

	Corrélation entre les $t_{sk,m}$ supérieures au seuil et la performance correspondante			Corrélation entre les $t_{sk,m}$ inférieures au seuil et la performance correspondante			
Seuil °C	r.	ddl	Signification	r.	ddl	Signification	Droite de régression perf. % = a $t_{sk,m}$ + b
23	0,06	35	NS	0,38	18	$p \leq 10\,\%$	
23,5	0,05	30	NS	0,48	23	$p \leq 5\,\%$	perf. % = 3,2 $t_{sk,m}$ + 16,8
24	0,1	28	NS	0,55	25	$p \leq 1\,\%$	perf. % = 4,3 $t_{sk,m}$ − 4,3

ddl : degré de liberté.
NS : non significatif.
$p \leq 5\,\%$: seuil de significativité.

3. DISCUSSION

La présente étude vise à mettre en évidence la diminution éventuelle de la dextérité chez les salariés qui travaillent dans des ambiances thermiques froides. Elle est donc réalisée sur le terrain sans que les conditions de travail des salariés soient modifiées. Cette situation expérimentale particulière influence l'organisation de l'étude ainsi que le dépouillement.

Chaque salarié étudié subit une contrainte thermique froide qui lui est propre. En effet, la tâche, le vêtement, la durée d'exposition et les caractéristiques de la contrainte thermique sont propres à chacun des salariés étudiés. Par exemple, certains salariés portent en permanence des gants, d'autres n'en portent jamais, d'autres encore n'en portent qu'épisodiquement, d'autres enfin ne portent qu'un seul gant. L'exemple des gants illustre bien l'hétérogénéité des contraintes thermiques subies par les salariés. En conséquence, le refroidissement des tissus cutanés et sous-cutanés du membre supérieur qui représente l'astreinte thermique des salariés exposés au froid (Enander et coll., 1979; Williamson et coll., 1984) n'est pas comparable d'un salarié à l'autre. Or, Clark et Cohen (1960) qui utilisent le test de nouage montrent que la performance dépend non seulement de la température cutanée mais aussi de la température des tissus plus profonds (muscles, nerfs, articulations). Ainsi, selon ces auteurs, pour une même température cutanée, plus la température des tissus profonds est basse, plus la performance est diminuée.

Cette observation a deux conséquences. En premier lieu, il n'est pas possible de proposer dans la présente étude une relation liant la baisse de la dextérité au refroidissement. En effet, en raison de l'hétérogénéité des conditions expérimentales, le refroidissement des membres supérieurs de chaque salarié est spécifique, donc différent de chacun des autres salariés. Il s'ensuit que pour deux salariés dont le refroidissement des tissus profonds est différent, la performance au froid sera différente bien qu'il soit possible que leurs températures cutanées soient identiques. En second lieu, le choix de l'indicateur de refroidissement s'avère complexe. Aussi, ces deux questions doivent-elles être discutées en tenant compte des données bibliographiques.

Auparavant, il est aussi nécessaire de justifier le choix du test du boulon parmi les différents tests disponibles.

Les différents auteurs qui ont étudié l'influence du froid sur la dextérité ont montré l'importance que revêt le choix

test. C'est le test du boulon de nnardel qui a été choisi pour la présente étude. Il ne figure pas dans la liste des tests retenus par Wyon 177) pour évaluer la baisse de la xtérité chez l'homme exposé au ...oid. Le test du boulon présente néanmoins les critères requis pour e retenu. En effet, les auteurs qui lisent des tests nécessitant des ouvements fins des doigts (test de nouage (knot tying), de licelage (block stringing) et de rapidité digitale (coun- g task)) observent une diminution : la performance au froid (Gaydos et sek, 1958; Clark et Cohen, 1960; Tanaka et coll., 1983). En revanche, les auteurs qui utilisent des tests ne cessitant pas de mouvements fins s doigts mais plutôt des mouve-...ents du poignet ou du coude (certains tests du laboratoire de psycho-logie de l'université du Minnesota; st de vissage – dévissage avec urnevis) n'observent pas de diminution de la performance (Teichner, 1957; Lockhart, 1968). Le test du oulon implique des mouvements fins s doigts et Bonnardel le considère mme un test de dextérité. C'est donc un test pertinent pour mettre en évidence la baisse de la dextérité ez les salariés exposés au froid.

Le refroidissement du membre supérieur ou d'une partie de celui-ci est ffisant pour entraîner une baisse de dextérité (Leblanc, 1956; Lockhart et ess, 1971). Or, c'est essentiellement cette partie du corps qui se refroidit chez les salariés exposés au froid. De lus, parmi les différentes températures cutanées qui peuvent être relevées au niveau du membre supérieur, Tanaka et coll. (1983) montrent que la température cutanée du dos de la ain ($t_{sk,m}$) est celle qui reflète le ieux l'influence du froid sur la dexté-...té. Cette observation est partagée par d'autres auteurs (Fox, 1967; Enander, 1984). La température cutanée du os de la main doit donc être retenue omme étant l'indicateur de refroidissement le plus pertinent.

e choix de la nature de la relation ant $t_{sk,m}$ à la performance soulève en evanche plus de difficultés qui ne sont pas sans conséquence sur le dépouillement des résultats. En effet, e choix de l'outil statistique qui permet de dépouiller les résultats dépend de la nature de cette relation. Dans une analyse bibliographique, Fox (1967) estime que la baisse de la dextérité n'apparaît que lorsque $t_{sk,m}$ atteint une valeur seuil. Pour cet auteur, le refroidissement de la main entraîne une hypoesthésie tactile et une diminution de la dextérité. Celles-ci n'apparaissent qu'à partir d'un seuil de $t_{sk,m}$ qui serait, selon l'auteur, de 8 °C pour la sensibilité tactile et de 12 à 16 °C pour la dextérité. Fox (1967) fonde son opinion sur l'analyse d'études qui sont réalisées en laboratoire ou sur le terrain. La relation en forme de courbe à seuil ne semble pas toutefois compatible avec les résultats présentés par d'autres auteurs. Lockhart et Kiess (1971) et Tanaka et coll. (1983) trouvent, en effet, des corrélations significatives entre $t_{sk,m}$ et la performance des sujets pour des tests qui impliquent des mouvements fins des doigts. Cependant, Lockhart et Kiess (1971) limitent la portée de la relation linéaire qu'ils ont relevée parce qu'ils considèrent que $t_{sk,m}$ n'est peut-être pas l'indicateur de refroidissement le plus pertinent.

Or, l'expérience de Clark et Cohen (1960) le démontre. C'est pourquoi, Enander (1984) qui retient la relation en forme de courbe à seuil propose d'y inclure deux limites, d'une part le test choisi doit impliquer des mouvements fins des doigts et d'autre part la température cutanée ne reflète pas précisément la température des tissus profonds dont le rôle apparaît déterminant. Cependant, dans toutes les expériences, seules les températures cutanées sont mesurées. En effet, la mesure de la température des tissus profonds est difficilement réalisable chez l'homme.

Les mécanismes à l'origine de la diminution de la dextérité sont mal connus. Lockhart et Kiess (1971) pensent qu'une exposition sévère au froid modifie la sensibilité tactile cutanée, affecte le contrôle des muscles des doigts, des mains et des bras et réduit la mobilité articulaire. Hunter et coll. (1952) ont montré que la viscosité du liquide synovial de bovins augmente lorsque la température articulaire diminue. Vanggaard (1975) montre que la conduction nerveuse du nerf cubital chez l'homme diminue lorsque la température baisse et est bloquée lorsque sa température atteint 10 °C.

Dans la présente étude, une analyse de variance particulière permet de rechercher le seuil. Cette particularité tient au fait que les salariés étudiés n'ont subi aucun entraînement préalable car celui-ci n'était pas envisageable au regard de la situation expérimentale. C'est pourquoi l'échantillon des salariés étudiés est divisé en deux. Chaque groupe a subi deux fois les tests – une fois au froid, une fois dans les conditions de référence – mais dans un sens de passation différent, ceci afin d'intégrer l'influence de la répétition du test sur la performance. L'analyse de variance intègre donc deux facteurs, à savoir le sens de passation et $t_{sk,m}$. L'absence d'apprentissage, loin de gêner l'interprétation des résultats obtenus, contribue à démontrer l'existence du seuil. L'analyse de variance particulière utilisée peut donc être proposée dans des situations expérimentales où aucun apprentissage ne peut être envisagé.

Le seuil se situe entre 23 et 24 °C. Il est plus élevé que celui proposé par Fox (1967). Mais, dans une étude comparable à la présente étude et portant sur mille salariés, Meese et coll. (1984) observent que la baisse de la dextérité survient à une température plus élevée que celle proposée par Fox (1967) et Poulton (1970, cité par Meese). Sur la base des données recueillies dans l'étude réalisée par Meese, Schiefer et coll. (1984) situent le seuil de température cutanée de l'index entre 20 et 22 °C. Dans la présente étude, le seuil de $t_{sk,m}$ est situé entre 23 et 24 °C. Il est donc tout à fait comparable avec celui proposé par Schiefer et coll. (1984). En effet, la température cutanée du doigt est toujours plus basse que celle du dos de la main.

Les résultats obtenus présentement, bien que ne pouvant valider la relation en forme de courbe à seuil, sont en concordance avec cette hypothèse. D'autre part, l'examen de ces résultats montre que 27 des 57 salariés qui ont subi le test du boulon ont une température de la main inférieure au seuil de 24 °C, soit près d'un salarié sur deux. En conséquence, la baisse de la dextérité chez les salariés travaillant dans une ambiance thermique froide est une réalité. Ce constat amène les deux conclusions suivantes :

– le travail des salariés doit être organisé de telle sorte que les tâches impliquant des mouvements fins des doigts soient supprimées,

– le froid doit être considéré comme un facteur de risque supplémentaire vis-à-vis des accidents du travail.

L'auteur remercie Messieurs Cnockaert et Emond pour leur collaboration.

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Le travail au froid artificiel dans l'industrie alimentaire

Description des astreintes et recommandations

M. Aptel, centre de recherche de l'INRS

Working in refrigerated climates in the food industry.
Description of stress and recommendations

Little is known about the health effects of working in cold climates. The purpose of this study is therefore to describe the thermal stress to which exposed workers are subjected and to propose recommendations to improve their working conditions. The contents include: refrigeration in the food industry, cold stress, cold hands and dexterity, measuring cold environments by strain indexes proposal of a thermal stress indicator (the temperature of the dorsum of the hand), cold-induced pathology and recommendations (reducing cold strain, work organisation, protective clothing, rest periods, training and information, medical surveillance).

In conclusion, working in refrigerated environments does not give rise to any major problems of thermal or sensorimotor stress, but certain precautions must be taken.

L'influence du travail au froid sur la santé des salariés est mal connue. Aussi, cette note a pour but de décrire l'astreinte thermique (1) des personnes exposées et de proposer des recommandations afin d'améliorer leurs conditions de travail (2). Au sommaire : le froid artificiel dans l'industrie alimentaire, l'astreinte thermique, l'influence du refroidissement des mains sur la dextérité, l'évaluation des ambiances thermiques froides par les indices de contrainte, la présentation d'un indicateur d'astreinte thermique (la température cutanée du dos de la main), la pathologie due au froid et enfin recommandations (réduction de la contrainte froide, organisation du travail, vêtements contre le froid, pauses, formation et information, surveillance médicale).

En conclusion, le travail au froid artificiel ne soulève pas de problèmes d'astreinte thermique ou sensorimotrice majeurs, mais certaines précautions doivent être prises.

L'essor important de l'industrie alimentaire lors de ces quarante dernières années a nécessité la mise en place d'une réglementation stricte de la conservation des denrées périssables. Or, le froid est, parmi les différentes méthodes de conservation des produits frais, la technique de loin la plus répandue. Aussi, le nombre de chambres froides (1) et de chambres climatisées (1) a considérablement augmenté pendant cette période avec pour conséquence un accroissement du nombre de postes de travail exposant des salariés à des ambiances thermiques froides artificielles.

1. ASTREINTES LIÉES AU TRAVAIL AU FROID

1.1. Le froid artificiel dans l'industrie alimentaire

Les conditions de travail dans des ambiances thermiques froides artificielles doivent être distinguées de celles rencontrées dans les régions polaires ou lors de la période hivernale. En effet, le travail dans des conditions climatiques naturelles représente une situation de contrainte (1) thermique spécifique bien que certaines similitudes avec le travail au froid artificiel soient observées. Seules les conditions de travail au froid artificiel seront décrites ici.

(1) *Cf.* lexique.
(2) L'INRS a réalisé une étude sur les conditions de travail au froid dans l'industrie alimentaire qui a fait l'objet d'un mémoire de thèse. La présente note documentaire n'est qu'un résumé de cette étude; le mémoire de thèse peut être envoyé sur simple demande adressée à l'INRS à Nancy, Service de Physiologie Environnementale.

L'industrie alimentaire est la principale utilisatrice du froid artificiel. Deux principaux types d'activités sont rencontrés dans les enceintes froides de cette branche industrielle, à savoir : la transformation de certaines denrées et l'entreposage des produits frais ou surgelés. La découpe de la viande, de la volaille ou du poisson représente l'activité de transformation. L'activité d'entreposage succède en principe à la transformation. Cependant, de nombreuses denrées périssables n'ont pas été transformées au froid. Pour celles-ci, la chaîne du froid commence lors de l'entreposage.

A chaque activité correspond un métier spécifique. Aussi, deux principaux types de métiers sont rencontrés chez les salariés exposés au froid : les « bouchers » qui découpent la viande, la volaille ou le poisson et les manutentionnaires qui sont soit cariste soit préparateur de commandes (1). Le travail des manutentionnaires est identique quelle que soit la température du local.

Chaque denrée doit être transformée et/ou entreposée à une température précise. Le tableau I indique la température de l'enceinte froide pour chaque denrée. L'examen de ce tableau montre que la température des enceintes froides est théoriquement comprise entre −20 °C et +10 °C; en fait la température des chambres froides peut atteindre −30 °C le matin lors de l'ouverture des portes de l'entrepôt.

La population des salariés exposés au froid peut être évaluée à 80 000 personnes environ. Le tableau I indique la répartition de cette population en fonction des types d'activité décrits précédemment. En raison du développement récent de l'industrie alimentaire, la population des salariés exposés au froid est jeune comme le montre la figure 1. En effet, près de 60 % des salariés exposés au froid ont moins de 30 ans alors que dans la population totale des salariés travaillant en France, ils ne sont que 35 %.

Les pauses de travail ne font l'objet d'aucune réglementation particulière. Chaque entreprise organise, à sa façon, le régime des pauses. La répartition et la durée des pauses dépendent aussi de la température de l'enceinte froide. Ainsi, les salariés travaillant en chambre froide bénéficient de pauses plus fréquentes et/ou plus longues que les salariés travaillant en chambre climatisée.

La plupart d'entre eux ont à leur disposition des vêtements de protection contre le froid. Pour les salariés travaillant en chambre climatisée, il s'agit le plus souvent d'anorak ou de veste matelassée qui s'ajoutent aux vêtements personnels. En revanche, pour les salariés travaillant en chambre froide, l'employeur fournit un vêtement isotherme (1) particulier.

(1) *Cf.* lexique.

TABLEAU I

Température de conservation des denrées alimentaires et population des salariés exposés au froid

Produits conservés	Température des locaux	Estimation de la population exposée au froid
Fabrication + entreposage		
viande	+ 7 °C	
abats	0 °C à + 3 °C	40 000
steak haché	0 °C à + 3 °C	à
charcuterie	0 °C à + 4 °C	50 000
volaille	0 °C à + 4 °C	10 000
Entreposage seul		
poissons	0 °C à + 2 °C	
lait et dérivés	0 °C à + 6 °C	10 000
légumes et fruits	+ 6 °C à + 10 °C	
surgelés	maximum − 18 °C	10 000
crèmes glacées	maximum − 20 °C	

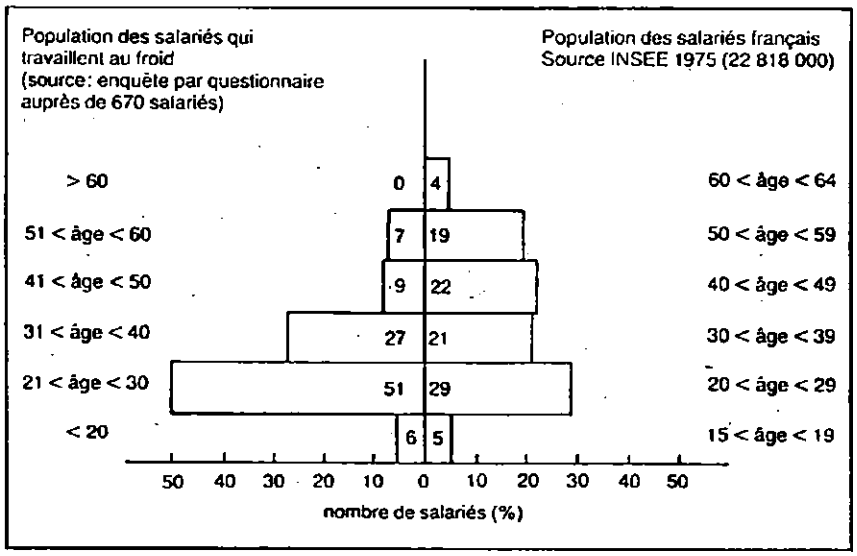


Fig. 1. Répartition, par tranche d'âge de 10 ans, de la population de tous les salariés français comparée à celle des salariés exposés au froid.

1.2. Astreinte thermique

Les résultats de l'étude menée par l'INRS auprès de salariés exposés au froid, complétés par les informations bibliographiques recueillies, peuvent être résumés comme suit.

Dans les conditions habituelles de travail, le refroidissement corporel est très faible. En effet, l'évolution de la température du noyau (1) au cours de la journée, appréciée par la mesure de la température rectale, demeure inchangée par rapport à celle de salariés non exposés au froid (Enander et coll., 1979). De même, la température de l'écorce (1), appréciée par la mesure de la température cutanée moyenne, calculée selon la pondération de Ramanathan (*cf.* annexe 1) varie très peu au cours de la journée de travail au froid (fig. 2). En conséquence, aucun danger d'hypothermie n'est à craindre. En revanche, le refroidissement des mains est important (fig. 2) sans toutefois entraîner ni engelures ni gelures, sauf cas particuliers.

C'est pourquoi, l'astreinte thermique se traduit essentiellement par un refroidissement des extrémités corporelles. Le port de gants et de chaussures n'assure pas une protection efficace contre le refroidissement des extrémités bien qu'il en limite l'intensité. Enfin, une grande dispersion interindividuelle du refroidissement des mains est observée, sans que celle-ci soit en rapport avec les seuls facteurs de contrainte thermique (température et vitesse de l'air).

D'autre part, l'étude menée par l'INRS a montré qu'une pause dont la durée est de 25 minutes environ n'assure pas un réchauffement suffisant des mains. En effet, la température cutanée de la main des salariés n'atteint pas, à l'issue de cette pause, une température comparable à celle mesurée avant le début de l'exposition au froid. Enfin, le réchauffement de la main pendant la pause est d'autant plus important que le refroidissement est plus intense.

En dernier lieu, la comparaison entre le refroidissement des salariés travaillant en chambre froide et celui des salariés travaillant en chambre climatisée montre que ces derniers se refroidissent plus que les premiers. Ce résultat, a priori paradoxal, est certainement lié au fait que la durée d'exposition continue au froid des salariés travaillant en chambre froide est plus courte que celle des autres salariés.

1.3. Influence du refroidissement des mains sur la dextérité

Le refroidissement des extrémités entraîne une diminution de la dextérité (Enander, 1984). L'influence du froid sur la dextérité est représentée par une relation en forme de courbe à seuil. Ainsi, tant que la température cutanée du dos de la main est supérieure au seuil, aucune modification de la dextérité n'apparaît. En revanche, dès que la température cutanée du dos de la main est inférieure au seuil, la dextérité diminue.

Dans l'étude sur le travail au froid menée par l'INRS, le test du boulon (visser le maximum de boulons pendant 2 minutes) a permis de montrer que le seuil de température cutanée du dos de la main est fixé à 24 °C. Autrement dit, tant que la température cutanée de la main est supérieure à 24 °C, le refroidissement de la main n'engendre qu'un inconfort thermique

(1) *Cf.* lexique.

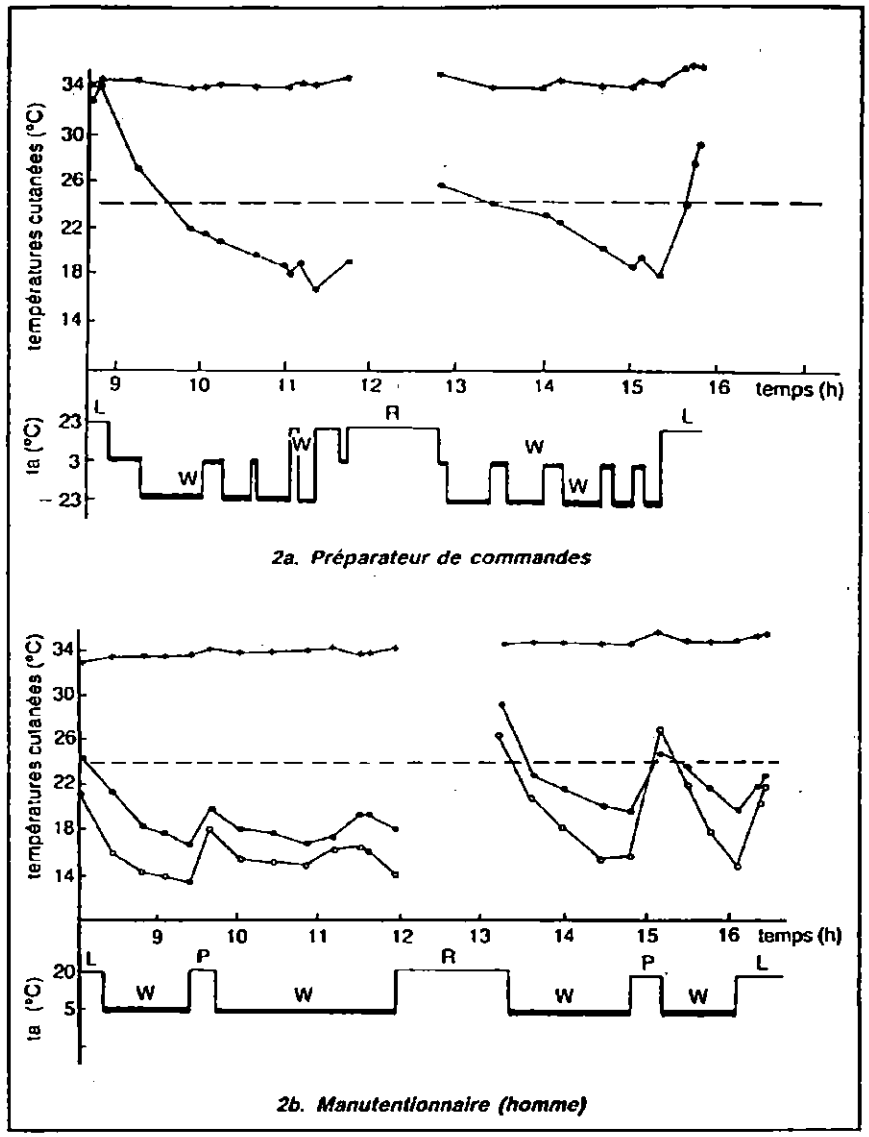


Fig. 2. Évolution de l'astreinte thermique cutanée et répartition des périodes d'exposition au froid au cours de la journée de travail de deux salariés.
Chaque figure se divise en deux partie : la partie supérieure représente les différentes températures cutanées et la partie inférieure les répartitions des périodes d'exposition au froid.
P : pause
R : repas
L : temps passé dans le local de préparation
W : période de travail
: température cutanée moyenne (Ramanathan)
: température cutanée du dos de la main gauche
: température cutanée du dos de la main droite
Le trait en pointillés à 24°C indique le niveau où la dextérité commence à diminuer. Sur la partie supérieure des figures, seuls les points correspondent à des températures cutanées relevées. Le trait ne sert qu'à relier ces points, permettant ainsi de mieux figurer les variations de température.

pour certains salariés. Mais dès que ce seuil est franchi, la capacité à effectuer des mouvements fins des doigts est réduite. Cette diminution de la dextérité peut donc être responsable d'une incapacité à réaliser certaines tâches, voire être à l'origine d'un accident du travail.

A titre d'exemple, 60 % des salariés qui ont participé à l'étude déjà mentionnée ont, au moins une fois pendant leur journée de travail au froid, une température cutanée de la main inférieure à 24 °C. Enfin, le port des gants n'assure pas systématiquement une température supérieure à 24 °C.

1.4. Évaluation des ambiances thermiques froides

L'évaluation globale des ambiances thermiques apporte au préventeur une information précieuse sur la sévérité de la contrainte thermique et permet la prévision ou l'appréciation de l'astreinte. Pour les salariés exposés au froid, le refroidissement global ou local du corps représente cette astreinte.

Deux modes principaux d'évaluation des ambiances thermiques froides sont distingués :

– les indices de contrainte qui, à partir de la mesure des différentes grandeurs climatiques, permettent de prévoir l'astreinte thermique;

– un indicateur d'astreinte qui, à partir de la mesure de la température cutanée du dos de la main, permet d'apprécier le refroidissement de la main et son retentissement sur l'aptitude sensorimotrice du salarié.

1.4.1. Indices de contrainte

Un document de travail ISO (1) portant sur l'évaluation des ambiances thermiques froides propose deux indices complémentaires : un indice de refroidissement global permettant de prévoir l'isolement vestimentaire requis (IREQ) (1) et un indice de refroidissement local, le Wind Chill Index (WCI) (1), permettant de prévoir l'intensité du refroidissement des extrémités (mains et pieds) et le risque que celui-ci représente pour le salarié.

IREQ : indice de refroidissement global

L'information fournie par IREQ est double. D'une part, plus IREQ est important, plus le pouvoir de refroidissement de l'ambiance thermique est grand. D'autre part, IREQ permet de prévoir l'astreinte thermique du salarié. En conséquence, cet indice doit être considéré comme un guide permettant de choisir les vêtements qui assureront un isolement thermique suffisant pour que le salarié puisse demeurer plusieurs heures au froid. Aucun risque d'hypothermie (1) n'est alors à craindre car le salarié est en équilibre thermique.

L'information apportée par IREQ n'a d'intérêt que si l'isolement vestimentaire des vêtements est connu. L'ISO propose, dans un autre document de travail, une méthode qui permet de calculer l'isolement vestimentaire de différentes pièces de vêtements (Icl) (1). Ainsi, en comparant la valeur de IREQ – isolement vestimentaire requis assurant l'équilibre thermique – à Icl – isolement des différentes pièces de vêtements effectivement portées par les salariés exposés au froid –, il est possible de savoir si ces salariés sont suffisamment vêtus et, au cas où ils le seraient insuffisamment, quel vêtement supplémentaire ils doivent porter.

En fait, le document de travail ISO portant sur IREQ propose de calculer deux IREQ, IREQ mini et IREQ neutre. IREQ mini représente l'isolement thermique minimum des vêtements que le salarié doit porter. Si l'isolement vestimentaire (Icl) est inférieur à IREQ mini, le salarié se refroidira trop et devra, après un intervalle de temps calculable, quitter l'enceinte froide. En revanche, IREQ neutre représente un isolement vestimentaire devant assurer le confort thermique au salarié. IREQ neutre est donc toujours supérieur à IREQ mini.

Dans l'étude INRS réalisée auprès de salariés exposés au froid, les résultats de la comparaison entre IREQ et Icl (fig. 3a et 3b) peuvent être résumés comme suit :

– pour les salariés travaillant en chambre froide, Icl est inférieur à IREQ mini. Aussi, les vêtements mis à leur disposition ont un isolement thermique insuffisant pour que ces salariés puissent demeurer dans une chambre froide, de façon continue, pendant plusieurs heures. Cependant, étant donné que leur durée continue d'exposition au froid est le plus souvent inférieure à 1 heure, leur isolement vestimentaire est satisfaisant comme le confirme la mesure de leur température cutanée moyenne *(cf.* paragraphe 1.2).

– pour les salariés travaillant en chambre climatisée, Icl est équivalent à IREQ neutre. Ces salariés se sont donc vêtus pour que leur situation thermique soit proche du confort.

WCI : indice de refroidissement local

L'indice local de refroidissement proposé par le document de travail ISO est Wind Chill Index (WCI). Mais aucun WCI calculé pour les conditions de contrainte thermique des salariés, qui ont participé à l'étude déjà citée, n'est excessif.

Ce résultat est logique. En effet, WCI est un indice qui vise à prévenir les accidents liés au refroidissement local excessif. Ce n'est donc pas un indice intéressant pour les contraintes froides auxquelles les salariés sont exposés car ces accidents ne sont que très rarement rencontrés. En revanche, WCI ne permet pas de prévoir la baisse de dextérité.

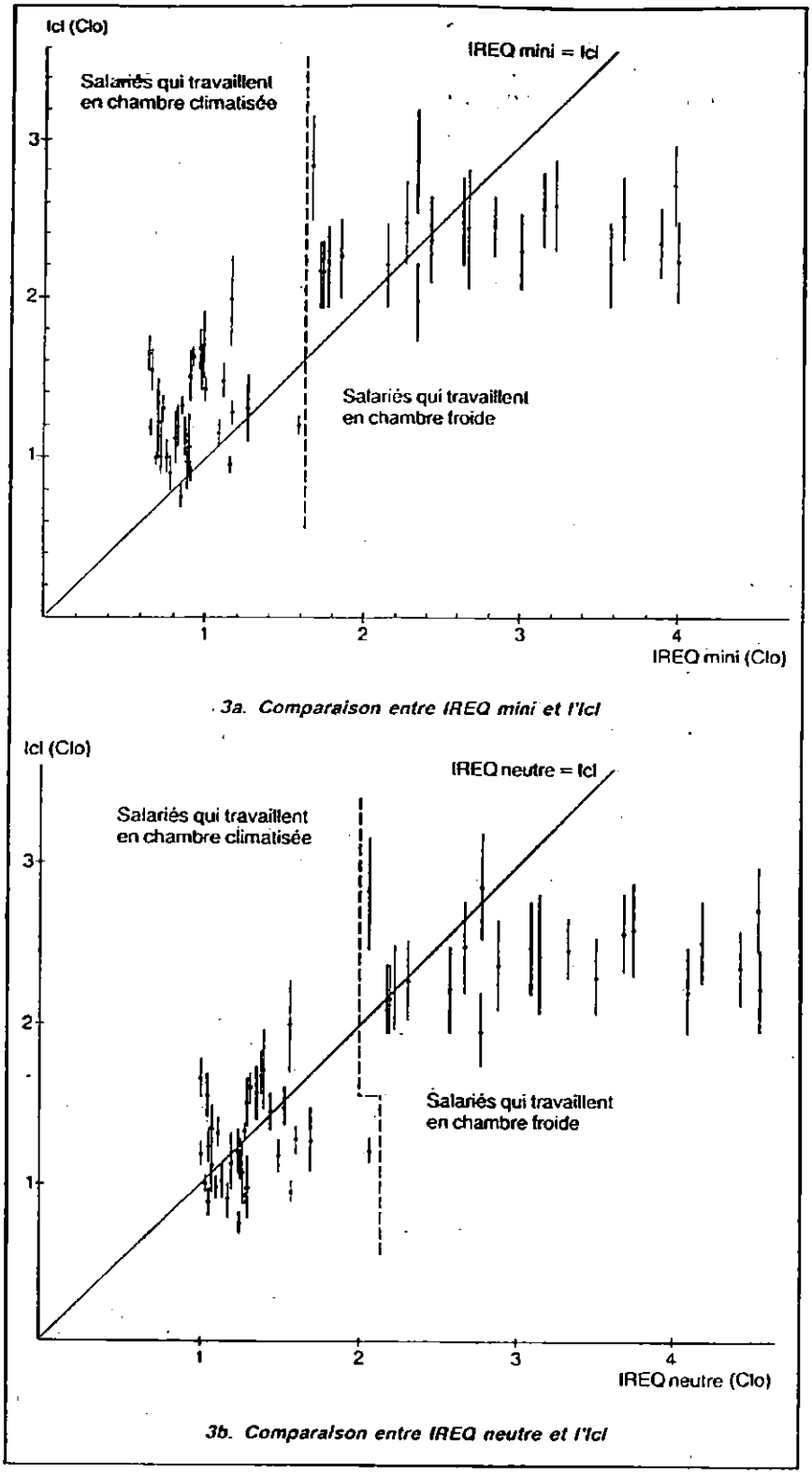
1.4.2. Température cutanée du dos de la main, indicateur d'astreinte thermique pour les salariés exposés au froid

Un hiatus existe donc entre les 2 indices proposés par l'ISO et l'astreinte thermique des salariés telle qu'elle est décrite précédemment *(cf.* paragraphes 1.2 et 1.3). En effet, ces 2 indices de contrainte visent à prévenir une situation qui n'est pas rencontrée chez les salariés exposés au froid, à savoir le refroidissement excessif du corps et les pathologies locales aiguës liées au refroidissement des extrémités. En conséquence, l'information fournie par ces indices est de portée limitée, car elle ne permet pas de prévoir la diminution de la dextérité.

Une nouvelle méthode d'évaluation doit être proposée.

La température cutanée de la main est la méthode d'évaluation qui, pour les conditions de travail des salariés exposés au froid, paraît la plus intéressante, bien que ne constituant pas un indice permettant de prévoir le refroidissement des salariés à partir de la mesure des grandeurs caractéristiques d'une ambiance thermique froide de travail. Pourtant, le choix de la température cutanée de la main comme indicateur d'astreinte est fondé sur les arguments suivants :

(1) *Cf.* lexique.



3a. Comparaison entre IREQ mini et l'Icl

3b. Comparaison entre IREQ neutre et l'Icl

Fig. 3.

– spontanément, compte tenu de leur contrainte thermique de travail, les salariés choisissent un isolement vestimentaire satisfaisant;

– lorsque la température cutanée de la main atteint 23 ou 24 °C, la capacité sensorimotrice de la main est diminuée (*cf.* paragraphe 1.3). Elle entraîne l'inaptitude du salarié à réaliser certaines tâches et peut être la source d'accidents du travail;

– les variations interindividuelles dans le refroidissement des extrémités sont très importantes et seul un indicateur d'astreinte peut les prendre en compte.

Toute température cutanée de la main supérieure à 24 °C correspond à un refroidissement de la main qui n'entrave pas l'activité du salarié. Dès que ce seuil est franchi, le refroidissement de la main doit être considéré comme potentiellement dangereux.

Enfin, la mesure de la température cutanée de la main est simple à réaliser et l'appareil de mesure peu onéreux (*cf.* annexe 2).

1.5. Pathologie due au froid

Deux types de pathologies doivent être distingués : la pathologie aiguë et la pathologie chronique.

La pathologie aiguë

Elle est représentée par l'hypothermie qui est un accident général et par les gelures, engelures ou « pied de tranchée » qui sont la conséquence du refroidissement excessif des extrémités. Cependant, pour les salariés exposés au froid, le risque d'être victime d'un de ces accidents est minime, voire inexistant. Il ne peut survenir que dans des conditions exceptionnelles lorsque le salarié est enfermé dans une chambre froide pendant un temps très long, mais le respect des consignes de sécurité vise à éliminer ce risque.

La pathologie chronique

Dans ce domaine, aucune certitude n'existe. Pourtant le froid est considéré comme un facteur de risque pour différentes maladies. Trois appareils sont concernés :

– l'appareil respiratoire,

– l'appareil circulatoire,

– l'appareil ostéo-articulaire, dans une moindre mesure.

En effet, le froid semble être un facteur de risque pour la bronchite chronique, les affections de la sphère ORL, les rhumatismes et le syndrome de Reynaud. Mais cette liste n'est pas exhaustive.

Sans vouloir faire une liaison formelle entre l'astreinte physiologique du salarié exposé au froid et la pathologie, certains aspects peuvent être envisagés. Ainsi, il est possible que l'inspiration régulière d'un air à $-25\,°C$ favorise des troubles morbides à type de bronchite chronique par exemple. De même, la vasoconstriction périphérique répétée et prolongée peut être un des facteurs à l'origine d'un processus physiopathologique responsable du syndrome de Reynaud. Cependant, ce ne sont que des hypothèses qui ne reposent sur aucune preuve.

L'étude de la responsabilité du froid dans la genèse de certaines maladies est à entreprendre. Le fait que la population de salariés soit jeune avec une faible ancienneté d'une part et que le délai d'apparition des premiers symptômes de ces maladies soit long rend plus difficile la mise en évidence de la responsabilité du froid en tant que facteur de risque. « L'exploration fonctionnelle thermique » peut être un moyen efficace de dépistage et/ou de prévention. Cependant, c'est actuellement un domaine encore peu étudié.

1.6. Questions en suspens

De nombreuses questions demeurent encore sans réponse en ce qui concerne l'effet du froid sur l'organisme. Ainsi, l'effet de variations brutales de température pouvant atteindre une amplitude de 50 °C en été, répétées plusieurs fois dans la journée, demeure inconnu, notamment l'effet sur l'appareil respiratoire. Or, de nombreux salariés se plaignent de gêne respiratoire lorsqu'ils sortent de la chambre froide. Par ailleurs, comment prévenir le refroidissement des extrémités?

Pour l'instant, il n'existe pas encore de protection satisfaisante des extrémités (mains et pieds). Ainsi, aucun type de chaussure ou de gant ne peut être considéré comme réellement efficace.

D'autre part, si l'isolement thermique est satisfaisant, le vêtement de travail des salariés n'est pas suffisamment adapté à leur tâche.

Par exemple, les variations brutales de charges de travail peuvent entraîner une modification importante de l'isolement vestimentaire requis ou générer des réductions notables de l'isolement thermique effectif. C'est ainsi qu'un travail intense, avec parfois une sudation importante, va diminuer l'isolement thermique du vêtement en raison de l'humidité que celui-ci absorbe. Dès que le travail sera moins intense, le vêtement humide ne sera plus suffisamment isolant. L'amélioration de la connaissance des mécanismes évaporatoires à travers les vêtements ainsi que la découverte de nouvelles libres textiles devraient permettre de résoudre ce problème.

2. RECOMMANDATIONS

La plupart des articles consacrés à la présentation de recommandations visant à améliorer les conditions de travail au froid considèrent plutôt les conditions de travail dans les régions polaires. Or, les problèmes rencontrés par les salariés exposés au froid artificiel dans notre pays sont différents. En effet, il ne s'agit pas de prévenir les risques d'hypothermie ou de gelure. Les mesures d'astreinte démontrent que ces accidents ne peuvent survenir dans les conditions habituelles de travail. Le faible refroidissement corporel est donc lié à l'efficacité, en tant qu'isolant thermique, des vêtements qu'ils portent.

C'est pourquoi, les recommandations qui vont être proposées suivent une orientation légèrement différente. Elles portent sur les points suivants :

- réduction de la contrainte froide,
- organisation du travail,
- amélioration de l'efficacité de l'isolement vestimentaire,
- critères d'efficacité des pauses,
- information et formation,
- surveillance médicale des salariés.

En France, le Code du travail ne prévoit qu'une seule obligation pour les salariés exposés au froid; ils doivent bénéficier d'une surveillance médicale spéciale (arrêté de juillet 1977).

Aussi, les recommandations présentées sont issues de documents provenant d'organismes officiels des États-Unis, de Norvège, de Suède, des Pays-Bas et de Suisse.

D'autre part, ces recommandations portent exclusivement sur les problèmes rencontrés par les salariés exposés au froid dans le cadre habituel de leur travail. Les problèmes de prévention des incendies, ou ceux liés à l'intoxication par les liquides frigorigènes, ne sont pas abordés.

Par ailleurs, cette présentation ne tient pas compte de la température du local. En effet, les problèmes des salariés travaillant en chambre froide ne sont pas fondamentalement différents de ceux des autres salariés.

Cependant à chaque fois qu'un problème spécifique se pose, il sera évoqué dans le cadre du plan adopté pour présenter ces recommandations.

2.1. Réduction de la contrainte froide

Les moyens de prévention technique sont très réduits. La température des locaux ne peut évidemment pas être modifiée. Cependant, la diminution de la vitesse de l'air est un moyen très efficace pour ralentir le refroidissement des salariés. Les documents consultés proposent différentes vitesses d'air maximales tolérables au niveau des zones de travail. Ainsi, pour l'ACGIH (3), la vitesse d'air maximale tolérable est de $1 ms^{-1}$, un règlement suédois prévoit $0{,}2\ ms^{-1}$, une recommandation norvégienne $0{,}1\ ms^{-1}$ et la CRAM de l'Ile-de-France propose $0{,}2\ ms^{-1}$. Nous pensons que $1\ ms^{-1}$ est une vitesse d'air beaucoup trop élevée. Par contre, le chiffre proposé par la CRAM est tout à fait satisfaisant. Pour obtenir une vitesse d'air faible, plusieurs solutions peuvent être proposées :

- placer les aérothermes le plus haut possible, autrement dit construire des entrepôts de hauteur suffisante;
- interposer entre les aérothermes et le local des faux-plafonds percés de petits orifices. Dès lors, la vitesse de l'air est réduite;
- arrêter, quand cela est possible, les aérothermes lorsque les salariés sont présents;
- placer autour des postes de travail des écrans de protection contre le vent;
- éloigner le plus possible les postes de travail des aérothermes.

(3) American conference of governmental industrial hygienists.

En ce qui concerne les outils, leurs manches doivent être faiblement conducteurs de la chaleur. De même, les sièges doivent être construits en matériaux thermiquement isolants.

Le réchauffement localisé du poste de travail avec des appareils de chauffage par rayonnement peut être une solution. De même, des réchaufleurs pour les mains peuvent être installés dans l'enceinte froide. Mais aucun de ces systèmes n'est utilisé dans les entreprises qui ont participé à l'étude INRS déjà citée.

Par ailleurs, les règlements prévoient que les portes doivent pouvoir s'ouvrir de l'intérieur. De plus, un signal sonore et lumineux doit être installé afin qu'un salarié qui se trouverait enfermé dans l'enceinte froide puisse signaler sa présence.

2.2. Organisation du travail

La production de chaleur par le corps humain détermine, dans une certaine mesure, la durée d'exposition au froid. Elle est liée au travail physique imposé par la tâche. Par conséquent, le travail sédentaire (métabolisme inférieur à 100 Wm^{-2}), ainsi que le travail intense, doivent être autant que possible limités (cf. paragraphe 1.6). C'est pourquoi, un travail régulier dont le métabolisme est compris entre 100 et 170 Wm^{-2} représente la situation « idéale ».

Il est nécessaire que le salarié puisse réaliser sa tâche avec des gants. Autrement dit, la tâche doit être organisée de manière à ce que le salarié n'ait pas besoin de les retirer. De ce fait, les travaux d'écriture doivent être défendus. De plus, les produits froids ne doivent jamais être manipulés à mains nues, surtout si la température de ces produits est inférieure à 0 °C.

Le travail doit être organisé de telle façon qu'un salarié ne se retrouve jamais seul dans l'enceinte froide.

2.3. Vêtements contre le froid

Le vêtement est un moyen de protection essentiel lors de l'exposition au froid. Toutefois, il ne fait que diminuer l'intensité des flux de chaleur perdue. Il est donc indispensable que des pauses soient organisées afin de permettre aux salariés de se réchauffer.

C'est presque toujours l'entreprise qui fournit les vêtements. Cependant, et c'est souvent le cas, il est nécessaire que les salariés soient consultés afin de donner leur avis sur les vêtements que l'entreprise achète.

L'expérience acquise dans le domaine de la protection vestimentaire contre le froid a permis de mettre en évidence l'intérêt du vêtement en 3 couches :

- la couche interne avec les sous-vêtements (tee-shirt, caleçon, chaussettes),
- la couche moyenne avec le pull et le pantalon en laine,
- la couche externe avec le vêtement spécialisé (parka, anorak, veste, pantalon).

Le système du vêtement en « 3 couches » comporte plusieurs avantages : la multiplication des couches permet l'ajustement de l'isolement thermique en fonction de la production de chaleur. De plus, elle permet d'emprisonner un maximum d'air immobile, l'air immobile étant un excellent isolant thermique. Enfin, elle permet de mieux épouser les formes corporelles, ce qui a pour effet de limiter les mouvements d'air entre la peau et le vêtement et, par conséquent, les pertes de chaleur.

Par ailleurs, certaines règles doivent être respectées :

- les vêtements doivent être secs et propres; il faut donc les changer dès qu'ils sont mouillés;
- les salariés doivent se sécher le corps avant de s'habiller;
- ils doivent renouveler périodiquement les vêtements, le nettoyage répété et/ou l'usure diminuant leur efficacité;
- ils doivent porter une protection de la tête (cagoule ou bonnet). De plus, lors du travail en chambre froide, le port d'un capuchon est indispensable;
- les chaussures de sécurité doivent avoir des semelles anti-dérapantes et comporter des semelles isolantes renouvelées régulièrement. La coque de protection doit être bien isolée thermiquement. En effet, cette coque est souvent en acier, bon conducteur thermique, ce qui accélère le refroidissement des pieds;
- les gants sont indispensables dès que la température est inférieure à 10 °C. Il est recommandé de fournir des gants spéciaux réduisant la surface de contact afin de prévenir les gelures. De plus, pour les salariés des chambres froides, le port de 2 paires de gants est indiqué. En effet, une paire de mitaines peut très bien être portée au-dessus de gants plus fins, ce qui améliore l'efficacité de l'isolement thermique des mains.

Les vêtements doivent, en outre, avoir les caractéristiques suivantes :

- veste ou parka recouvrant largement le pantalon;
- extrémités libres des vêtements bien adaptées à la peau par une bande élastique, sans toutefois serrer les membres;
- pas de compression au niveau des genoux ou des coudes, le port de bretelles étant préférable à celui de la ceinture;
- fermetures à glissière recouverte de tissu;
- vêtement de préférence en 2 parties. En effet, ce vêtement est préférable à la combinaison parce qu'il permet au salarié de se déshabiller plus facilement pendant les pauses. D'autre part, le capuchon doit être attaché à la veste afin de réduire les pertes de chaleur au niveau du cou;
- chaussettes ne serrant pas trop le pied. Si le salarié porte deux paires de chaussettes, la pointure de la seconde doit être plus grande.

2.4. Pauses

Pour le salarié exposé au froid, les pauses sont indispensables. Le local où a lieu la pause doit être correctement chauffé (température supérieure à 20 °C). En outre, il est conseillé de mettre à la disposition des salariés des boissons chaudes. D'autre part, il faut leur conseiller de retirer les vêtements de la couche externe pendant la pause afin de faciliter le réchauffement du corps. Les résultats de l'étude déjà citée ont montré que le temps de réchauffement des mains est relativement long. Aussi il est souhaitable que le temps minimal de pause soit de 20 minutes environ.

Green (1978), médecin du travail surveillant des salariés travaillant en chambre froide, propose un cycle de 40 minutes de travail au froid, suivi de 20 minutes de pause si le métabolisme énergétique est faible (exemple : cariste). Si le métabolisme énergétique est plus élevé (exemple : préparateur de commande), le cycle peut être de 60 minutes de travail suivi de 20 minutes de pause.

2.5. Information et formation

Les salariés nouvellement embauchés doivent pouvoir s'accoutumer pro-

LEXIQUE

Astreinte : effet de la contrainte sur l'homme en fonction de caractéristiques et aptitudes individuelles (référence : norme AFNOR X 35-001).

Chambre climatisée : enceinte froide dont la température est supérieure à 0 °C.

Chambre froide : enceinte froide dont la température est inférieure à 0 °C. En fait, la température de la plupart des chambres froides est inférieure à − 18 °C.

Contrainte : ensemble des conditions extérieures et des exigences qui, dans le système de travail, sollicitent les fonctions organiques et/ou mentales de l'homme (référence : norme AFNOR X 35-001).

Écorce : tissus superficiels du corps qui enveloppent le noyau. Du point de vue anatomique, l'écorce est représentée par l'ensemble des tissus cutanés et sous-cutanés. La température de l'écorce varie beaucoup plus que celle du noyau. La température cutanée moyenne représente la température de l'écorce. De nombreuses pondérations permettent de calculer la température cutanée moyenne.

Équilibre thermique : placé dans un environnement thermique froid, le corps humain perd de la chaleur. Si la production de chaleur liée au métabolisme est égale aux pertes de chaleur, le bilan thermique est nul et le salarié est en équilibre thermique.

Hypothermie : elle apparaît lorsque les pertes de chaleur sont plus élevées que la production de chaleur, entraînant un risque d'accident pour le salarié du fait du refroidissement de son corps.

Icl : isolement thermique total des différents vêtements portés. Une unité pratique est le Clo qui correspond à 0,155 $K.W^{-1}.m^2$.

IREQ : isolement thermique requis (en Clo). C'est l'isolement thermique des vêtements que le salarié doit porter pour maintenir l'équilibre thermique du corps lorsqu'il est dans une ambiance froide.

ISO (International Standard Organisation) : organisme responsable au niveau international de la normalisation. Le correspondant français est l'AFNOR.

Noyau : organes profonds du corps dont la température varie très peu. La mesure de la température rectale, de la température orale, de la température œsophagienne ou de la température du conduit auditif sont des moyens d'apprécier la température du noyau.

Préparateur de commandes : le salarié est muni d'un chariot et d'un bon de commande. Il collecte dans l'entrepôt les denrées commandées et les dépose dans le chariot.

Vêtement isotherme : ensemble vestimentaire destiné aux salariés travaillant en chambre froide. Il se compose de 2 parties, un pantalon matelassé remontant très haut et une veste matelassée munie d'une cagoule.

WCI : wind chill index. C'est un indice qui, à partir de la mesure de la vitesse de l'air et de la température sèche de l'air, permet de connaître la sévérité de la contrainte thermique froide. Pour ce faire, la valeur de WCI calculée doit être comparée aux valeurs limites contenues dans un tableau.

ANNEXE 1

Température cutanée moyenne calculée selon la pondération de Ramanathan (1964)

Parmi les nombreuses pondérations qui permettent de calculer la température cutanée moyenne ($\bar{t}_{sk}$), celle proposée par Ramanathan (1964 : RA) est très souvent utilisée sur le terrain du fait de sa commodité. Elle ne nécessite, en effet, que la mesure de 4 températures cutanées. La pondération est la suivante :

$\bar{t}_{sk}$, RA = 0,2 (température cutanée du mollet) + 0,2 (température cutanée de la cuisse) + 0,3 (température cutanée du thorax) + 0,3 (température cutanée du bras).

ANNEXE 2

Conseils pour mesurer la température cutanée de la main

Ces conseils ne visent qu'à permettre au préventeur de mesurer de façon sommaire une température cutanée. En effet, la présente note documentaire n'a pas pour objectif de décrire les techniques de mesure de cette variable physiologique.

Pour mesurer la température cutanée de la main, il est nécessaire que :

– la surface du capteur (thermistance ou thermocouple) soit de faible dimension ($\leqslant 1\ cm^2$) et que la lecture de la température affichée ait lieu après que le capteur soit en équilibre thermique avec la peau. Il est préférable que le capteur de température soit placé entre deux rubans adhésifs en cuivre.

– la peau soit dégraissée et rasée. Le capteur doit être fixé sur la peau au milieu du dos de la main en dehors de l'aire de projection cutanée d'une veine superficielle.

A titre d'exemple, le capteur de température CRAFTEMP associé au lecteur CRAFON est un moyen de mesure simple et peu onéreux de la température cutanée. ■

gressivement à la température des locaux durant les premiers jours de travail.

Par ailleurs, le personnel doit être informé des risques qu'il encourt et des moyens de les prévenir. Ces conseils seront affichés.

Des programmes de formation portant sur les risques liés à leurs conditions de travail peuvent être envisagés. Ces séances de formation peuvent porter sur la protection vestimentaire ou sur les méthodes de travail favorisant la sécurité.

2.6. Surveillance médicale des salariés

La surveillance médicale des salariés est laissée à l'initiative du médecin du travail. Celui-ci peut fixer librement la fréquence des visites médicales et choisir les examens complémentaires. En France, les salariés doivent passer au moins une visite médicale par an.

Les résultats obtenus dans l'étude INRS montrent l'importance de la température cutanée de la main pour apprécier le refroidissement des salariés. Dans le cadre du « tiers-temps », le médecin du travail dispose ainsi d'un outil très simple pour l'évaluer.

Par ailleurs, le médecin joue un rôle fondamental dans le dépistage des premiers symptômes des maladies dont le froid peut être responsable.

En ce qui concerne l'examen médical proprement dit, il devrait être orienté vers la recherche des signes cliniques des maladies évoquées au paragraphe 1.5. De plus, les examens complémentaires suivants peuvent être conseillés :

– électrocardiogramme,

– radiographie du thorax et explorations fonctionnelles respiratoires pour les salariés présentant des signes d'atteinte bronchique.

D'autre part, des inaptitudes médicales sont parfois proposées. Ainsi, une recommandation suisse propose comme contre-indications définitives au travail en chambre froide :

– allergie au froid,

– crampe musculaire en rapport avec la vasoconstriction,

– troubles vasculaires (infarctus, insuffisance cardiaque, hypertension artérielle et les antécédents de thrombose),

– le syndrome de Raynaud,

– les maladies rhumatismales,

– les affections chroniques des voies aériennes,

– l'épilepsie et les antécédents de pertes de connaissance,

– l'alcoolisme.

Puis, comme contre-indications provisoires :

– les infections de la sphère ORL et pulmonaires non guéries.

Les salariés âgés de plus de 40 ans doivent bénéficier d'une surveillance médicale particulière. Il sera parfois nécessaire d'envisager pour eux une diminution de la durée d'exposition, voire une mutation. Cette décision doit être prise à la lecture du dossier médical et en concertation avec le salarié.

Enfin, l'entraînement physique améliorant la tolérance au froid des salariés, des conseils d'hygiène de vie peuvent leur être proposés.

3. CONCLUSION

Le travail au froid artificiel ne soulève pas de problèmes d'astreinte thermique ou sensorimotrice majeurs. Cependant, certaines précautions doivent être prises en compte, en vue d'améliorer les conditions de travail des salariés. Ainsi, un régime de pauses adapté, la suppression des tâches nécessitant des mouvements fins des doigts, le choix de vêtements adéquats et une surveillance médicale rigoureuse sont recommandés pour que cette contrainte de travail soit sans risque.

Enfin, les résultats de l'étude sur le travail au froid menée par l'INRS ont clairement démontré la validité de la mesure de la température cutanée du dos de la main comme méthode d'évaluation de l'astreinte thermique des salariés. Aussi du fait notamment de sa simplicité (voir annexe 2), l'utilisation de cet indicateur d'astreinte thermique peut être aussi recommandée.

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Sur quoi on peut jouer : - circulation d'air
2 m/se à 1 m/s
- énergie sur des couches d'air
- l'acuité des Trav
- 10°C il faut absolument gants
- pauses + liquide chaud
- 3 épaisseurs de vêtement

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Effects of work in cold stores on man

by ANN ENANDER, M.A., ANN-SOFIE LJUNGBERG, M.Sc., and INGVAR HOLMÉR, Ph.D.[1]

ENANDER, A., LJUNGBERG, A. S. and HOLMÉR, I. Effects of work in cold stores on man. *Scand. j. work environ. & health* 5 (1979) 195—204. A work physiological study was conducted during three different types of work in cold stores, i.e., at dairies and in the cutting and packaging of meat. Peripheral cooling, especially of the fingers and hands, was noted in all the subjects. The work load was relatively light for the packers but varied considerably in the dairy work. In both dairy and packaging work, clothing was unsatisfactory in terms of thermal insulation and flexibility. The butchers were subjected to less cooling, as a result of a relatively intense but even work rate and clothing adapted to the work. The subjects were very capable of perceiving temperature changes in the peripheral parts of their bodies. Individual variations were considerable, especially with respect to cooling and the perception of temperature and discomfort.

Key words: body temperature, climate, cold, cold stores, dairy work, discomfort, ergonomics, meat cutting, meat packaging, perceived temperature, skin temperature, work load.

A cold climate is a reality in many outdoor jobs and also in indoor work in, e.g., cold stores. The need for a low temperature (below + 10°C) in the storage and handling of food is a complicating factor with regard to a satisfactory work environment.

Occupational exposure to a cold environment may have an adverse effect on man's performance, health and comfort. Cold is regarded by the workers in this kind of work as one of the main causes of accidents, illness and different types of complaints.

The problem of work in a cold climate has been studied in laboratories and under field conditions. Several reviews have been published on this topic (1, 2, 9). Various behavioral effects of exposure to cold have been reviewed by Fox (4). Some field studies on occupational work have been performed in the Scandinavian countries. Workers in the fishing industry were studied with respect to cold both in the laboratory (5) and in the field (11). The biological effect of meat cutting and packaging in low temperatures has also been studied (8). However, there is still a shortage of documentation on the effects during practical work. The present report summarizes a physiological study of work in cold stores in the food industry (6, 7, 10).

The objectives of the study were to determine energy requirements during work, to record the nature and extent of the effects of exposure to a cold climate and cold

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goods on individuals, and to study the perception of temperature in relation to corresponding objective measurements.

CLIMATE AND ACTIVITY AT THE DIFFERENT WORK SITES

The following three different types of work in cold stores were studied: (a) storeroom and loading work in a dairy, (b) the cutting down and rough cutting of beef quarters, and (c) the fine cutting and packaging of meat (fig. 1). The climatic conditions are listed in table 1.

In *dairy cold stores* (+ 4°C) the staff picked out goods according to customer orders and placed these goods onto a floor-level conveyor belt. The work involved a great deal of movement, lifting, and carrying.

In the *meat-cutting unit* (+ 10°C) the butchers alternated weekly between cutting down and rough cutting beef quarters. Cutting down involved movements with many changes in work position. Lifting of pieces weighing 40 kg also occurred. The slabs of beef were rough cut into 2- to 8-kg chunks. This work consisted mainly of stationary arm work.

Work in the *packaging department* (+ 10°C) involved the additional processing of the chunks of beef produced by the meat-cutting unit. These chunks were sliced, minced or processed in this room. Packaging and price marking also took place there. The work was mainly stationary. Order-filling work in a cold-storage room (+ 4°C) was also studied in the packaging department.

MATERIAL AND METHODS

Approximately eight subjects from the staff were studied at each work site. They were of normal height and weight, and their physical work capacity was moderate or slightly below average. The subjects were men between 19 and 60 years of age, with the exception of three women be-

Fig. 1. Measurement of the oxygen uptake of a packer during work in the packaging department.

Table 1. Variation in the temperature, humidity and velocity of the air and the surface temperature of the products at the different work sites.

Parameter	Dairy	Meat cutting	Packaging	
			Packaging room	Cold-storage room
Air temperature (°C)	1—6	10—13	8—15	2—5
Air velocity (m/s)	0.1—0.4	< 0.2	0.0—0.3	0.1—0.5
Air humidity (%)	83—95	65—85	48—73	64—75
Surface temperature of products (°C)	2	0—6	(—9) 2—6	2—6

tween 19 and 35 years of age in the packaging department. The subjects wore their ordinary workclothing during the work sessions. White cotton clothing was supplied by the company. Most workers wore a short jacket, trousers, underpants, one or two pairs of socks, clogs, and sometimes also undershirts, cotton gloves, aprons or a cap. The estimated clo values varied from 0.8 to 1.2 (3). Clothing in the packaging department was supplemented with an insulating vest and trousers which increased the estimated clo values to 1.0—1.5.

Each subject was studied for 2 h during ordinary work on two different occasions. At 20- to 30-min intervals during the measurement sessions the subjects estimated their *perception of temperature* and *discomfort from heat or cold* in their body, hands and feet with the aid of two 20-point rating scales. Each scale had a neutral midpoint and verbally defined end-points (+ 10 and — 10), termed maximal warmth/discomfort from warmth and maximal cold/discomfort from cold, respectively.

Body temperature was measured with an oral (butchers and packers) or rectal (dairy workers) thermometer before and after each session. *Skin temperature* was recorded with six linear thermistors (accuracy: ±0.5°C) taped on the right side of the body (e.g., the top of the index finger, back of the hand, chest, shoulder or forehead, heel or leg, and big toe). The signals were recorded on a portable, 2-channel tape recorder which also recorded *heart rate.*

In order for the energy requirements of the work to be calculated, *oxygen uptake* was determined in the subjects on two different occasions during each work session with the aid of the Douglas-bag technique. The volume of expiratory air from 2—5 min of work was measured with a gas meter, and ventilation (BTPS) was calculated. The oxygen (Beckman OM11) and carbon dioxide (Beckman LB2) concentrations were determined. Oxygen uptake (STPD) was then calculated. Energy requirements were calculated on the basis of oxygen uptake according to the following relationship: 1 l O_2/min ≈ 350 W ≈ 5 kcal/min.

During each measurement session, subject activity was noted and regular climatic measurements were made. The surface temperature of the goods, the table the floor, and the walls was measured with an infrared meter (Raynger).

RESULTS

Oxygen uptake and heart rate

The work rate in the *dairy cold stores* was governed by the need to load the delivery trucks rapidly. This was especially the case during early morning sessions. In conjunction with these sessions, the values for oxygen uptake were found to vary from 0.5 to 1.5 l/min with individual peaks exceeding 2 l/min (fig. 2). The mean heart rate during work varied from 90 to 130 beats/min during the early morning and late morning sessions (fig. 3). The work was essentially intermittent with periods of high work intensity with peaks in heart rate exceeding 140 beats/min succeeded by rest pauses or lighter work. The individual variation in heart rate was largely ascribable to individual variations in physical work capacity (maximal oxygen uptake). In an assessment of the physiological work load, it was found that the workers periodically utilized 50—70 % of their physical work capacity in conjunction with work peaks.

Physical requirements were lower during the afternoon session. A varying work load resulted in individual values for oxygen uptake ranging from 0.4 to 1.8 l/min. The mean heart rate during afternoon work varied from 75—110 beats/min and was generally lower than in the morning.

The butchers could usually determine their own work intensity, and they selected an even and moderate work rate. During *cutting-down work* the mean heart rate varied from 100—110 beats/min. Oxygen uptake was found to amount to 0.8—2.1 l/min during work, corresponding to 35—50 % of the respective individual's physical work capacity. The highest work loads were obtained in conjunction with the cutting down of bull carcasses, especially in work on hard or tough meat. Individual peaks in heart rate of about 140

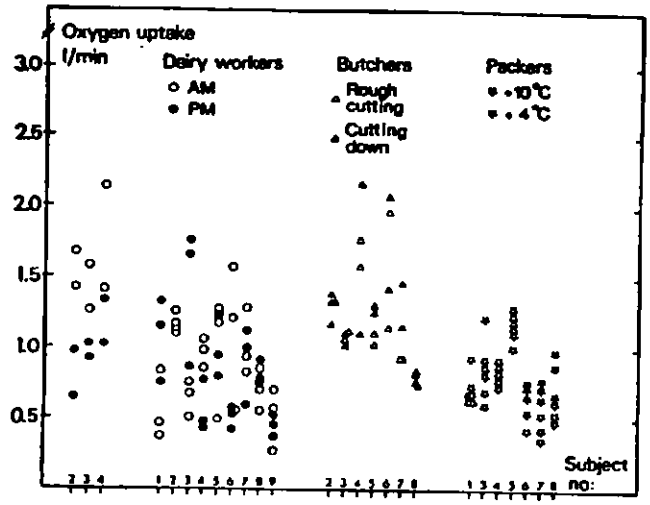

Fig. 2. Oxygen uptake values measured on two different occasions during each 2-h work session in the cold for all subjects and measurement sessions.

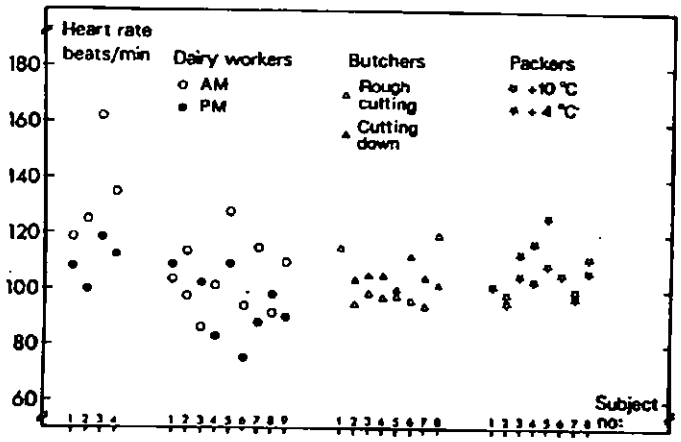

Fig. 3. Mean heart rate during 2 h of work in the cold for all subjects and measurement sessions.

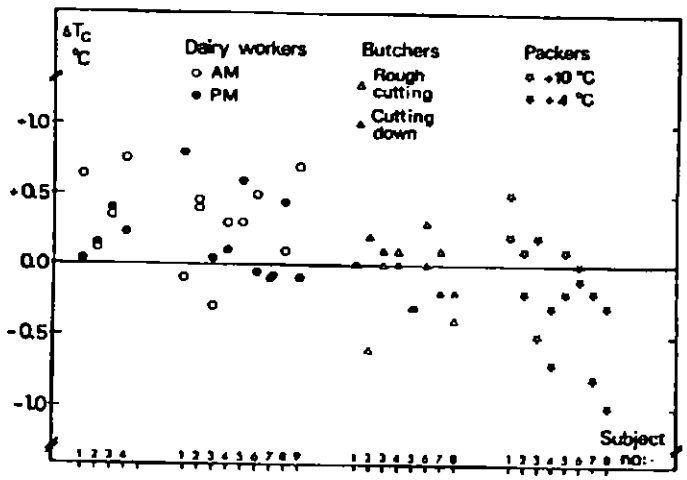

Fig. 4. Change in body temperature (ΔTc) after 2 h of work in the cold for all subjects and measurement sessions.

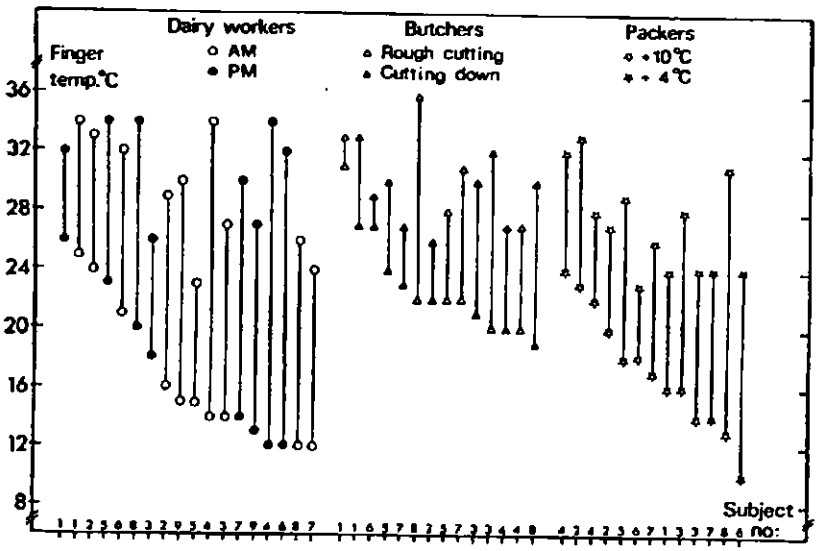

Fig. 5. Initial values and lowest skin temperatures measured on the fingers for all subjects and measurement sessions. Subjects listed within each group according to the lowest temperature measured.

beats/min were then occasionally noted. The work load was somewhat lower during rough cutting, the heart rate being about 8 beats/min lower and the values for oxygen uptake also being somewhat lower (fig. 2 and 3).

In the *packaging department* work intensity was on an even but clearly lower level than in the meat-cutting unit. The oxygen uptake of the men varied from 0.6 to 1.3 l/min. The oxygen uptake of the women amounted to 0.4—0.6 l/min during work in 10—13°C. Their work in the cold-storage room (about +4°C) was somewhat heavier, and oxygen uptake varied from 0.6 to 1.0 l/min (fig. 2). The mean heart rate averaged 95—120 beats/min, peaks occasionally rising to 130 beats/min (fig. 3). In general, heart rate remained fairly constant for the packers during the work session, even if the brief pauses and breaks made the work appear to be intermittent. In relation to oxygen uptake, their heart rate was somewhat higher than for, e.g., the butchers, primarily because of the age and sex differences between the groups. The work staff studied in the packaging department mainly consisted of older men, but it also included three women.

Body and skin temperature

Fig. 4 and 5 show individual values for body and finger skin temperature at the different work sites and sessions. Fig. 6 shows the individual response pattern for skin temperature at different parts of the body of one woman from the packaging department.

In the *dairy cold stores* an increase in body temperature (rectal temperature) was generally noted during sessions with high activity. Body temperature remained almost unchanged during low-activity sessions.

The hands and fingers were always the coldest parts of the body. Finger skin temperatures of 12—15°C were measured for several subjects. The back of the hand was generally a few degrees warmer, 15—20°C. Skin temperatures on the lower limbs were generally 25—30°C, while the corresponding values for the feet were 20—25°C. It is interesting to note that the skin temperature of the chest was 3—4°C higher, on the average, for the four subjects from one of the dairies than for the others. For all four of these subjects increases in body temperature were also measured. The explanation of these findings is probably to be found in a higher work intensity at this dairy, which contributed to a higher heat production.

Body temperature (oral temperature) was almost constant during *meat-cutting work* (fig. 4). However, it dropped 0.2—0.6°C in a few subjects.

The lowest skin temperature (finger)

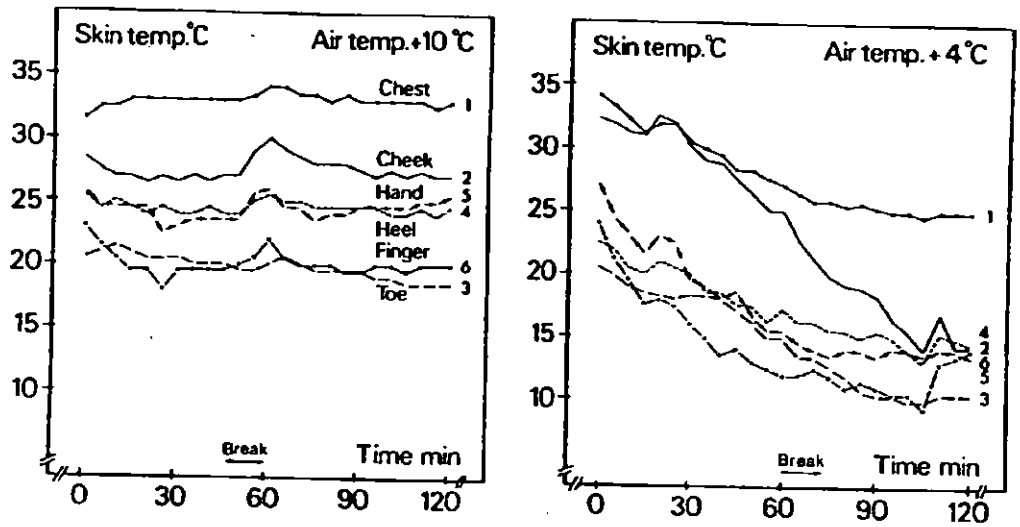

Fig. 6. Skin temperature measured at different parts of the body for one woman during 2 h of work in the meat-packaging department (on the left) and in the cold-storage room (on the right).

measured during cutting work varied from 19—30°C (fig. 5). The temperature on the back of the hand was much more even, i.e., about 25—32°C. The skin temperature of the chest and shoulder was almost always more than 30°C. The temperature of the heel and toe also displayed wide interindividual variations, the values ranging from 20° to 35°C.

Work intensity in the *packaging department* was also even, but of low intensity, and warmer clothing was often required in order to maintain heat balance. Body temperature (oral temperature) displayed wide interindividual variations (fig. 4). The body temperature of two of the women dropped by nearly 1°C during work at + 10°C. During order filling in the cold-storage room of the packaging department (+4°C), the body temperature of the women remained more or less unchanged, probably as a result of a higher work intensity and warmer clothing.

The skin temperatures measured were generally somewhat lower in the packaging department than in meat-cutting work. During periods of direct contact with cold meat or work at +4°C, skin temperature dropped even further, especially in the hands and fingers (fig. 5 and 6). A very low skin temperature, (+10°C) was measured for the fingers of one subject.

In all the types of work studied, the skin temperature of the hands was a few degrees higher when cotton gloves were worn. As mentioned earlier, the interindividual variation was striking, especially in respect to cooling of the hands. The skin temperature of unprotected hands was often extremely low. Hand and skin temperatures were affected by the work and work details, such as contact with cold products, whereas body temperature was more dependent upon work intensity and ambient temperature. The skin temperature of covered body parts, such as the chest, back and neck, was generally only slightly affected during the measurement sessions. In conjunction with pauses and breaks in heated rooms, the hand and finger temperatures increased for most subjects.

Temperature perception

At all the work sites, skin temperature variation of central parts of the body was rather slight. In general, the temperature of the body was perceived to be rather constant, and estimated values were around the neutral or warm part of the scale. The butchers' perception of body temperature differed during cutting down and rough

cutting even though each individual used equivalent clothing in each of the two work sesisons. Most subjects felt somewhat warmer when cutting down than when rough cutting, even when the chest temperature was directly comparable. Rough cutting work was less active, and most subjects sometimes felt cold.

Both inter- and intraindividual variations in skin temperature were considerable in peripheral parts of the body. In almost every subject, a change in temperature was also accompanied by a corresponding change in perception. This relationship was especially striking for the hands, as illustrated on the left in fig. 7. Finger temperature and the equivalent estimate paralleled one another very closely. The foot temperature varied less, as was also reflected in the perception of skin temperature. The general feeling of warming up during a break also affected the perception of foot temperature.

A difference in temperature between the left and right hand was found in several cases, mainly among the butchers and packers, e.g., when they held cold goods with one hand. The subjects proved to be able to estimate these differences, as exemplified on the right in fig. 7. A difference of 4—5°C in the temperature of the left and right hand of a subject was clearly reflected in the perceived temperature of the respective hands, whereas the objectively measured skin temperature did not differ in those cases in which the same perceived value was given for both hands. In most subjects, a difference of 2—3°C between hands was sufficient to elicit discriminating ratings.

The interindividual variation in the level of perceived temperature was considerable at all the work sites. Nevertheless, certain tendencies were common to all the subjects examined. Hands and feet began to feel cold at finger and toe temperatures under about 25°C. At a finger temperature of less than 20°C, almost every subject perceived his/her hands as rather or very cold.

As a rule, discomfort from cold was only reported in conjunction with very low skin temperatures. In the dairies most of the subjects experienced discomfort in their hands and/or feet on some occasion. Discomfort from cold was noted at temperatures under 20—21°C. The finger temperature of the butchers was generally somewhat higher, and they did not report discomfort from cold hands. One subject in the packaging department, whose work involved laying slices of semithawed liver on plastic trays, had a finger temperature below + 10°C during one period, and she reported great discomfort in the form of finger pain and stiffness in conjunction with these duties.

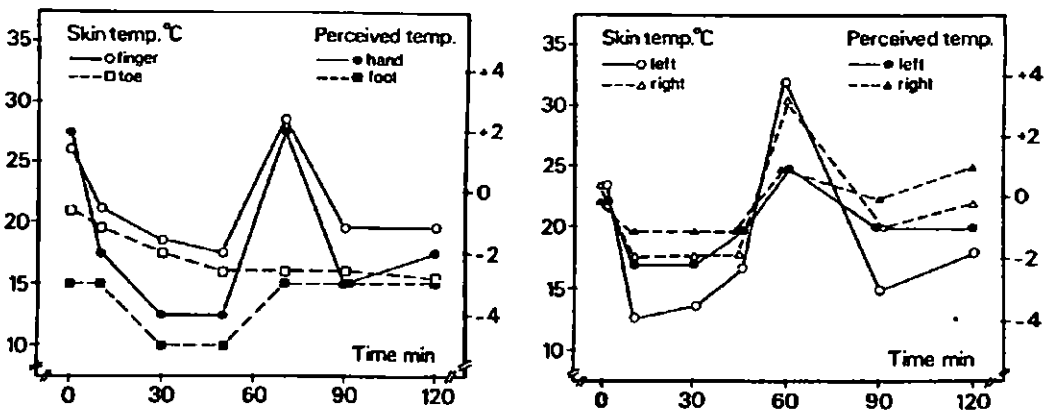

Fig. 7. Skin temperature and corresponding ratings of perceived temperature (see methods section) on the left hand and foot (on the left) and on the right and left hand (on the right) of one subject. The measurements were made during 2 h of work in the meat packaging department (+ 10°C).

DISCUSSION

Two different types of climate-related physiological problems could be distinguished in the cold-store work studied. One concerned the measures required to prevent general cooling of the body, i.e., to maintain body temperature. The other concerned local cooling of peripheral body parts, especially the hands.

The body's heat balance is affected by work intensity (the body's heat production) and the insulating properties of clothing, in addition to the effect of climate. The subjects adapted their clothing to heavy and intensive work phases by wearing clothing with relatively little thermal insulation. The required thermal insulation of clothing was estimated at approximately 0.8 clo under these conditions (1). Nevertheless, many workers became hot and sweaty when activity was at its peak, especially in the dairies. This sweating contributed to more rapid cooling during low activity. The heat production during low activity resulted in a need for two to three times as much insulation in clothing, or 2—3 clo. The work clothing used could not meet this requirement. It should be emphasized that great individual variations in energy expenditure existed, and therefore different needs for clothing insulation existed. The values presented and discussed are average estimates.

Work intensity in the dairies was mainly governed by external factors. Peaks of high work load could occur during the day, and these were especially fatiguing to people with a low physical work capacity. A better distribution of work could reduce the load while simultaneously simplifying the clothing problem.

The air temperature was somewhat higher and the work intensity more even in the meat-cutting room. The butchers were therefore able to adjust their clothing to their work intensity and did not have as great a problem as dairy staff in protecting themselves against the cold. The relatively high work intensity enabled them to wear rather light clothing with an estimated clo value at about 0.8. This value is in agreement with the predicted required clo value for these conditions (1). None of the butchers used additional insulation clothing. A cold draft radiated from a long row of cold (0—6°C) animal carcasses hanging on hooks about 1 m behind the meat-cutting table. The fact that this cold draft did not appear to affect the subjective ratings may be due to the very active nature of the work.

The muscular strain occurred in meat cutting primarily in the back, shoulder and cutting arm. Heart rate increased when the animal carcasses were especially cold or tough. Increased cutting resistance was the probable reason for this phenomenon. More-detailed studies are necessary in order to quantify the manner in which muscular strain is affected by, e.g., temperature and meat quality.

Work intensity in the packaging department was low, making warmer clothing necessary. Most of the staff did wear extra, insulating clothing providing an overall clo value of 1—1.5. Maintaining a normal body temperature still proved to be difficult. In comparison with meat-cutting work, packaging work under otherwise similar climatic conditions called for clo values between 1.5—2.0 in order to attain heat balance (1). A drop in air temperature from + 10 to + 4°C in the same type of work increases the clothing insulation required by about 25 % at an oxygen uptake of about 0.5 l/min (1). In general, the workers underestimated the insulation requirements of clothing needed during less physically demanding activities.

The cooling of peripheral body parts, the hands in particular, is the other major problem in work in a cold climate. Cooling may lead to a decreased sense of touch and manual dexterity, factors which may increase the risk of accidents in the processing of meat with sharp-edged tools, especially in work with hard or tough meat. Hands became more or less cooled in all the types of work studied. The palm of the left hand in particular easily became cooled in meat cutting and packaging because of the direct contact with cold and moist meat. Dry cotton gloves reduced cooling by a few degrees. These gloves were also used by about 75 % of all the butchers employed in the meat-cutting unit studied. Unfortunately, the gloves became wet after a relatively short period of time as a result of contact with the meat products. Gloves can also lead

to an impairment of manual performance capacity, especially when they do not fit well.

In all three phases of the study, the subjects were able to assess temperature changes in peripheral parts of the body well. Even relatively slight changes in the temperature of the skin of the hands were detected by most of the subjects. The skin temperature at one site on the periphery was used throughout as the objective measure with which subjective assessments were compared. However, this temperature may vary considerably at different sites on the hand. It can also shift in different directions at different sites, as was noted in many butchers during breaks. It is apparent that the perception of hand temperature reflected a relatively complex process.

In most subjects, the perception of temperature could vary considerably without any discomfort being reported. On the other hand, the variations in temperature perception provided information on deviations from the optimum comfort range for each individual. These deviations were to be found in the peripheral parts of the body for almost all the subjects. As a rule, discomfort from cold hands was experienced at temperatures at which previous studies also recorded a decline in manual performance capacity (4). When there was pronounced discomfort because of cold hands, the hand temperature of several subjects approached the pain threshold, i.e., around +10°C (5).

The wide individual variation in response patterns underlines the difficulties in assessing the effect of cold on the individual merely on the basis of climatic measurements. An assessment of this kind must be supplemented with biological measurements to a greater extent. There is currently no relevant climatic index which can be used to assess the physiological effect on man in moderately cold environments.

To summarize, the climate-related physiological problems associated with work in the cold mainly involve the cooling of peripheral parts of the body, the hands in particular. Unsatisfactory design of work clothing, especially with respect to insulation and ventilation properties, is another problem. In both these respects, basic and applied efforts are needed to provide information on the measures required to reduce or eliminate the unfavorable effect of cold climate in the work environment.

ACKNOWLEDGMENTS

The authors should like to convey their warm thanks to everyone who helped carry out the study, especially to the participating staff from the work sites, the occupational health centers at the ARLA Dairies in Bromma and Enskede and Samfod's meat-cutting and -packaging department in Johanneshov.

The study was part of a project with the objective of studying the effect of work in a cold climate on man. The project has been supported by grants from the Swedish Work Environment Fund (74/176).

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Reactions to hand cooling in workers occupationally exposed to cold

by Ann Enander, MA, Björn Sköldström, MSc, and Ingvar Holmér, PhD [1]

ENANDER A, SKÖLDSTRÖM B, HOLMÉR I. Reactions to hand cooling in workers occupationally exposed to cold. *Scand j work environ health* 6 (1980) 58—65. Ten men occupationally exposed to cold and ten office workers participated in the study. Reactions to immersion of the hands in cold water (+ 10°C) for 2 min were studied during the following 30 min at two different ambient temperatures, 10 and 20°C. Hand skin temperature was recorded in thermograms, and the subjects rated cold sensation and pain. Considerable interindividual differences in hand skin temperature reaction were found in both groups. On the average the occupationally exposed workers had a somewhat higher hand skin temperature than the office workers during the recovery period in the 10°C ambient temperature, although the difference did not reach significance. The office workers rated significantly greater cold sensation as a result of the cold immersion, especially during an ambient temperature of 10°C, and the frequency of pain ratings was higher for this group. The results suggest that cooling among the occupationally exposed workers at work was not severe enough to produce physiological adaptations, although some psychological adaptation was indicated.

Key terms: adaptive responses, hand cooling, pain, skin temperature, thermal sensation.

Exposure of the hands to cool or cold ambient conditions while the rest of the body is subjected to a comfortable microclimate occurs in some occupational activities (2, 3, 6, 9, 11, 12, 14). Many kinds of outdoor activities in the winter, as well as work in cold stores, may produce long-lasting, repeated exposures with hand skin temperatures below 20°C and finger skin temperatures below 15°C (3, 14).

Adaptive responses to local cooling of hands have been reported in many investigations [for reviews see Carlson et al (1) and Hellström (6)]. Adaptation is the most obvious in populations permanently exposed to cold (Eskimos, Lapps, Arctic regions, etc), eg, they have a quicker onset and a higher frequency of cold-induced vasodilatation (2, 9). Although similar findings have been obtained from fishermen (9), fish filleters (11) and ice-chamber workers (17), occupational exposure to cold in general is less severe and involves smaller adaptive responses (3, 6, 16, 17). Hand blood flow and cold-induced vasodilatation did not differ significantly in groups exposed to cold occupationally in comparison with the referents studied by Hellström (6). In the same study (6) however the cold-exposed group maintained a higher hand skin temperature and perceived pain at lower hand skin temperatures in comparison with nonexposed individuals.

The purpose of the present study was to investigate the extent to which men occupationally exposed for many years to a moderately cold climate (+ 5 to + 10°C) display physiological or psychological adaptations similar to those found in more severe cold exposure in response to local cooling.

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Material and methods

Subjects

A total of 20 male subject
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Table 1. Age and
skin temperature
pationally exposed

Subject number	Ag (a
1	6
2	5
3	5
4	5
5	4
6	4
7	3
8	2
9	2
10	2
Mean	4
SD	1

Material and methods

Subjects

A total of 20 male subjects participated in the study; 10 of the subjects were workers exposed to cold (approx + 10°C) in the meat-cutting and packaging departments of a slaughterhouse. Age and exposure data for this group are given in table 1. Included also are the lowest hand and finger skin temperatures of some of the workers as measured during a normal workday in a separate study (3). The remaining 10 subjects were a reference group of office workers matched according to age (table 1). These subjects were no more acclimatized to cold than could be expected for the time of year (November—December). There were six smokers in the cold-exposed group and five in the reference group.

Experimental procedure

In the experiment the subjects' hands were exposed to a cold test under two different climatic conditions, ambient temperature + 10 and + 20°C. The two sessions were run consecutively, and the sequence was reversed for half of the subjects in each group. For sessions at 20°C the subjects wore a short-sleeved cotton T-shirt, white cotton slacks and jacket, underpants, socks and shoes. At 10°C the standardized clothing was supplemented by thermal trousers and a thermal jacket.

Before the start of the experiment the subjects received information on the study and instructions concerning the procedure. During the 30-min break between sessions the subjects completed a questionnaire regarding, eg, health status, previous hand injuries, experience of cold exposure and frost bite, etc.

The cold test used in the study consisted of immersing rubber-gloved hands up to the wrists in cold water (+ 10°C) for 2 min (18). Thermograms of the palmar surface of the dry, naked hands were taken immediately prior to immersion (upon entering the climate chamber) and after 0.5, 2, and then every fourth minute up to 30 min after the immersion. During this time the subjects remained seated and kept their hands still at waist level. Immediately after each thermogram the subjects were requested to rate their perception of temperature and pain in the hands.

Measurements

The experimental sessions were conducted in a climate chamber with controlled air temperature (± 0.5°C), relative humidity (40 %) and air velocity (less than 0.2 m/s). Body temperature was measured with a rectal thermometer at the start of the ex-

Table 1. Age and exposure data for the two groups. Lowest finger and hand skin temperatures measured during normal work are reported for the occupationally exposed group (3).

Subject number	Occupationally exposed group				Reference group
	Age (a)	Exposure (a)	Skin temperature (°C)		Age (a)
			Finger	Hand	
1	61	20	20	23	65
2	56	30	22	28	58
3	54	17	14	20	54
4	53	14	18	23	52
5	47	30	—	—	46
6	47	30	—	—	40
7	33	13	—	—	32
8	28	11	25	26	28
9	22	3	—	—	25
10	21	4	20	22	23
Mean	42	17	19.8	23.7	42
SD	15	10	3.7	2.9	15

periment, between the two sessions, and at the end of the experiment. Temperature was rated on a 19-point scale with verbal definitions on every second point as follows:

9	
8	Very, very warm
7	
6	Very warm
5	
4	Warm
3	
2	Somewhat warm
1	
0	Neither warm nor cold
1	
2	Somewhat cold
3	
4	Cold
5	
6	Very cold
7	
8	Very, very cold
9	

Pain was rated on a continuous scale with five verbally defined points, ranging from no pain to unbearable pain.

The thermography equipment consisted of an AGA Thermovision System mod 680/102B, operated at a sensitivity of approximately 2°C per color with a total temperature range from 14 to 34°C. A temperature reference, AGA mod 1010, set at a temperature of 30°C, was used for system calibration and in the thermograms. Each thermogram depicted the hands in up to 10 different colors according to skin temperature.

Evaluation and analysis

Each thermogram was evaluated with regard to 22 points on each hand as shown in fig 1. The temperature value corresponding to the color/colors at each point was determined (accuracy ± 1°C) and typed into a minicomputer (Alpha LSI-2). The following variables were calculated on both hands for further analysis: mean fingertip temperature (points 1—4), mean finger temperature (points 1—14), mean

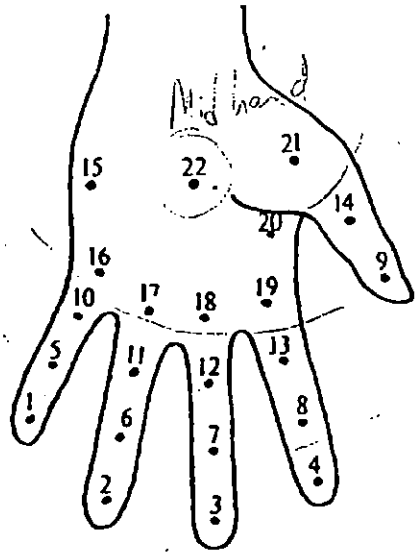

Fig 1. Location of the 22 points used in evaluating the thermograms of the hand.

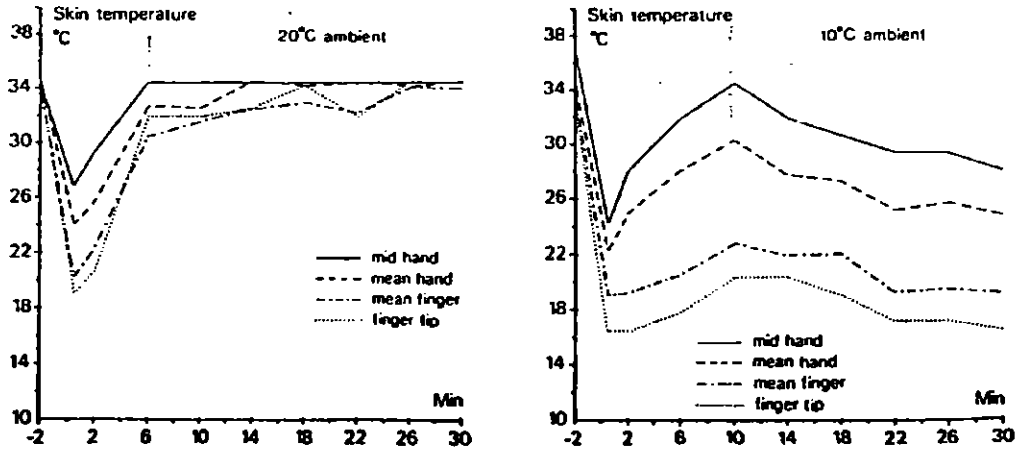

Fig 2. Change in hand skin temperature on the right hand of one occupationally exposed subject.

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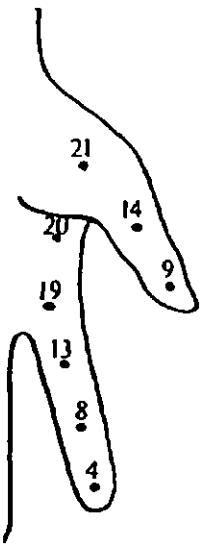

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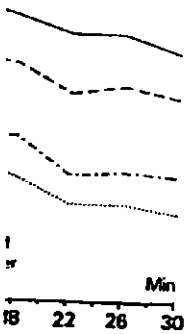


onally exposed sub-

hand temperature (points 15—22) and mid-hand temperature (point 22). Each individual temperature point weighed equally in the calculation.

For the statistical analysis of skin temperature and perceived temperature data a three-way analysis of variance model with repeated measurements on two factors was used (20). Group, ambient temperature, and measurement occasion constituted the three sources of variation.

Results

General reaction pattern

After a considerable drop following the cold water immersion, the change in hand skin temperature during recovery displayed great interindividual variation. In some subjects there was a more or less pronounced negatively accelerated increase in temperature with time; the increase brought some of the temperatures, but not all, back to the preimmersion level within 30 min. In other subjects hand skin temperature remained nearly constant at the first postimmersion value during the entire recovery period. This latter reaction was more frequent when recovery took place in an ambient temperature of 10°C, as compared to 20°C. Fig 2 illustrates the temperature reaction in different parts of the hand of one subject in the two environments.

No relationship could be observed between changes in hand skin temperature and body temperature, age, number of years of exposure to cold, or smoking habits. Neither were there any systematic differences in the response of the two hands to the immersion and recovery procedure. Cooling was in no case sufficient to elicit vasodilatation.

The perceived temperature of the hands closely followed the variation in the objectively measured temperatures of most of the subjects. Even quite small variations in finger temperature could cause a change in perception. Fig 3 illustrates the finger temperature and perceived temperature for one subject during an experimental session. Several subjects indicated a subjective difference in the temperature of the two hands, or in the different fingers of one hand, which in most cases could be found also in the thermograms.

Comparison between groups

Apart from a markedly higher frequency of cuts and injuries of the hands among the occupationally exposed group, no differences between the groups as regards health status or other factors were revealed in the responses to the questionnaire.

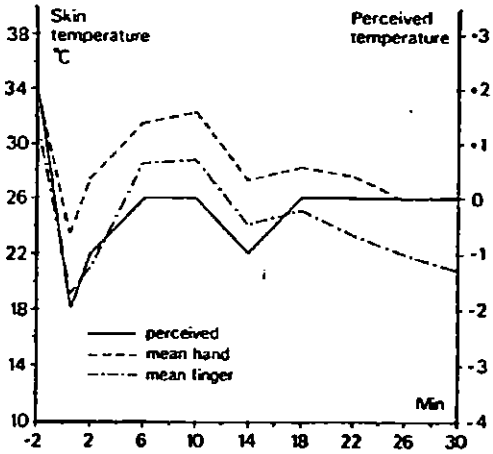


Fig 3. Hand skin temperatures and perceived temperature in the hand of one occupationally exposed subject during a session with an ambient temperature of 10°C.

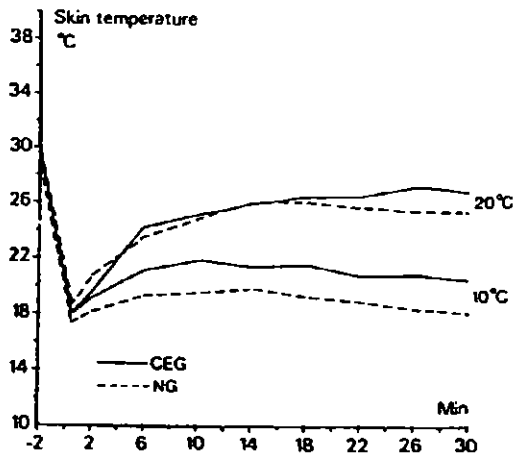


Fig 4. Mean finger temperature of the right hands of both groups (CEG = occupationally cold-exposed group, NG = occupationally non-exposed group) at ambient temperatures of 10 and 20°C.

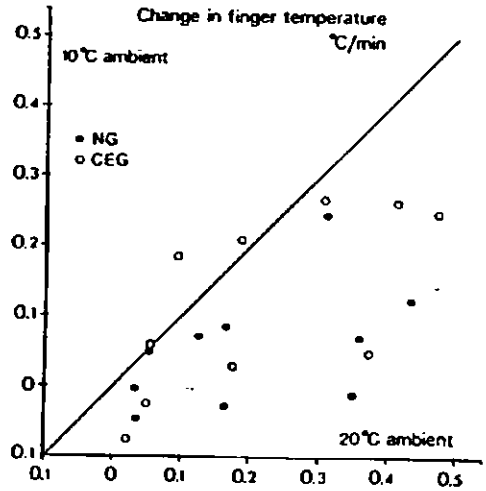


Fig 5. Mean change in finger temperature per minute during rewarming in an ambient temperature of 10°C in comparison with 20°C. Each point represents one subject. (NG = occupationally nonexposed subject, CEG = occupationally cold-exposed subject)

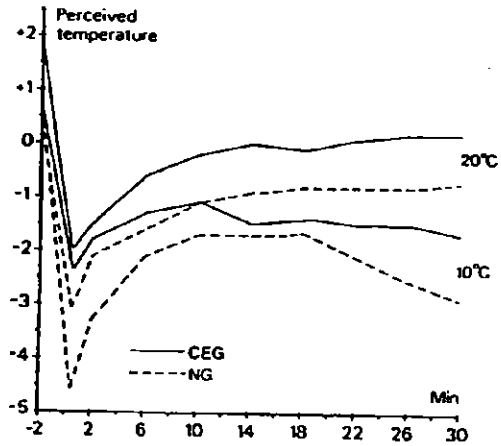


Fig 6. Mean perceived temperature ratings for the right hand for both groups (CEG = occupationally cold-exposed group, NG = occupationally nonexposed group) at ambient temperatures of 10 and 20°C.

Table 2. F-ratios and degrees of freedom (df) obtained in the analysis of variance of perceived temperature ratings for the right hand in response to cold immersion. The analysis was performed on the values before and immediately after immersion.

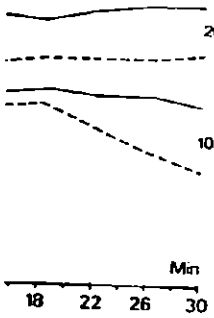
Source of variation	df	F-ratio
Group (G)	1/18	6.58 •
Ambient temperature (A)	1/18	4.92 •
Measurement occasion (M)	1/18	112.79 •••
G × A	1/18	< 1
G × M	1/18	1.69
A × M	1/18	1.00
G × A × M	1/18	6.05 •

• $p < 0.05$, •• $p < 0.01$, ••• < 0.001.

The two groups demonstrated a similar decrease in mean finger skin temperature during immersion. The interindividual variation in reactions during recovery was considerable within both groups. As illustrated in fig 4, the mean temperature of the occupationally exposed group was however consistently higher than that of the reference group during recovery. This difference in reaction between the groups remained for all the temperature variables studied, but only under the 10°C conditions. No differences were observed at an ambient temperature of 20°C. In the analysis of variance of finger skin temperature data during recovery, no differences between the groups or interaction with groups reached significance.

The average change in finger temperature per minute was calculated for each individual and is given in fig 5. Almost all subjects in both groups showed a smaller rate of increase in temperature when the ambient temperature was 10°C than when it was 20°C. The groups differed somewhat at 10°C in that five subjects in the occupationally exposed group had a value of 0.16°C/min or higher, as compared to only one subject in the reference group.

Fig 6 shows the mean perceived temperature ratings for the right hand for both groups at the ambient temperatures of 10 and 20°C. The analysis of variance of the subjective reaction to the cold immersion (values before and immediately after the immersion, table 2) disclosed a significant difference between the groups ($p < 0.05$) and a significant interaction between the groups, climate and time ($p < 0.05$). The reference group felt somewhat colder than the occupationally exposed group in both climate types, and this difference was especially marked after the cold immersion at 10°C. For both groups there was a significant difference in ratings between the two climate types



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($p < 0.05$) and, naturally, before and after immersion ($p < 0.001$).

The analysis of variance of perceived hand temperature over the entire recovery phase (values from 0.5 to 30 min after immersion) showed no significant differences as regards the groups or interactions with the groups. During recovery the mean temperature rating was somewhat higher for the occupationally exposed than for the reference group in an ambient temperature of both 10 and 20°C (fig 6). However, the wide interindividual range in temperature reaction during the recovery phase was accompanied by a considerable variation in the perception rating of both groups.

Most subjects in both groups felt some pain in the hands during the immersion test, although the pain often decreased rapidly after they removed their hands from the cold water. Immediately after the cold immersion there was a greater frequency of pain ratings among the referents in an ambient temperature of both 10 and 20°C (7 and 6 out of 10, respectively) than among the occupationally exposed group (4 and 2 out of 10, respectively). These differences did not, however, reach significance when tested with the chi-square test (13). A few subjects in both groups indicated slight pain throughout the recovery phase.

Discussion

The hands show the most pronounced adaptations after prolonged exposure to cold environments with, eg, modifications in the onset, frequency, and magnitude of cold-induced vasodilatation and maintained higher levels of skin temperature in response to local cooling (1, 6). A key factor in the occurrence of adaptation is that the tissues are actually cooled for some time and with sufficient intensity. Furthermore, the nature and extent of adaptation are dependent on the interaction of local temperature, mean skin temperature, and body core temperature (1, 19). Unfortunately, many studies on habituation to cold present no other data on conditions of exposure than the air temperature of the environment. Under such circumstances it is difficult to assess the actual factor stimulating the habituation process. This may be one explanation for the discrepancy of results from different studies as reviewed by Hellström (6).

Cold-induced vasodilatation was not studied in our subjects since the water bath test was too short and too small a cooling stimulus to evoke it (8). Since the occupationally exposed group was accustomed to a relatively moderate cold climate, a less severe cold test was chosen.

No significant differences in hand skin temperatures were found between the two groups in this study. The occupationally exposed group did however tend to have higher hand skin temperatures in the 10°C environment than the referents did. This tendency is in accordance with previous results (6, 11, 16, 17).

Apparently, the absence of any significant physiological adaptation of the occupationally exposed groups can be explained by the fact that cold stress was not severe enough to produce tissue cooling stimulating the habituation process. This conclusion is supported by Tanaka (17), who reported smaller adaptations in coolroom workers in comparison with, eg, ice-chamber workers and swimmers.

In six of the ten subjects of the occupationally exposed group in this study, skin temperatures were monitored on two different occasions during a normal workday (3). The average hand and finger temperatures were 23.7 and 19.8°C, respectively, with great interindividual variations (table 1). In the same study it was found that body core temperature remained almost constant and normal during the observation period (3). At higher rates of work in ambient temperatures of 0—10°C with appropriate clothing it is easier to maintain thermal balance and reduce, or even prevent, peripheral cooling of, eg, hands and feet. Under the same conditions the rewarming of cold hands and feet can take place (7) and has been found to be quicker and more pronounced in cold-exposed outdoor workers (16).

On the other hand the relatively high hand and finger skin temperatures observed during normal work can be a result of acclimatization. Glaser & Shephard (4) clearly showed that hand skin temperatures fell progressively less during succes-

sive exposure to cold (air temperature 3—6°C) in lightly clad, resting subjects, averaging 15.5°C on the 11th day. This hand skin temperature is about 5° lower than that measured for six of our subjects during work.

In both climates the occupationally exposed group rated hand temperature as less cold than did the referents. The question remains as to whether this reflects a difference in perception or in the use of the rating scale per se between the two groups. The subjects' previous experience of the stimulus dimension to be evaluated should be considered when different groups are compared with verbal definition scales. All the occupationally exposed subjects in this study had been repeatedly exposed to low hand temperatures, and this exposure could have conceivably resulted in a shift in the meaning attached to the verbal definitions used on the temperature scale as compared to the referents' responses.

Regardless of the level at which the subjects set their ratings, the referents showed a significantly greater change in perceived temperature in response to immersion at 10°C. No such differences were found at 20°C, and only the referents rated a greater drop in temperature in 10°C than in 20°C. Since there were no corresponding differences in mean hand temperature in response to immersion, it would seem reasonable to attribute these results to differences in experience with cold between the groups. It can be hypothesized that a low ambient temperature to which subjects are unaccustomed has the effect of increasing the subjective reaction to local cooling in comparison with that of subjects accustomed to cold exposure.

Evidence of experimentally induced adaptation to cold pain has been shown in several studies (10, 15). Hellström (6) found a lower frequency of pain reaction in outdoor than in indoor workers within the same finger temperature range. A similar, but nonsignificant, tendency was found in the present study between the two groups, although the cold immersion test was less severe than that usually used in studies of cold pain.

To summarize, local cooling of the hands with occupational cold exposure in the present study was not severe enough to produce significant physiological adaptation. There was however some evidence of a psychological adaptation to cold sensation and pain among the cold-exposed workers studied.

Acknowledgment

This study was part of a project with the objective of studying the effect of work in a cold climate on man. The project has been supported by grants from the Swedish Work Environment Fund (74/176).

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RISQUES RELATIFS A LA MANIPULATION (A MAINS NUES) DE POULETS CONGELES

CENTRE DE

référence

DE LA CSST

Commission de la santé et de la sécurité du travail du Québec

CREF: 85021201

RISQUES RELATIFS A LA MANIPULATION (A MAINS NUES) DE POULETS CONGELES

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RISQUES RELATIFS A LA MANIPULATION (A MAINS NUES) DE POULETS CONGELÉS

Par: Irina Tsarevsky, m.d.

Direction de la médecine du travail
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Soutien scientifique et technique
Centre de référence

TABLE DES MATIÈRES

CREF: 85021201

QUESTION

Quels sont les risques relatifs à la manipulation (à mains nues) de poulets congelés ?

INTRODUCTION

L'homme est beaucoup moins protégé contre l'effet du froid par rapport aux animaux. L'organisme humain possède quand même un mécanisme complexe de thermo-régulation.

L'exposition au froid n'est pas si rare qu'on peut se l'imaginer: des milliers de personnes sont quotidiennement exposées à des températures basses à leur travail. On peut mentionner quelques exemples: les travailleurs de la construction, les fermiers, les forestiers, les travailleurs des usines de congélation, des usines de transformation de la viande, du poisson, et il y en a beaucoup d'autres.

Le travailleur qui oeuvre dans une ambiance froide est habituellement protégé par un habillement approprié mais ses extrémités demeurent toujours plus à risque.

On ne peut pas séparer l'effet local du froid sur les extrémités de la réaction générale de tout l'organisme envers l'agresseur thermique.

Notre corps est en contact permanent avec l'environnement. Voici le schéma des échanges de chaleur entre l'organisme et l'environnement.

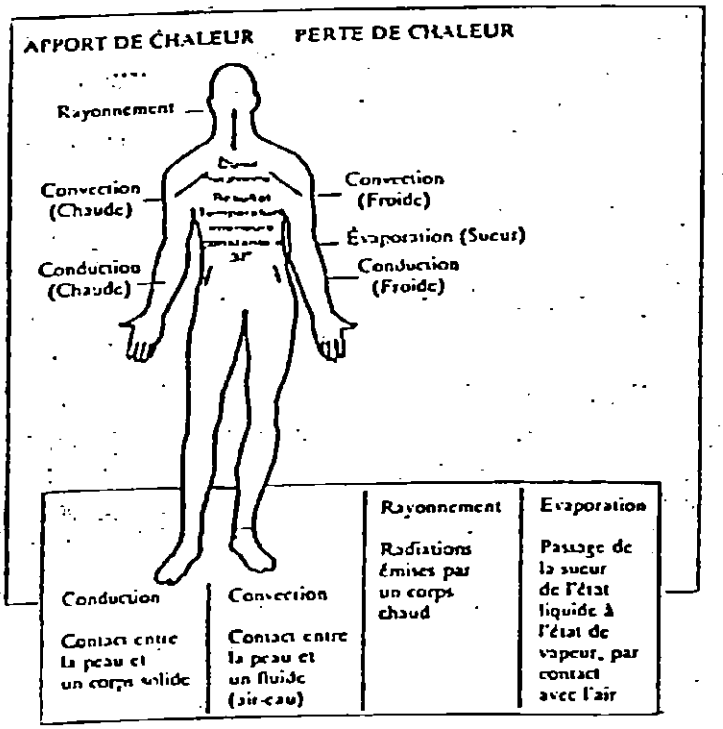

Figure 1. SCHÉMA DES ÉCHANGES DE CHALEUR ENTRE L'ORGANISME ET L'ENVIRONNEMENT (Extrait de "Les rotativistes" CNAM/ANACT, 1982). (1)

MÉCANISMES DE CONSERVATION DE LA CHALEUR ET DE L'AUGMENTATION DE LA PRODUCTION DE CHALEUR QUAND LE CORPS SE REFROIDIT

Le corps humain est destiné à fonctionner à une température interne constante égale à 37°C.

La température du corps est contrôlée par voie nerveuse et humorale.

* Humorale - qui se rapporte aux humeurs. On parle de la voie humorale comme d'un moyen de transport de la plupart des substances à l'intérieur de l'organisme. On oppose assez souvent dans les mécanismes physiologiques de la voie humorale à la voie nerveuse (Larousse, Dictionnaire médical).

Quand la température toube en dessous de 37°C, un mécanisme spécial qui a pour but de conserver la chaleur interne et d'assurer l'augmentation de la production de chaleur est déclenché.

La conservation de chaleur est assurée par la vasoconstrition et par l'abolition de la transpiration.

Premièrement, le froid amène une baisse de la température cutanée et il produit ensuite un refroidissement du sang dans les capilaires périphériques. Le sang refroidi arrive par le courant sanguin à la région thermo-sensible du cerveau. La chute de la température s'enregistre dans la région pré-optique de l'hypothalamus.

L'hypothalamus fonctionne comme un thermostat: il compare l'information obtenue avec son seuil ("Set Point") et il déclenche les réactions adéquates pour maintenir la balance thermique (figure 2).

Les glandes surrénales sont stimulées pour produire l'adrénaline. Une vasoconstriction adrénergique maîtrise la fonction des glandes sudoripares pour prévenir les pertes de chaleur par évaporation.

L'hypothalamus dirige aussi la réponse du système humoral. L'hypophyse est stimulée pour augmenter la production d'hormone thyreotrope. Cette dernière, à son tour, stimule la glande thyroïde qui produit plus de thyroxine, l'hormone qui accélère l'oxygénation.

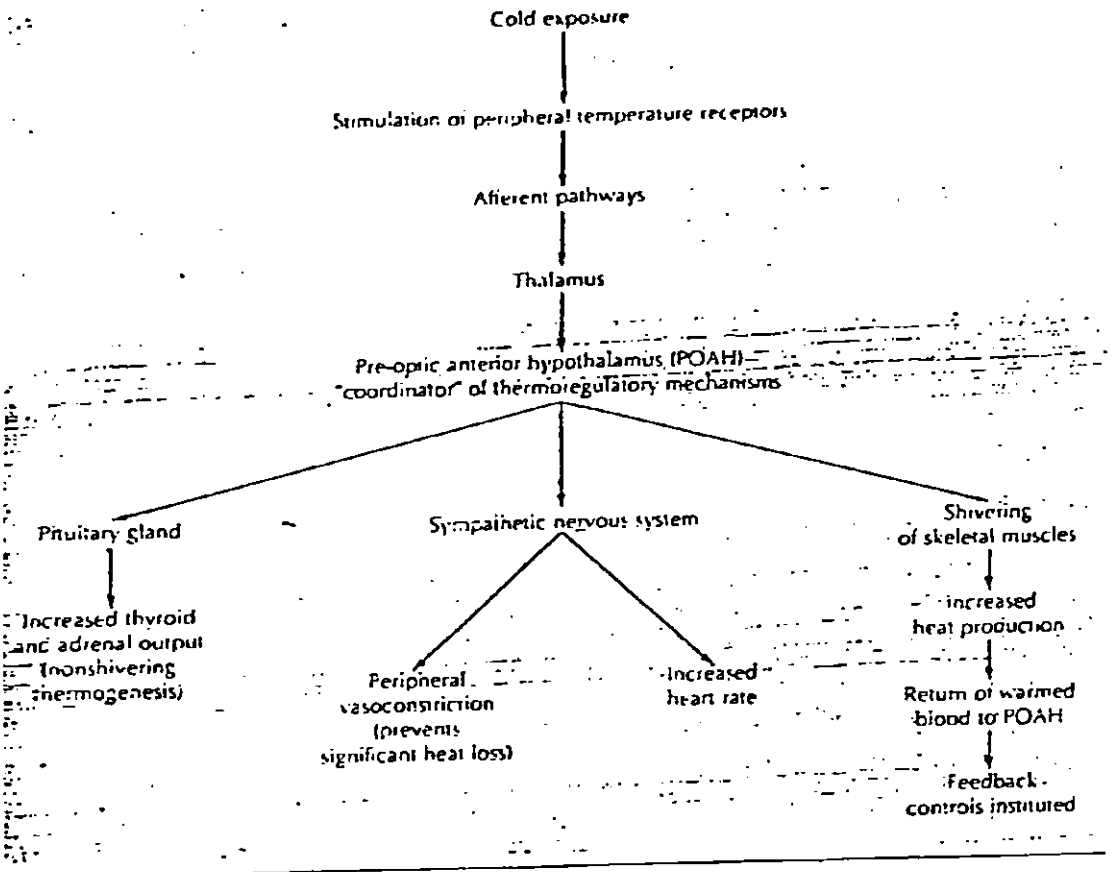

Figure 2. BASIC THERMOREGULATORY MECHANISMS IN RESPONSE TO COLD EXPOSURE (4)

(Par M. L. Dembert, m.d.)

Le glycogène accumulé dans le foie se libère et se transforme en glucose pour fournir l'énergie additionnelle.

Le frisson, lui aussi, est induit par l'hypothalamus. Des contractions rapides des muscles produisent la chaleur supplémentaire nécessitée. Cette réaction augmente le niveau du métabolisme de l'organisme. On remarque un accroissement de l'appétit et une demande élevée de nourriture ayant une grande valeur calorique pour équilibrer la balance énergétique.

FACTEURS INDIVIDUELS DANS LA RÉSISTANCE AU FROID

Le niveau de résistance au froid varie d'une personne à l'autre. Il est assez difficile de faire une distinction entre les facteurs jouant un rôle plus important dans la sensation d'inconfort chez une personne particulière. La taille, la forme du corps ainsi que sa condition physique sont des facteurs qui influencent le niveau des pertes de chaleur. Par exemple, si la chaleur est exprimée en unité par poids, la demande de maintenir la température interne constante sera plus grande chez un enfant que chez un adulte, ce qui est dû au fait que la surface exposée à l'ambiance est plus large par unité de poids quand le corps, au total, est plus petit.

Si deux personnes sont exposées à la même température basse mais qu'elles sont de taille différente, les pertes de chaleur seront plus importantes pour la personne la plus grande. C'est en grande partie dû au fait que la personne la plus grande possède évidemment de plus longs bras et de plus longues jambes. La surface exposée au froid devient donc, par le fait même, plus importante.

Un autre facteur important de tolérance au froid est la couche des tissus adipeux hypodermiques. La conductivité thermique du gras est beaucoup moins importante que celle des muscles. Donc, les pertes de chaleur à l'environnement deviennent moins importantes chez une personne plus grasse (corpulente). Tel que mentionné précédemment, les pertes de chaleur dépendent de la différence entre la température de la surface du corps et celle de l'environnement.

Les personnes ayant très peu de substances grasses commencent à frissonner lorsque la température de la peau atteint 30,8°C tandis qu'une personne possédant plus de substances grasses commencera à frissonner à une température atteignant 21,1°C. (5)

On peut donc conclure que le gras hypodermique est un facteur très important pour l'isolation et que la différence de quantité de substances grasses entre deux personnes peut expliquer la différence de tolérance individuelle au froid.

La figure 3 montre qu'une immersion dans l'eau froide (15°C) durant 30 minutes produit de plus grandes chutes de température rectale chez des personnes plus maigres.

L'activité physique au cours de l'exposition au froid devient le plus important facteur pour la tolérance au froid et l'augmentation de la production de chaleur.

La condition physique est un autre facteur important de tolérance au froid. L'habitude de l'exercice augmente la vascularisation et la grandeur des muscles striés ainsi que la masse musculaire du coeur, donc la capacité de travail pour ces tissus augmente également.

Figure 3. EFFECT OF SUBCUTANEOUS FACT ON HEAT PRODUCTION AND BODY INSULATION IN COLD WATER (°C). RESULTS FROM 2 FAT AND 2 THIN MEN AFTER THEY HAD STABILIZED THEIR DEEP BODY TEMPERATURES IN STIRRED WATER AT DIFFERENT TEMPERATURES. THE 2 LOWER CURVES = THIN MEN (MEAN SKINFOLD THICKNESSES 6,5 AND 6,7 MM). THE 2 UPPER CURVES = FAT MEN (MEAN SKINFOLD THICKNESSES 26,7 AND 26,8 MM). Dans "Man in the Cold", p. 21. (5)

LA RÉPONSE VASOMOTRICE AU FROID - LA RÉGULATION DE TEMPÉRATURE DES EXTRÉMITÉS

Les extrémités du corps peuvent être définies comme les parties du corps ayant très peu de muscles et de tissus viscéraux capables de produire de la chaleur.

L'anatomie de ces régions est telle qu'elles sont entièrement dépendantes de la circulation du sang pour leur production de chaleur.

Dans une ambiance froide, les pertes de chaleur sont prévenues par l'effet de vasoconstriction. Par contre, si la température des extrémités descend très bas, un dommage aux tissus peut survenir. Dans ce cas, une chaleur additionnelle doit être fournie laquelle peut être produite par une augmentation de la circulation sanguine.

L'anatomie vasculaire des extrémités présente deux caractéristiques spéciales, lesquelles influencent grandement l'effet de thermorégulation par les changements dans la circulation sanguine. Premièrement, la circulation du sang dans les extrémités est conçue de façon à ce que le sang se rende jusqu'au bout et revienne.

Les systèmes veineux et artériels sont très proches l'un de l'autre. Il y a un complexe additionnel de veines placées très près de la surface de la peau mais qui n'ont pas d'artères attenantes majeures.

Le sang chaud s'en retourne par le système veineux superficiel, ce qui peut occasionner des pertes de chaleur. Mais, dans une ambiance froide, les veines superficielles sont fermées et pour s'en retourner, le sang utilise les

veines profondes lesquelles sont placées très près du système artériel, ce qui cause un refroidissement des extrémités. Le sang artériel, en entrant dans l'extrémité, se trouve en contact très étroit avec le sang froid des veines.

Une autre particularité anatomique des extrémités serait une très haute densité des anastomoses artério-véneuses lesquelles, quand elles sont ouvertes, assurent une très mince résistance pour la communication directe entre artérioles et veinules.

La circulation sanguine par les anastomoses des tissus superficiels des extrémités sert à la thermorégulation, indépendemment des demandes en oxygène de ces tissus et de leurs métabolites.

Il faut souligner que malgré plusieurs études visant à comprendre le mécanisme de la circulation périphérique, l'aspect de la réponse vasomotrice au froid n'est pas toujours clairement expliqué.

L'effet de vasodilatation, lui non plus, n'est pas très clair. Lewis l'a décrit pour la première fois en 1930. Dans son expérimentation, il a démontré que des doigts plongés dans un mélange d'eau et de glace ont refroidi jusqu'à 1°C mais dans un laps de temps d'une à deux minutes, leur température a augmenté à 8°C. Une chute de la température jusqu'à 0°C a suivi cette augmentation. (7). L'effet d'augmentation de la température a été imputé à l'augmentation massive de la circulation sanguine. Lewis a expliqué ce phénomène par la réaction du réflexe d'axone du nerf sensoriel.

Par contre, d'autres études ont relevé qu'une vasodilatation peut être produite chez des sujets avec sympatectomie et sera présente dans la forme modifiée même après la dégénérescence complète de tous les nerfs sensoriels et moteurs. Il a été aussi suggéré que la vasodilatation est un effet dû aux agents humoraux.

En 1983, une étude sur la participation vasculaire lors de la sensation de douleur profonde a été présentée par H. Fruhstorfer. On a assumé que la douleur au froid était reliée à la température interne des extrémités et que les récepteurs responsables de cette réaction étaient très proches des veines. Pour tester cette hypothèse, on a injecté une petite quantité (20 ml) de solution isotonique froide de sel dans les veines vides des bras de 16 sujets. (8)

La solution isotonique inférieure à 26°C produit la sensation pure du froid; la température inférieure à 20°C produit la sensation de froid et de douleur tandis que la température de 5°C a été jugée comme la limite de tolérance à la douleur pour plusieurs sujets.

L'apparition de douleur a été constatée après l'exposition au froid et elle disparaissait avant ou en même temps que le froid. On a suggéré qu'il y avait deux types de récepteurs vasculaires: le récepteur spécifique et sensible au froid et le récepteur de douleur, avec une limite de tolérance aux environs de 20°C.

LA PEAU ET LA CIRCULATION CUTANÉE

Pendant l'exposition au froid, la vasoconstriction réduit la circulation du sang dans la peau ce qui a pour but de réduire les pertes de chaleur par convection. Un refroidissement très fort des extrémités peut apporter l'inconfort, l'incapacité et un risque de gelure. La réaction vasomotrice à l'effet du froid sert à deux objectifs confrontants: la nécessité de minimiser les pertes de chaleur et de maintenir l'intégrité des tissus.

Les pêcheurs en eau profonde peuvent travailler en plongeant leurs mains dans une eau si froide qu'elle serait insupportable pour d'autres personnes. Alors on peut assumer que la circulation sanguine dans les mains de ces pêcheurs est ajustée et plus régulière que chez la plupart des autres personnes.

La réaction de différentes personnes au refroidissement local par la technique classique d'immersion des doigts ou encore des mains dans l'eau froide a démontré que les personnes acclimatées sont capables de mieux tolérer ces tests selon la sensation de douleur, d'engourdissement et de dextérité manuelle. Le mécanisme de cette acclimatation n'est pas encore bien expliqué.

Il est prouvé que la capacité de tolérance au refroidissement local est due à la capacité individuelle d'acclimatation et non aux caractéristiques raciales héréditaires.

L'acclimatation au refroidissement intensif produit une augmentation de la circulation sanguine ainsi qu'une augmentation des pertes de chaleur. On a assumé que la circulation totale dans les tissus superficiels durant

l'exposition au froid pouvait être réduite chez les personnes acclimatées, même si le courant sanguin dans les extrémités était augmenté mais cette hypothèse n'a pas été confirmée.

REVUE DES ÉTUDES SPÉCIFIQUES SUR L'EXPOSITION DES MAINS AU FROID

La deuxième partie de ce document apportera une brève revue des publications qui ont été jugées pertinentes pour l'élaboration du présent document.

Ce sont des études expérimentales qui avaient pour but d'étudier: la réaction des humains à une exposition locale au froid; la limite acceptable du refroidissement par la sensation de douleur; l'effet cardio-vasculaire à une exposition locale au froid; et le changement de la force du poing par l'exposition au froid.

Il faut aussi souligner que ces études ont été effectuées sur un nombre limité de personnes. De plus, elles ne sont pas uniformes par la méthodologie d'expérimentation et elles présentent, à l'occasion, des résultats contradictoires.

L'étude de Tanaka faite sur 14 hommes a démontré que les travailleurs exposés à des froids extrêmes présentaient une température de la peau plus élevée et un temps de première augmentation de température après l'immersion plus court que les travailleurs exposés à une température fraîche (15°-18°C). (10)

L'index de résistance au froid* a été significativement plus élevé pour le groupe de travailleurs habitués à une exposition à des froids extrêmes.

Une autre étude présentée par Ann Enander avait pour but de voir s'il y avait une différence entre le groupe exposé occasionnellement au froid et d'autres groupes exposés journalièrement à des refroidissements des mains.

Pour les deux groupes, de 10 personnes chacun, les mains des sujets avaient été plongées dans l'eau à une température de 10°C, pendant deux minutes.

La différence n'était pas significative. Par contre les travailleurs non exposés régulièrement au froid montraient une sensation de froid ainsi qu'une sensation de douleur plus fortes. (11)

La conclusion tirée des résultats de cette étude était que l'exposition des travailleurs au froid n'était pas assez importante pour produire l'adaptation physiologique.

L'effet d'un refroidissement local de la main par l'air a été étudié ainsi que les sensations thermiques et douloureuses. Dix-huit sujets ont été exposés à trois températures différentes soit: 0°C, 7°C et 15°C pour une durée de 95 minutes pour chaque condition thermique.

* L'index de résistance au froid, c'est l'intensité de la résistance de l'organisme aux changements thermiques.

Les variations inter-individuelles dans la réaction au refroidissement étaient jugées considérables (12). Il a été conclu que la relation calculée entre la sensation thermique et la température cutanée de la main est stable et indépendante des conditions de la température ambiante locale.

Les études sur la douleur comme réaction au refroidissement ont été présentées dans d'autres séries d'expérimentations.

L'étude de Croze (1978) a conclu que la limite de la sensation de douleur se situe aux environs de 10°C (13).

Le même auteur, en 1983, a étudié les relations entre l'exposition au froid et la sensation de douleur. Neuf personnes ont été le sujet d'expérimentations alors que leurs deux mains étaient exposées aux températures suivantes: 15°, 10°, 5° et 0°C.

Il a été démontré que l'intensité de la douleur ressentie au cours de l'exposition au froid et celle de la stimulation montre une corrélation linéaire. (14).

Une autre série de travaux a été faite pour évaluer l'influence de l'exposition au froid sur la force manuelle d'une pression de la main fermée.

Les résultats d'une étude de D. J. Johnson ont démontré une diminution significative de la force, immédiatement après l'expérimentation ainsi qu'une augmentation significative de la force dans les 80 minutes suivant l'expérimentation (15). Douze étudiantes avaient participé à

cette expérience d'une durée de 30 minutes d'exposition des bras dans un bain froid (10°-15°C). Un groupe de contrôle avait les mêmes conditions d'expérimentation mais en excluant l'exposition à l'eau froide.

Quatorze personnes ont participé à une expérimentation qui avait pour but de déterminer les effets d'une exposition dans un bain d'eau à une température de 10°C, sur la force des poings. L'exposition fut d'une durée de 30 minutes et un groupe contrôle a été utilisé.

La force a diminué significativement après l'expérimentation; elle est revenue à un niveau normal dans les 40 minutes suivant celle-ci. Aucune augmentation de force après l'immersion n'a été constatée (16).

Comme on l'a déjà mentionné, le refroidissement des extrémités produit une réaction générale de l'organisme. L'effet cardio-vasculaire lors de la stimulation de la main et du visage par le froid a été étudié par le groupe de chercheurs du département de physiologie de l'université Laval (17).

Lors de la stimulation de la main par le froid chez 13 sujets, une augmentation de la fréquence cardiaque, de l'index cardiaque*, de la pression artérielle moyenne et des résistances périphériques a été constatée.

* L'index cardiaque= $\frac{(Dd^3 - Ds^3) \times F.C.}{\text{surface corporelle}}$ (Feigenbaum 76)

ou Dd^3 est le volume diastolique
Ds^3 est le volume systolique
Dd^3-Ds^3 est le volume d'éjection systolique
F.C. - est la fréquence cardiaque.

Les résultats suggèrent que la réaction cardio-vasculaire à la stimulation de la main par le froid est une réaction du type sympathique.

L'étude de temps systolique pendant le refroidissement des mains était combinée avec la bascule tête élevée (Head-up-tilt). L'immersion des mains a produit une augmentation de la pression artérielle diastolique ainsi qu'une augmentation concominante de la durée de la période de pré-éjection (18).

L'EFFET DU FROID SUR LA PERFORMANCE MANUELLE

Plusieurs études sur la performance manuelle ont conclu que les personnes ayant les mains froides démontrent une incapacité significative même si leur corps est chaud et qu'au contraire, les personnes ayant les mains chaudes ne démontrent aucune incapacité même si leur corps est froid (22).

Le froid change la force musculaire des mains: il produit un changement dans la sensibilité tactile.

Par contre, il faut souligner que les individus qui sont habitués à travailler au froid ont de meilleures performances pour des tâches manuelles que les individus non habitués.

L'expérience du travail au froid produit une adaptation physiologique. Comme on l'a déjà mentionné, l'endurance manuelle ainsi que l'adresse au travail dans le froid se développent chez les travailleurs suite à l'expérience.

Il a été démontré que dans une ambiance froide, la température des articulations baisse plus que celle des muscles et de la peau.

Cet abaissement de la température des articulations cause une grande résistance aux mouvements ainsi qu'une diminution de la vitesse des mouvements.

Les études sur la dextérité manuelle ont démontré que les fonctions de la main sont sérieusement détériorées quand la température des surfaces des doigts descend en dessous de 15°C. A partir de 10°C, on admet la difficulté de se servir des mains et en dessous de 5°C, une perte totale de la sensibilité tactile a été constatée. La sensibilité tactile souffre d'une grande détérioration par le refroidissement.

Le froid cause un effet anesthésique partiel sur les mains. Les mains perdent leur capacité d'évaluer les objets qui sont tenus.

Il nous faut souligner que des changements dans la performance manuelle peuvent devenir la cause d'accidents.

LES PROBLÈMES MÉDICAUX RELIÉS A L'EXPOSITION AU FROID

L'exposition au froid occasionne le syndrome de Raynaud, lequel se traduit par la constriction de petites artères et artérioles. Il se développe par un changement de couleur de la peau aux parties distales. Les changements de couleur touchent un ou plusieurs doigts et ont

typiquement trois phases, lesquelles sont: pâleur, cyanose et rougeur. La douleur et l'engourdissement peuvent être notés pendant la phase de pâleur et la phase cyanotique. (19).

Le problème des verrues (virus Papilloma) parmi les travailleurs du secteur de la volaille n'a été rapporté que récemment. La manipulation des objets froids a été relevée comme un des facteurs du milieu de travail reliés, de façon significative, à la présence de verrues. (21).

Il est présumé que le contact continuel des mains avec des objets froids comme des poulets amenés à une température de 4°C, par exemple, amènerait une vasoconstriction qui empêcherait une bonne circulation au niveau des mains et par conséquent, une bonne défense de l'épiderme contre le virus des verrues.

Une étude Bulgare publiée en 1983 présente les résultats sur la réactivité neuro-végétative des membres supérieurs chez les travailleurs exposés au froid local systématique.

Elle rapporte que selon des résultats d'examens cliniques de plusieurs tests physiologiques ainsi que de données du questionnaire, il y a une différence significative dans la manifestation de la pathologie neuro-végétative angiodystonique* entre les cas et les témoins.

* Angiodystonie neurovégétative est une altération de la tonicité des vaisseauix lié au dérèglement fonctionnel des systèmes sympathique ou parasympathique.

On voudra souligner que l'étude est basée sur un nombre limité de travailleurs. On ne la mentionne ici qu'à titre d'information. En effet, à cause de la langue, plusieurs éléments de l'étude sont difficiles à saisir.

De plus, elle est la seule en son genre à présenter de tels résultats.

CONCLUSION

On a présenté l'information générale pour pouvoir évaluer le risque relié à l'exposition des mains au froid.

On peut conclure que le niveau de connaissance scientifique actuel ne nous permet pas de nous prononcer au sujet de l'existence du risque à l'exposition des mains au froid.

Malgré tout, on peut cependant affirmer que les verrues, ainsi que le traumatisme lié à l'engourdissement des mains par le froid, présentent un risque réel pour les travailleurs affectés à la manipulation des poulets congelés.

Comme mesures préventives, on suggère le port de gants appropriés, lesquels doivent assurer une protection suffisante contre le froid local, l'infection virale et le traumatisme.

Un changement de procédé technologique visant à éviter la manipulation directe des objets froids peut aussi régler le problème relié à l'exposition au froid local.

En conclusion, il nous semble très souhaitable que la recherche épidémiologique vienne documenter l'existence et la gravité des problèmes de santé liés à l'exposition quotidienne au froid local.

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travail posté; travail de nuit

3 - TRAVAIL POSTE (SHIFTWORK) ET TRAVAIL DE NUIT

Les humains vivent selon un rythme physiologique sur une période de 24 heures. Ces rythmes biologiques sont le plus souvent appelés rythmes circadiens. Ce sont des facteurs synchronisateurs endogènes qui répondent au temps du jour et de la nuit, à la connaissance des heures, aux expériences de la famille et au rythme social d'éveil et de sommeil. Seulement 10% de la population aime le travail posté, 20 à 30% ne l'aime pas et la majorité le tolère.

L'ajustement des horaires de nuit et de jour entraîne des baisses de rendement, de la fatigue, des pertes de sommeil, des troubles de l'appétit et des symptômes gastro-intestinaux. La vie sociale est en général assez dérangée sinon perturbée.

Surveillance médicale et prévention

En ce qui a trait à la surveillance médicale et à la prévention, il n'y a pas de recettes toutes faites. Avant toute intervention visant à modifier le travail posté ou de nuit il faut s'assurer d'une bonne connaissance théorique des effets sur la santé de ce genre d'horaire. Des facteurs comme la durée de travail, les horaires, la rotation des quarts de travail, les troubles du sommeil et les problèmes de santé individuels feront ensuite partie de l'évaluation. Parfois, l'inventaire des symptômes peut nécessiter qu'on propose un questionnaire approprié. Enfin, on ne doit pas s'attendre à des résultats mirobolants. Les intervenants en santé au travail devraient ajuster leurs interventions aux conditions particulières de chaque milieu de travail et utiliser avec discernement les suggestions de solutions de la littérature scientifique. Nous vous référons aux articles de l'INRS et de Rutenfranz qui résument bien le sujet et proposent des approches validées par l'expérience.

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Psychological and psychophysiological effects of shift work

by Torbjörn Åkerstedt, PhD[1]

ÅKERSTEDT T. Psychological and psychophysiological effects of shift work. *Scand J Work Environ Health* 1990;16(suppl 1):67—73. The psychophysiology of shift work is mainly related to circadian rhythmicity and sleep-wake phenomena. Individuals on a rotating three-shift or similar system work the night shift at the low phase of circadian rhythm. On retiring to bed in the morning they fall asleep rapidly but are prematurely awakened by their circadian rhythm and exhibit severe sleepiness and reduced performance capacity. In connection with the morning shift the circadian psychophysiology makes it difficult to fall asleep as early as needed during the preceding night. Around 0400 to 0500, when the individuals should rise, they have difficulties awakening because of the sleep loss and the circadian rhythm, which at that point is at its lowest. Subsequently, day work is characterized by sleepiness and reduced performance. It should be emphasized that it does not seem possible to improve one's ability to adjust over time, even with permanent night work. Older age and "morningness" personality are related to higher than average problems in adjusting.

Key terms: circadian, psychophysiology, sleep, sleepiness.

Shift work is one of the more apparent and dramatic components of the work environment. It has been clearly linked to a series of acute and chronic effects on the organism, most of them related to the circadian rhythmicity of the body. The major effects concern sleep, alertness, and performance, but also long-term health. The purpose of the present paper is to provide a brief review of these effects and to discuss mechanisms and countermeasures.

Before turning to the effects, however, the term "shift work" needs to be defined. The term usually refers to an arrangement of workhours which employs two or more teams (shifts) of workers in order to extend the hours of operation beyond that of conventional office hours. It has, however, become customary to apply the concept also to groups with more unstructured and irregular workhours and to groups with permanent night or evening work. With this usage the proportion of shift workers make up at least one-fourth of the working population in most industrialized nations (1). In the present overview I have restricted the discussion to shift work that, at least occasionally, involves night work, since such schedules are the most interesting from a psychophysiological point of view. Permanent night work, rotating three-shift work, night-oriented roster work, and irregular workhours are included.

Circadian physiology

The psychology and psychophysiology of shift work is intimately related to the rhythmic timing system of humans, particularly that having a 24-h period — the circadian (from *circa dies* = approximately 24 h) system. It has its neural basis in the lower frontal hypothalamus, situated above the optic chiasma (2). These suprachiasmatic nuclei produce a cyclic oscillation with a period of 24 h. Although the rhythm is rather stable, it may be modified by environmental synchronizers such as light, sleep, food, etc. The speed of adjustment to a new time zone is usually about 1 h/d although this speed may differ between variables.

In order to describe the circadian rhythm of an individual, frequent measurements are needed — during work, leisure time, and sleep. This need places a considerable burden on the subjects, and researchers have, for this reason, tended to focus on functions that are easy to measure, such as oral temperature and urinary constituents (2, 3). Figure 1 derives from one of the most extensive studies of oral temperature, with a total of 133 workers in all (4). During the day of the first night shift an increase occurs from the time of rising in the morning to a peak in the evening. Thereafter, the temperature falls during the night shift towards a minimum around 0400, after which a rise is seen towards the end of the shift and the new morning bedtime. The fifth shift shows a similar pattern but with seemingly low temperature during the morning. (No measurements were taken during sleep.) Such a pattern, with low night levels and high day levels, has been demonstrated for many physiological variables, eg, cortisol, potassium, adrenaline, etc (2, 3).

In contrast to the variables just presented, which have a strong endogenous rhythmicity partly unaffected by behavior, other variables mainly reflect di-

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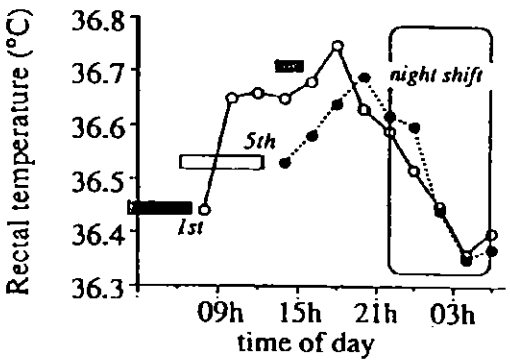

Figure 1. Mean oral temperature of >50 shift workers during the first and fifth night shifts. The 24-h period with the first night shift began as a normal day with awakening around 0700-0800 after a night's sleep (filled bar) but contains an afternoon nap around 1500 (filled bar). (Figure redrawn from reference 4)

rect changes in the rest-activity pattern. This holds true for, among others, noradrenaline excretion, heart rate, and blood pressure. Incidentally, a rather peculiar observation in this context is that the subjective effort associated with a certain heart rate at a given work load is higher during the night shift than during the day shift (5, 6). In some sense this phenomenon could be interpreted as the subjects being "older" on the night shift. Maximum work capacity does not differ though. A somewhat related observation is the occurrence of ventricular ectopic activity in connection with night work (7).

With respect to adjustment over several consecutive shifts figure 1 suggests that a few hours' delay of the nightly fall of oral temperature has occurred by the fifth night shift. Still, the minimum occurs at the same time as during the first night shift. If at all present, the adjustment over the five night shifts must be considered marginal. The same pattern has been observed in many other studies (3). It is likely, however, that part of the apparent adjustment is a direct effect of the environment, unrelated to the biological clock but "masking" its output (8). Lying down will, eg, reduce body temperature, and activity will raise it, both masking the underlying circadian pattern. Actually, it might be argued that the endogenous circadian rhythm never adjusts in shift workers (8). The reason for the marginal or nonexisting adjustment is that the circadian system, as discussed later, is very persistent and needs a longer time for adjustment than night workers ever enjoy since they usually revert to a diurnal life when off duty.

Laboratory studies allow a much better control of environmental influences and make it easier to carry out around-the-clock measurements. In one of the classic studies Colquhoun et al (9) showed that oral temperature across 12 consecutive night shifts flattened but never completely adjusted. Similar results have been published by, eg, Knauth et al (10) and Weitzman & Kripke (11). On the whole, most of the adjustment tends to occur during the first 1 to 3 d and then proceeds at a slower pace. It should be observed that in these studies all environmental synchronizers (light, food, social life) were geared towards a nocturnal life. This is something the night worker has little chance to experience.

It should be emphasized that most of the studies of the physiological circadian rhythms of shift workers are mainly of theoretical interest since a clear relation between rhythm adjustment and health parameters has seldom been demonstrated, except for a few studies suggesting that individuals who have difficulties tolerating shift work may have desynchronized rhythms or small amplitudes of their entrained rhythms (12).

Sleep

Disturbed sleep is perhaps the most dramatic effect of shift work. A number of survey studies have indicated that shift workers have difficulties mainly at maintaining sleep after the night shift and initiating sleep before the morning shift (13). The afternoon shift has usually presented no sleep problems.

The standard psychophysiological approach to sleep usually involves recording an electroencephalogram, an electrooculogram, and an electromyogram on paper and scoring the output visually in sleep stages per 30-s intervals (14). The standard sleep stages include wakefulness (stage 0), superficial to deep sleep (stages 1 to 4), and rapid eye movement sleep (stage REM — dream sleep).

Sleep studies of shift workers have mostly been carried out in the laboratory (13). Recently, however, some studies of shift workers' sleep have been made in the workers' natural sleeping environment (15—17). The results are fairly conclusive in that sleep length on the night and morning shifts of rotating shift workers is reduced by 1 to 4 h. This reduction mainly affects stage 2 and REM. Stages 3 and 4 [which together make up slow wave sleep (SWS) or deep sleep] seem seldom to be affected. Furthermore, sleep latency is increased in connection with the morning shift and is shortened in connection with the night shift. Figure 2b demonstrates a hypnogram (sleep stages plotted against time) for the night shift. Note that the post-workday sleep is short but otherwise exhibits a normal pattern with two sleep cycles.

Rather little is known about the adjustment process across a series of night shifts. The available studies suggest that sleep length does not improve a great deal (18, 19). Permanent night workers seem to sleep longer, however, than rotating shift workers on the night shift (19—23).

The reason for the shortened daytime sleep has in several studies been attributed to higher noise levels at that time (24, 25). This may certainly be one of the causes of disturbed daytime sleep. On the other hand,

eep after the night shift is shortened also under optimal laboratory conditions (26, 27). Thus noise does not seem to be the major cause of disturbed day sleep. ', stronger influence is exerted by the circadian rhythm. ostponing sleep to different times of day under conitions of isolation from time-of-day cues (26) shows that the more sleep is postponed from the evening owards noon the next day, the more truncated it beomes, and when noon is reached the trend reverts. 'hus sleep during the morning hours is strongly interfered with, despite the sizeable sleep loss that, logically, should enhance the ability to maintain sleep. similar observations have been made for subjects who can select their own preferred sleep-wake pattern under conditions of long-term isolation from time cues 27, 28). In the latter studies it has been demonstrated hat the factor most closely associated with the premature termination of sleep is the rising phase of the temperature cycle.

Sleepiness

Many questionnaire studies have demonstrated that shift workers report more fatigue than do day workers (29). Usually, the fatigue is particularly widespread on the night shift, hardly appears at all on the afternoon shift, and is intermediate on the morning shift. In some studies sleepiness has been reported to be severe enough to have resulted in actual incidents of falling asleep during the night shift.

The upper part of figure 2 illustrates the 24-h pattern of rated sleepiness in a group of 24 three-shift workers at a paper mill (17). In connection with the afternoon shift sleepiness never reached high levels but was low during the day-evening and reached a medium level at bedtime. In connection with the night shift sleepiness increased during the night and reached a pronounced peak during the second half of the night shift. This pattern of early morning sleepiness has been demonstrated in many other studies (19, 30).

Physiological evidence of night shift sleepiness is more scarce. However, in the study illustrated in figure 2, electroencephalography and electrooculography were also carried out. These procedures were done with the aid of small subject-worn tape recorders (Medilog) for a duration of 24 h on three occasions involving morning, afternoon, and night shifts. The lower part of figure 2 shows the hypnogram of one worker during the night shift (17). During work two episodes of sleep can be seen. They are followed by a (short) day sleep of little more than 4 h, and later on by a 45-min nap during leisure time. Similar incidents of sleep occurred for approximately one-fourth of the subjects. Usually they occurred during the second half of the night shift and never in connection with any other shift. Importantly, sleep on the job was not condoned by the company, nor was there any official awareness that sleep would or could occur during workhours. Similar results but with ultrashort intrusions of sleep (as judged by electroencephalography, electrooculography, and electromyography) have been demonstrated for locomotive engineers during work (31) and for other groups (32, 33).

Incidentally, the general impression from most studies of sleepiness during activity is that, although a certain sleepiness is clearly perceived by the individual, there seems to be no "final warning" before dozing off (29). This, very likely, constitutes a major safety problem in many occupations.

As to adjustment over shifts, there is a clear impression that night shift sleepiness will gradually delay its appearance over successive shifts (34—38) in a manner very similar to the behavior of oral temperature discussed earlier. There is no indication, however, that more than a marginal adjustment takes place. This seems to be the case also for permanent night workers.

The cause of night shift sleepiness is apparently the combined influence of circadian and sleep-loss factors. The former was obvious in many of the field studies already cited and is practically always correlated with the body temperature rhythm. The influence of sleep loss is more difficult to isolate in field studies but may be readily observed in laboratory sleep deprivation studies (39). In addition Carskadon & Dement (40) have demonstrated that 3 h of sleep reduction results in increased subjective and physiological sleepiness (using the multiple sleep latency test). Furthermore this sleepiness measure showed accumulation across successive days of restriction.

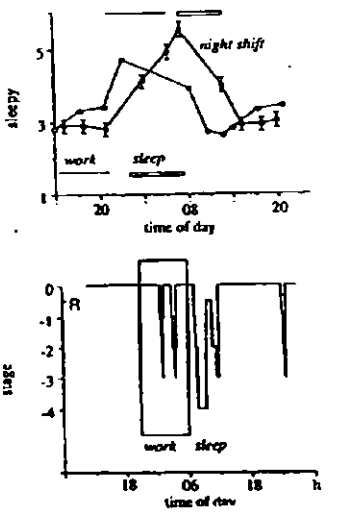

Figure 2. Upper figure: mean and standard errors of self-rated sleepiness during a 24-h period with a night shift and an afternoon shift; lower figure: hypnogram representing a 24-h period with a night shift for one of the subjects in the upper figure. [Figure redrawn from reference 17]

Performance

If sleepiness on the night shift is as widespread and as dramatic as has already been indicated, one would expect to see pronounced effects on performance, and consequently on output and safety. One of the classics in this area is the study by Bjerner et al (41), who showed that errors in meter readings over a period of 20 years in a gas works had a pronounced peak on the night shift. There was also a secondary peak during the afternoon (figure 3). Similarly, Browne (42) demonstrated that telephone operators connected calls at a considerably slower pace at night. Hildebrandt et al (43) found that locomotive engineers failed to operate their alerting safety device more often at night than during the day, with a secondary peak around 1500.

Most other studies of performance have used laboratory types of tests and demonstrated, eg, reduced reaction time or poorer mental arithmetic on the night shift (15). Flight simulation studies have, furthermore, shown that the ability to "fly" a simulator at night may decrease to a level corresponding to that after moderate alcohol consumption (0.05 % blood alcohol) (44). To these results may be added those from numerous laboratory studies which have demonstrated that performance on many tasks deteriorates during the night hours (45).

Adjustment across shifts has very seldom been investigated under practical conditions. Laboratory investigations, however, clearly indicate that adjustment does occur, although it may take up to two weeks. Frequently, the body temperature rhythm adjusts in parallel.

The impression of the night shift deterioration of performance is mainly based on fairly simple psychomotor types of tasks. There is, however, some speculation that high-level cognitive tasks, because of a high memory load, might show a differently phased rhythm (45). The latter would not, however, apply to the situation where sleepiness has come close to actual sleep, since any type of activity would then be interfered with.

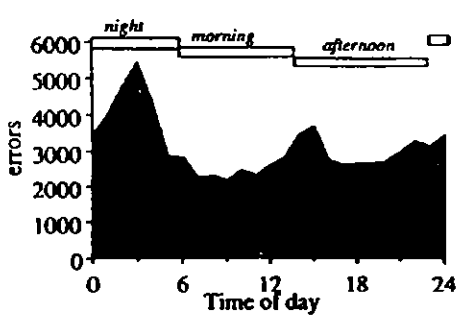

Figure 3. Number of meter reading errors accumulated over 19 years for three three-shift workers. Bars indicate the three shifts. [Figure redrawn from reference 41]

Another important point is that common sense and available data suggest that the output from a production process will not be affected by night work as long the major determinant of the production flow is machines rather than people. Thus, it seems rather unlikely that sleepiness induced by the nightshift would affect output in all occupations.

A more important area of impact may be safety. If sleepiness is severe enough, interaction with the environment will cease, and, if this interaction coincides with a critical need for action, an accident may ensue. Such potential performance lapses due to nightwork sleepiness were seen for several of the locomotive engineers discussed earlier (31). The transport area is, in fact, where most of the available accident data on night shift sleepiness has been obtained. Thus Harris (46) and Hamelin (47, 48) convincingly demonstrated that single vehicle accidents have, by far, the greatest probability of occurring at night (early morning). Most of these accidents are thought to be due to sleepiness. With respect to air transport Ribak et al (49) found military flight accidents to be increased in the early morning, and Price & Holley (50) argued that also many civil air transport accidents may be caused by fatigue due to work scheduling. Finally, a number of spectacular nuclear accidents (including those at Chernobyl and Harrisburg) have been partly attributed to fatigue-inducing work schedules (51).

As with sleepiness, the main reason for night shift deterioration in performance is circadian rhythmicity and sleep loss (45).

Modifying factors

Several factors influence the adjustment to shift work. One such factor is the direction of rotation of the shift schedule. Since the free-running (spontaneous) period of the human sleep-wake cycle averages 25 h and since it can be entrained by environmental time cues only within 1 to 2 h of the free-run period, phase delays are easier to accomplish than phase advances (52). For the rotating shift worker this situation implies that schedules that delay, ie, rotate clockwise (morning-afternoon-night) should be preferred to those that rotate counterclockwise. There has been, however, very few practical tests of this theory. Still, Czeisler et al (53) have demonstrated that a change from counterclockwise to clockwise rotation, together with a change from 7-d to 21-d rotation, improved production and well being for three-shift workers. Orth-Gomér (54) found that a change in the same direction among rapidly (1 d) rotating police officers reduced blood pressure and improved well being.

The length of a work shift is another parameter that one would expect to influence at least sleepiness and performance. In the laboratory it is usually the case that performance falls with time if learning effects are eliminated (55). Still, in one study of policemen, Peacock et al (56) found no effects of a change from 8 h

(nine shifts across 8 d) to 12-h shifts (two nights-one free-two days-three free) on overall alertness. However, the distribution of free days changed at the same time. Two other studies of nurses (57) and industrial shift workers (58) have produced similar results. Recently Rosa & Colligan (59) used 2-h ratings in a field experiment and demonstrated that the 12-h night shift, indeed, produced higher ratings of fatigue than 8-h night shifts. In addition, in a study of accidents of truck drivers, Hamelin (48) demonstrated a U-shaped relation between hours driven and accidents, ie, after an initial "warm up" period accident risk was low, with an increase towards 11 h of driving.

As may be expected, also the watch-keeping systems (4 on, 8 off) on ships are associated with low alertness and poor performance during the night (60). Apparently, rotating systems cause greater disturbance to the individual than do stable systems.

Another type of unusual workhours is that of air crews on transmeridian routes. Then, not only are the workhours displaced to "biological" night time, but also the time reference is changed through time-zone shifts. As with other types of shift work, survey studies have demonstrated disturbed sleep and wakefulness (61). The disturbed wakefulness has been evidenced also in flight simulator studies.

In some occupations the personnel may sleep at the worksite until needed. This is the case for, among others, physicians. Since the greater part of such nights are often are spent working, sleepiness-fatigue is often pronounced, and performance tends to be reduced, although the practical implications (for the patients) are still unknown (62, 63). Other forms of "on-call" systems may be found among, for example, engineer officers in the merchant marine (64).

Among individual differences age has been related to sleep disturbances (65, 66). In electroencephalographic studies trends have been found towards more superficial sleep in middle-aged shift workers (16). The studies by Foret et al (65) and Åkerstedt & Torsvall (66) also indicated that experience was negatively related to general well being over a number of years. Koller et al (67) found that reduced health appeared earlier among shift workers than among day workers. Dahlgren (68) found no effects of three years of night work on the rhythm of rated activation across night shifts. Neither did Wynn et al (69), over a temporary 10-week period of weekly alternation between night and day work in a group of nurses. Dumont et al (70) found that the amount of sleep-wake and related disturbances in present day workers was positively related to their previous experience of night work. Guilleminault et al (71) found an overrepresentation of former shift workers with different clinical sleep/wake disturbances appearing at a sleep clinic. Although not directly related to sleepiness, it is still of interest to observe that Angersbach et al (72) have demonstrated an earlier occurrence of gastrointestinal disease among three-shift workers than among day workers. Similarly, Knutsson et al (73) demonstrated that the incidence of myocardial infarction (and cardiovascular disease in general) is related to the amount of exposure to shift work.

Finally, the trait of morningness (having a tendency towards early sleep-wake preferences) has frequently been associated with poor adjustment to shift work (74, 75). This has also been the case for the trait of sleep rigidity (76).

Concluding comments

Taken together, the reviewed literature clearly indicates that shift work that involves night shifts strongly influences the psychology and psychophysiology of the individual.

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Séance d'information

Travail de nuit, travail posté [1)]

Le *travail posté* est un mode d'organisation du travail qui répond à une production continue sur 24 heures, ou qui couvre une portion de la journée assez grande pour nécessiter la succession d'au moins deux équipes.

Le *travail de nuit* (de 22 heures à 5 heures du matin) n'est autorisé que pour les hommes, sauf dérogations, dont certaines sont importantes (les infirmières, par exemple).

Le système d'horaires comprend en général deux équipes successives (2 × 8) ou trois (3 × 8); les embauches se font vers 6 heures, 14 heures et 22 heures. Mais, sur cette trame, nombreuses sont les combinaisons possibles, car l'on peut jouer sur plusieurs facteurs :

– l'horaire du poste : il peut être fixe (« toujours de nuit »), ou au contraire alternant (le matin, puis l'après-midi, puis la nuit, etc.), cas le plus fréquent en France;

– le nombre d'équipes : il est d'au moins quatre pour assurer un « feu continu ». Mais la tendance actuelle est d'aller à cinq équipes ou plus, ce qui diminue la durée moyenne du travail, et rend donc moins fréquents, pour une même personne, les postes du même type;

– la vitesse de rotation : les travailleurs peuvent rester au même poste deux ou trois jours consécutifs, ou une semaine, ou plus. La tendance actuelle est aux rotations courtes (deux, trois ou quatre postes de même horaire d'affilée).

En 1982, le travail posté concernait 17,3 % des ouvriers (25,6 % dans les seules industries de transformation), pourcentage qui diminue régulièrement depuis le milieu des années soixante-dix (respectivement 21,9 % et 31,3 % en 1974). À noter toutefois que cette proportion est très variable d'un secteur à l'autre : on comptait ainsi, en 1982, 53,7 % d'ouvriers travaillant en équipe dans l'industrie du caoutchouc, 44,2 %dans le pétrole, et seulement 6,6 % dans la fabrication de produits pharmaceutiques, ou 5,2 % dans l'industrie du cuir.

Le travail posté contraint le travailleur à deux « déviances », à la fois par rapport aux horaires spontanés de repos et d'activité (problème essentiellement biologique) et par rapport aux horaires de vie de l'ensemble de la société (problème psychologique, sociologique, mais aussi biologique).

Le travail posté, c'est évident, crée des problèmes de relations dans la vie familiale et sociale. Cela affecte et le travailleur et son entourage, en particulier le plus proche. Tout individu a en quelque sorte dans la vie plusieurs rôles (celui de travailleur, mais aussi de mari, de père, de citoyen, etc.); or, s'il a des horaires de vie « anormaux », certains de ces rôles se trouvent difficilement remplis. Cela peut susciter des insatisfactions, engendrer une exclusion des formes « normales » de vie sociale, et conduire à la longue, sur le plan social, à un repli sur lui-même d'un individu ou d'un groupe d'individus (avec tout ce que cela comporte d'injustice, d'inefficacité) et, sur le plan personnel, à une régression psychosomatique se manifestant au niveau de la sphère digestive (douleurs digestives, prise de poids) et de l'« équilibre nerveux » (état dépressif ou, au contraire, état d'hyperexcitation, besoin de médicaments, excitants ou hypnotiques, pour « tenir »).

Tous ces troubles peuvent aller jusqu'à la maladie déclarée (ulcère d'estomac, dépression nerveuse). Mais les statistiques médicales mettent mal en évidence la fréquence de ces affections, entre autres parce que, avec le temps, il s'opère une sorte de « sélection-élimination » parmi les travailleurs postés (ceux qui le supportent mal chercheront ou seront amenés à changer d'emploi).

1) Source: Casson, B., Les risques du travail, Ed. La découverte, Paris, p. 94-99, (1985)

Travailler à des horaires anormaux pose aussi un problème biologique grave dont les termes sont désormais bien connus (chronobiologie). Les horaires de vie anormaux entrent en conflit avec les rythmes biologiques innés de l'organisme humain et obligent perpétuellement ceux-ci à tenter de s'adapter aux nouveaux horaires de veille et de sommeil [298].

La base biologique du problème

Les rythmes circadiens : pratiquement toutes les fonctions physiologiques humaines ont un niveau d'activité qui suit un rythme circadien (du latin *circa* : environ, et *dies* : jour). Cela se traduit en général par un maximum et un minimum d'activité qui se répètent toutes les 24 heures, à la même heure (par exemple, la température corporelle passe par un maximum à la fin de l'après-midi, et par un minimum en fin de nuit ; le taux de cortisol dans le sang, très bas dans la journée, présente un pic important à la fin de la nuit et au début de la matinée, après le réveil). Ces rythmes circadiens sont endogènes, c'est-à-dire qu'ils ne sont pas directement provoqués par l'alternance nuit/jour, mais qu'ils sont inscrits dans l'héritage génétique de chacun, d'où leur très grande résistance à toute forme de manipulation.

Les synchroniseurs sociaux : leur importance est capitale. Quand on place des êtres humains en isolement total, sans qu'ils puissent deviner l'heure ni l'état de la société environnante, leurs rythmes circadiens spontanés s'établissent en moyenne à 25 heures. Dans la vie réelle, nos rythmes sont entraînés exactement sur 24 heures par ce qu'on appelle des « synchroniseurs » sociaux ; ces synchroniseurs sont avant tout les horaires d'activité et la façon dont la société s'organise autour d'eux (horloges, répartition quotidienne des diverses activités : repas, vie en famille, transports, niveaux de bruit et de lumière correspondants, etc.). Tous ces synchroniseurs sont, pour la plupart des gens, cohérents entre eux (on dort aux heures où il y a le moins de bruit, on prend ses repas, ou l'on devrait les prendre, à des moments où il y a baisse de l'activation interne).

Or, le travail à horaires changeants a deux conséquences. L'une est immédiate : un changement de poste perturbe les rythmes circadiens, car il impose à l'organisme une « journée » de trente heures (premier poste de nuit) ou de seize heures (jour de repos après un poste de nuit). Mais les rythmes circadiens sont trop rigides pour suivre d'emblée un changement aussi brusque des synchroniseurs. Un grand désordre s'établit dans l'évolution temporelle des fonctions biologiques, et dans leur équilibre.

La seconde conséquence est différée ; quelques jours après la prise du poste de nuit, une contradiction insoluble demeure entre les divers synchroniseurs sociaux auxquels doit se conformer l'organisme du travailleur. La société, d'un côté, lui signifie les meilleures heures pour se reposer et pour être actif (ce sont les heures dites « normales ») ; le poste de nuit, par ailleurs, l'oblige à travailler quand les autres se reposent et à se reposer quand les autres travaillent. Même si un ajustement partiel s'opère après quelques jours, il sera forcément brisé par la survenue d'une période de repos, car le travailleur reprendra alors des horaires de vie normaux. De ce fait, il n'y aura jamais adaptation complète.

L'impression de fatigue et de malaise est en partie due au manque de sommeil, conséquence directe des heures biologiquement défavorables auxquelles il est pris. Mais il est très vraisemblable que cette fatigue soit surtout due à ce « désordre » des rythmes circadiens que nous venons de décrire. Et, bien entendu, le manque de sommeil fait qu'il est encore plus difficile de « récupérer » le décalage horaire.

ÉVOLUTION DU POURCENTAGE D'OUVRIERS
(NOUVELLE
Unité :

ACTIVITÉ ÉCONOMIQUE	1974
Pétrole	47,4
Extraction de minéraux divers	28,3
Production et première transformation des métaux	71,0
Industrie des produits minéraux non métalliques	38,4
dont : Industrie du verre	58,0
Industrie chimique	34,6
dont : Fabrication de produits pharmaceutiques	4,2
Fabrication d'ouvrages en métaux	18,5
Construction de machines et de matériel mécanique	18,7
Construction électrique et électronique	21,6
Construction d'automobiles et de pièces détachées	58,3
Construction d'autre matériel de transport	14,9
Fabrication d'instruments de précision, d'optique et similaires	13,2
Industries des produits alimentaires, des boissons et du tabac	21,8
Industrie textile	50,2
Industrie du cuir	8,3
Industrie des chaussures et de l'habillement	4,0
dont : Industrie des chaussures	2,8
Industrie de l'habillement (sauf fourrure et peaux)	1,7
Industrie du bois et du meuble en bois	10,0
Industrie du papier et fabrication d'articles en papier	52,6
Imprimerie et édition	33,8
Industrie du caoutchouc	52,5
Transformation des matières plastiques	46,6
Autres industries manufacturières	9,3
Bâtiment et Génie civil	1,4
Transports terrestres et auxiliaires	4,9
Autres transports et activités connexes	22,0
Hygiène	3,8
INDUSTRIES DE TRANSFORMATION (non compris le bâtiment)	31,3
dont : INDUSTRIES TRANSFORMATRICES DES MÉTAUX	27,0
INDUSTRIES DE TRANSFORMATION (y compris le bâtiment)	24,3
TRANSPORTS (non compris SNCF et RATP)	9,3
TOTAL (non compris combustibles minéraux solides, gaz et électricité, SNCF et RATP)	21,9

Source : ministère des Affaires sociales « Enquête sur l'activité

TRAVAILLANT EN ÉQUIPES DE 1974 A 1982
NOMENCLATURE)
pourcentage

1977	1981	1982
52,0	37,0	44,2
24,3	19,3	20,5
70,1	69,3	66,1
39,1	35,7	33,3
53,8	55,9	52,7
32,8	34,2	32,4
2,8	6,1	6,6
17,1	17,4	16,5
15,4	16,0	14,6
20,8	19,2	18,0
57,9	57,1	52,6
13,4	15,1	16,0
8,5	6,0	5,7
24,1	23,2	21,7
49,1	40,3	38,4
8,6	4,2	5,2
2,0	0,9	1,0
3,0	2,8	2,6
1,2	0,3	0,5
8,0	5,2	3,3
53,1	49,0	47,4
29,3	27,3	27,6
65,1	63,5	53,7
47,4	42,5	39,5
8,9	7,0	5,6
1,4	1,0	0,6
5,4	4,0	3,6
23,6	10,8	16,7
2,3	2,6	1,8
29,9	27,5	25,6
25,4	26,2	24,5
23,3	22,3	20,7
8,7	6,1	7,8
20,4	18,5	17,3

et les conditions d'emploi de la main-d'œuvre » (ACEMO).

Les effets sur la santé

À l'encontre de tout ce que les travailleurs postés ressentent et disent, les statistiques médicales ne prouvent pas clairement que le travail posté par lui-même affecte leur état de santé. D'abord, parce qu'en matière d'effets sur la santé, il est difficile de faire la part de responsabilité du travail posté lui-même, de la nature du travail effectué et du vieillissement. Ensuite, parce qu'il ne s'est pas dégagé de pathologie spécifique au travail posté.

Mais la fatigue, si souvent ressentie, doit être regardée comme un symptôme qui peut en annoncer d'autres (les mêmes que dans toute situation du travail où il existe une forte charge mentale, une attention soutenue longtemps, une forte responsabilité, une situation stressante, etc.)

Quels symptômes? Dans la sphère digestive, cela peut aller des troubles de l'appétit, de la digestion, de l'assimilation (la prise de poids excessive chez les travailleurs postés est significative), à des troubles organiques allant de la simple gêne à l'ulcère déclaré [213]. Au niveau du système nerveux, il s'agit avant tout de difficultés à dormir de façon satisfaisante; or, ces troubles du sommeil interfèrent avec la fatigue générale du travailleur et l'accentuent. Mais il y a aussi des aggravations anormales de tendances individuelles allant vers l'hyperexcitation ou au contraire la dépression et des perturbations de l'humeur qui, en un cercle vicieux, rendent insupportable la situation.

Les difficultés vécues par les travailleurs postés s'accentuent en intensité et en fréquence au fur et à mesure qu'ils vieillissent. Elles deviennent particulièrement sensibles à partir de quarante/quarante-cinq ans et peuvent amener à l'impossibilité de rester en poste. Elles ne sont pas seulement de nature économique ou sociofamiliale. L'évolution normale avec l'âge de nombreuses fonc-

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tions physiologiques (dont le sommeil, qui se modifie beaucoup) joue sûrement un rôle dans les problèmes des travailleurs postés vieillissants.

Par ailleurs il se confirme de plus en plus que, indépendamment de toute expérience du travail posté, le vieillissement (au-dessus de quarante ans environ) s'accompagne d'altérations notables de certains caractères des rythmes circadiens (réduction de leur amplitude, raccourcissement de la période). Plus étonnant encore est le fait que ces modifications ressemblent beaucoup à celles qui se manifestent dans le cas de dépressions spontanées. Il se pourrait ainsi que le complexe travail posté-vieillissement-dépression ait comme point commun avec l'état dépressif des perturbations des rythmes biologiques circadiens, mais on en est encore, dans ce domaine, au stade des hypothèses.

Que faire?

Tenter d'appliquer certains principes, quelques-uns relevant du bon sens, d'autres étant le fruit d'études spécifiques. Au niveau du processus de production, rechercher les possibilités techniques qui diminuent le besoin de présence la nuit (par exemple, ralentissement de la production, marche à vide des installations). Au niveau de l'organisation, c'est la diminution du temps de travail moyen et/ou l'augmentation du nombre d'équipes, l'amélioration des « tournantes » : les postes doivent se succéder dans un ordre logique (matin, après-midi, nuit, repos) et les changements doivent être rapides (deux ou trois postes semblables d'affilée, et suppression des rotations hebdomadaires ou semi-mensuelles, comme c'était l'habitude autrefois); enfin, il faut retarder les embauches trop matinales (pas avant 6 heures du matin), le poste du matin étant toujours perçu comme le plus pénible.

Mais le problème du travail posté ne doit pas être séparé de celui des conditions et du contenu du travail. Du fait de leur nature, certains travaux sont particulièrement difficiles à faire la nuit ou pendant une longue durée... Surveiller la marche d'une raffinerie et surveiller une coulée de fonte sont deux travaux qui ne peuvent être simplement comparés entre eux, même s'ils ont lieu tous deux la nuit.

Plus généralement, il s'agira d'essayer d'introduire le maximum d'imagination dans ce domaine où toute tentative de changement se heurte systématiquement à des oppositions très variées, y compris de la part des intéressés eux-mêmes.

Jean Foret

Les nouvelles technologies

Écrans de visualisation [106], automatismes d'atelier [103], automatismes de processus [104] et bien d'autres : l'expression « nouvelles technologies », qui se généralise pour désigner la transformation des méthodes de production, est trompeuse quand on s'intéresse aux conditions de travail et à leurs conséquences sur la santé.

Les situations, en effet, sont très diverses selon les branches, et les pages qui suivent montrent qu'un même matériel peut avoir des conséquences très différentes en fonction des conditions dans lesquelles il est implanté. Il n'y a pas de problème de conditions de travail lié aux « nouvelles technologies », il y a des situations concrètes qui doivent être analysées en détail. De plus, les conditions dans lesquelles vont travailler les opérateurs et les opératrices confrontés à de nouvelles machi-

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EXPOSURE TO BRIGHT LIGHT AND DARKNESS TO TREAT PHYSIOLOGIC MALADAPTATION TO NIGHT WORK

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Abstract Working at night results in a misalignment between the sleep–wake cycle and the output of the hypothalamic pacemaker that regulates the circadian rhythms of certain physiologic and behavioral variables. We evaluated whether such physiologic maladaptation to nighttime work could be prevented effectively by a treatment regimen of exposure to bright light during the night and darkness during the day. We assessed the functioning of the circadian pacemaker in five control and five treatment studies in order to assess the extent of adaptation in eight normal young men to a week of night work.

In the control studies, on the sixth consecutive night of sedentary work in ordinary light (approximately 150 lux), the mean (±SEM) nadir of the endogenous temperature cycle continued to occur during the night (at 03:31±0:56 hours), indicating a lack of circadian adaptation to the nighttime work schedule. In contrast, the subjects in the treatment studies were exposed to bright light (7000 to 12,000 lux) at night and to nearly complete darkness during the day, and the temperature nadir shifted after four days of treatment to a significantly later, midafternoon hour (14:53±0:32; $P<0.0001$), indicating a successful circadian adaptation to daytime sleep and nighttime work. There were concomitant shifts in the 24-hour patterns of plasma cortisol concentration, urinary excretion rate, subjective assessment of alertness, and cognitive performance in the treatment studies. These shifts resulted in a significant improvement in both alertness and cognitive performance in the treatment group during the night-shift hours.

We conclude that maladaptation of the human circadian system to night work, with its associated decline in alertness, performance, and quality of daytime sleep, can be treated effectively with scheduled exposure to bright light at night and darkness during the day. (N Engl J Med 1990; 322:1253-9.)

APPROXIMATELY 7.3 million Americans work at night, either on permanent shifts or on schedules requiring a rotation of day, evening, and night work.[1] These workers forgo nocturnal sleep and then attempt to sleep during daylight hours. Yet, as Benedict first noted at the turn of the century, a complete physiologic adaptation of endogenous circadian rhythms to such inversion of the daily routine does not occur[2-4] even after years of permanent nighttime work.[5,6] Physiologic maladaptation to an inverted schedule results in diminished alertness and performance during nighttime work, with attendant increases in the number of fatigue-related accidents during nighttime hours.[6-9] Then, despite the nocturnal deprivation of sleep, these workers typically experience daytime insomnia.[10-14] Long-term exposure to variable work schedules that include work at night is also associated with an increased risk of cardiovascular disease, gastrointestinal illness, reproductive dysfunction in women, and sleep disorder.[15-18] Improvements in performance and well-being have been achieved as a result of modifications in work-schedule design,[14] but true physiologic adaptation to night work under field conditions has not previously been demonstrated.

During the past 20 years, considerable progress has been made in understanding the underlying neurophysiologic processes that regulate adaptation to the periodic aspects of the external environment. Studies involving ablation, transplantation, and other procedures have demonstrated that the suprachiasmatic nuclei of the hypothalamus serve as the principal pacemaker of the circadian timing system in mammals.[19-21] A specialized retinohypothalamic tract links the retina to these nuclei, forming a nonvisual photoreceptive system that mediates the synchronization, or entrainment, of the circadian pacemaker with the light-dark cycle.[22] Even though corresponding structures subserving rhythmicity and photic entrain-

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ment in the brain have been identified,[23-25] it was thought that the human circadian pacemaker was uniquely insensitive to light and that it instead relied on "social contacts" to achieve synchrony with the 24-hour day.[26] However, we have demonstrated that the light–dark cycle has a direct synchronizing effect on the human circadian pacemaker.[27,28] Furthermore, we have recently discovered that properly timed exposure to bright light and darkness can reset the pacemaker by as much as 12 hours within two to three days.[29] We found that the pacemaker's resetting response to bright light depends on the timing of the average midpoint of the total daily exposure to light, after weighting for brightness.[29] Therefore, the bright light to which nighttime workers are often exposed during the day (e.g., during the return home from work) may prevent them from adapting to night work. On the basis of these results, we designed a pattern of exposure to bright light and darkness in the work and home environments by which the phase of the pacemaker can be reset rapidly and effectively in persons who work at night, even if they are exposed to natural light on the way home from work each morning.

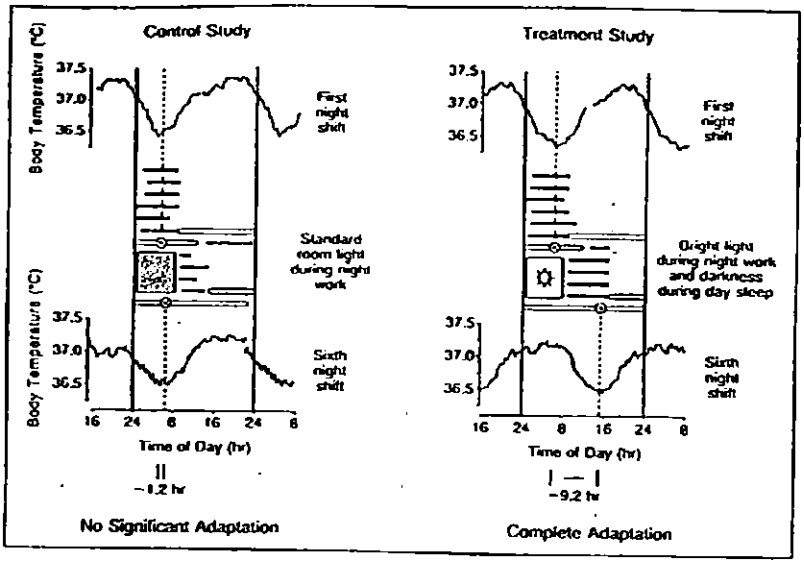

Figure 1. Overall Study Protocol (Middle Panels) and Changes in Temperature Recorded during the First and Sixth Night Shifts (Upper and Lower Panels) in One Man during a Control Study and a Treatment Study.

Solid bars indicate daily sleep episodes, open bars constant routines, and circled x's the initial and final endogenous circadian temperature nadirs as derived from the temperature data (vertical dashed lines) measured during the constant routine. During the second through fifth nights of work (midnight to 08:00 hours), the men were exposed either to ordinary indoor light (approximately 150 lux; stippled box) in the control studies or to bright light (7000 to 12,000 lux; solar symbol in the open box) in the treatment studies. To facilitate visual comparisons, segments of the temperature data have been double-plotted.

Methods

Subjects

Ten two-week studies were carried out in eight healthy men, 22 to 29 years old. The subjects had no medical, psychiatric, or sleep disorders as determined from their medical histories, physical examinations, chest radiographs, electrocardiograms, biochemical screening tests, and psychological screening questionnaires (the Minnesota Multiphasic Personality Inventory). None had worked regularly at night on a permanent or rotating shift within the preceding year, and none had traveled to another time zone during the previous six weeks. They were not taking any medications and were instructed to abstain from the use of alcohol, recreational drugs, and products containing caffeine for the duration of the study. Urinary toxicologic screening was used to verify that they were drug-free at the time of the study.

The first two subjects participated in the control study and then in the treatment study, after an interval of three to five weeks during which they lived at home and maintained a schedule of regular daytime activity and nocturnal sleep. To facilitate recruitment the remaining six men were asked to participate in only one study; each was randomly assigned to either the control study or the treatment study after the successful completion of an initial evaluation of his circadian phase.

All the studies were carried out in the summer, to avoid seasonal variation in exposure to outdoor light during the week of night work. The experimental procedures and the procedure for obtaining informed consent were approved by the Committee for the Protection of Human Subjects from Research Risks of Brigham and Women's Hospital. Written informed consent was obtained from each man before participation in the study.

Overall Study Design

Five control and five treatment studies were performed; each consisted of one week of ambulatory recording of base-line temperature, physical activity, and heart rate, followed by a week of night-shift work. The men lived at home throughout each study, reporting for "work" in the laboratory each night of the second week. To evaluate the extent of physiologic adaptation to nighttime work, the output of the circadian pacemaker was evaluated[30] during the first and sixth consecutive night shifts. On those nights, and during each of the immediately preceding days, the activity of the subjects was restricted to the enforced semirecumbent wakefulness of a laboratory constant routine as described below. Both the control and the treatment protocols are shown in Figure 1.

During the week of base-line recording, the men maintained regular bedtimes and waking times (within a range of ±1 hour). Their subjective sleep–wake logs were verified for accuracy by comparison with the results of continuous ambulatory monitoring of wrist activity, heart rate, and body temperature (PMS-8 Recorder, Vitalog, Redwood City, Calif.) throughout both weeks of the study. In the case of two men (one control and one treatment subject) whose behavior during the study did not conform to the protocol, the results were excluded before the outcome of their experimental trials was determined.

On the second through the fifth nights of work, the men reported to the laboratory at 23:45 hours and spent the eight hours between midnight and 08:00 seated at a desk. On those four nights, the men in the treatment studies were exposed to bright light (7000 to 12,000 lux, an intensity comparable to that of natural sunlight just after dawn) between 00:15 and 07:45 hours, whereas those in the control studies were exposed to ordinary room light (approximately 150 lux). All subjects completed cognitive-performance tasks hourly

during this time and subjective assessments of alertness and mood every 20 minutes. They were otherwise free to do their own work and were given dinner and a snack during each night shift. In all but two trials, the subjects (one in the control study and one in the treatment study) consumed their meals at times of their own choosing. A technician monitored the subjects throughout each night shift to ensure that they remained awake.

After each night shift, the men left the laboratory and traveled home. They were thus exposed to outdoor light each morning during this travel time. The men in the treatment studies were instructed to remain in the dark from 09:00 to 17:00 hours each day, in bedrooms in which the windows were covered with opaque material to exclude sunlight. In contrast, the men in the control studies were not scheduled to remain in the dark at any particular time each day, although most did use their existing window shades or curtains while they slept, at times of their own choosing. No other restrictions were placed on the activities of the subjects in either group during their "nonwork" hours. All were provided with a breakfast and a lunch to take home and eat at will.

Assessment of Endogenous Circadian Phase

Previous attempts to evaluate the extent of circadian adaptation to night work have been complicated by the masking effects of activity on the physiologic variables monitored. In this study, the constant-routine method was used to reveal the endogenous component of the body-temperature rhythm, an established marker of the endogenous circadian pacemaker.[31-33] During the constant-routine procedure, we determined the endogenous circadian phase (the particular point at which a regularly recurring event occurs in an intrinsic oscillatory process) at which the nadir of the daily body-temperature cycle occurred. Our method involved an extension and refinement of a technique first proposed by Mills et al.,[34] according to which the subjects are studied under constant environmental and behavioral conditions in order to eliminate (or distribute across the circadian cycle) the physiologic responses evoked by environmental or behavioral stimuli, such as sleeping, eating, changing posture, and changing light levels. During all the constant-routine studies, the men were restricted to absolute, semirecumbent bedrest in a room with constant indoor lighting (approximately 150 lux) and required to remain awake. Wakefulness was monitored by a research technician and verified by continuous polysomnographic recording.[30] During the constant routine, the men's daily nutritional and electrolyte needs were met by identical hourly snacks, with approximately 150 mmol of sodium and approximately 100 mmol of potassium evenly distributed over the 24-hour period. The caloric requirements for weight maintenance were calculated with use of the Wilmore nomogram[35] to determine the basal metabolic rate; they were then adjusted upward by a 10 percent activity factor. Since the constant-routine procedure required that the subjects lose at least one night of sleep, it was carried out concurrently with the first and sixth night shifts. Each constant routine was begun just after the subject awakened on the day of the shift, and it continued for as long as was necessary (at least 21 hours) to determine accurately the endogenous circadian temperature nadir. In two subjects (one in the control study and one in the treatment study), an additional 24 hours was required for this determination during the final constant routine.

Physiologic and Behavioral Measures

Throughout each constant routine, the core body temperature of the subject was recorded at one-minute intervals from a disposable thermistor (Yellow Springs Instrument Company, Yellow Springs, Ohio) inserted 10 cm into the rectum. In addition, blood samples were collected in syringes and transferred to heparin-coated tubes every 15 to 25 minutes on a randomized sampling schedule from an indwelling intravenous catheter with side holes (Deseret Medical, Sandy, Utah) that was placed in a forearm vein[32]; the samples were chilled immediately and centrifuged within two hours, and the plasma was frozen at −20°C. The plasma cortisol concentrations were measured within five months of sample collection by an ^{125}I-coated tube radioimmunoassay procedure (Diagnostic Products, Los Angeles) in the Core Laboratory of Brigham and Women's Hospital General Clinical Research Center (intraassay coefficient of variation [n = 10], 6.2 percent at a mean of 50 nmol per liter and 3.9 percent at a mean of 491 nmol per liter; interassay coefficient of variation [n = 150], 13.2 percent at a mean of 47 nmol per liter and 7.3 percent at a mean of 502 nmol per liter). The urinary volume was measured at three-hour intervals.

Subjective alertness was assessed three times per hour with use of a linear, nonnumeric, 100-mm bipolar visual-analogue scale.[32] Cognitive performance was measured hourly by a test involving calculation that included 125 randomly generated pairs of two-digit numbers.[36] The men were given four minutes to sum as many pairs as possible, and their tests were scored according to the number of calculations completed in the time allowed.

Exposure to Bright Light

The subjects participating in the treatment studies were seated at a desk and exposed to bright light (7000 to 12,000 lux) from one of two sources: either a wall-mounted bank of 80 2.4-m (8-ft), 96-watt "ion-gard" F96TH12 Vitalite wide-spectrum fluorescent lamps (Duro-test, North Bergen, N.J.), separated from the subject by floor-to-ceiling panels made of two sheets of clear glass 3.175 mm thick, separated by a layer of polyvinylbutyl plastic (laminated safety glass); or a portable bank of 16 1.2-m (4-ft) "cool-white" 40-watt lamps (North American Philips Lighting, Bloomfield, N.J.), separated from the subject by a wire-mesh screen. Each subject's daily exposure to ultraviolet light during the trials was well within the guidelines for safety of such exposure established by the American Conference of Governmental Industrial Hygienists and the U.S. Army and recommended by the National Institute for Occupational Safety and Health.[37-39] The men participating in the last four bright-light trials wore clear, ultraviolet-excluding polycarbonate Ultra-Spec 2000 safety glasses with 4C coating (Uvex Winter Optical, Smithfield, R.I.) throughout the exposure to bright light. Illuminance was measured at five-minute intervals with research photometers (International Light, Newburyport, Mass.), each equipped with a detector with a photopic spectral bias and a cosine angular response; the detectors were placed at the subjects' foreheads and directed toward the line of gaze. Fifteen minutes of transitional illumination preceded and followed each exposure to bright light.

Statistical Analysis

The endogenous circadian phase was assessed by nonlinear least-squares analysis to fit a two-harmonic regression model to the data on core body temperature collected during the constant routines.[40] Temperature data gathered during the first five hours of the constant routine, when the thermoregulatory system was not yet in a steady state, were excluded from the analysis. The endogenous circadian temperature nadir was defined as the average of the fitted minimums from the single-harmonic and composite wave forms of the model and was used as a reference marker for the phase of the endogenous circadian temperature cycle. In the two studies in which the final constant routine was extended an additional 24 hours, the temperature data used in the analyses were those from the second half of the constant routine, since the estimates of phase derived from the first and second half of the temperature data during similarly extended constant routines were highly correlated (Pearson's correlation coefficient = 0.998; $P<0.001$) (unpublished data).

Paired comparisons between the values obtained for the phase and amplitude of endogenous circadian temperature initially (during the first night shift) and at the end of the study (during the sixth night shift) were made for both the control and the treatment studies by the paired Student t-test (parametric analysis),[41] with confirmation of significant results by the Wilcoxon signed-rank test (nonparametric analysis). Comparisons between the control and treatment studies with respect to the initial endogenous circadian phase, the final endogenous circadian phase, the shift in phase between the first and sixth nights, the values for alertness and performance obtained during these nights, and the amplitude of vari-

ation in the endogenous circadian temperature cycle were made with use of Student's unpaired t-test (parametric analysis), with confirmation of significant results by the Wilcoxon rank-sum test. All statistical analyses were two-tailed.

Finally, in both groups the body temperatures, subjective-alertness and cognitive-performance scores, urinary excretion rates, and plasma cortisol concentrations were averaged according to the time of day during the initial constant routines and compared with the averages for the same times of day during the final constant routines. For the less frequently sampled among these variables (subjective alertness, cognitive performance, and urinary excretion rate), the mean value of the data for each man was calculated every two hours, and an average for all subjects was obtained; for the remaining variables (body temperature and plasma cortisol concentration), the mean (±SEM) value for all subjects was calculated at regular intervals (every 100 minutes).

Results

Sleep–Wake Schedules

During the week of base-line recording, each man maintained a regular sleep–wake schedule consistent with that required for regular daytime work. There were no significant differences between the control and the treatment studies with respect to either the average (±SEM) bedtime (00:22±0:18 vs. 00:04±0:21 hours) or the average waking time (07:48±0:19 vs. 07:33±0:29 hours) during the week of base-line recording.

During the scheduled night shifts the men in both studies slept during daytime hours, as shown in Figure 1. However, the men in the treatment studies slept an average of two hours longer per day than the men in the control studies after each of the second through the fifth nights of work (7.7±0.1 vs. 5.7±0.5 hours per day; $P = 0.0103$), as reported in their sleep–wake logs and independently verified on the basis of the monitoring data.

Assessments of Endogenous Circadian Phase

The mean initial nadir of the endogenous circadian temperature cycle occurred at 04:59 hours, 2.7 hours before the men's habitual waking time in the week before each study. There was no significant difference between control and treatment studies with respect to the timing of this nadir ($P = 0.1564$) (Fig. 2). In the control studies, the mean times of the initial and final nadirs of the endogenous circadian temperature cycle (04:38±0:11 vs. 03:31±0:56 hours) were similar. In contrast, in the treatment studies, the mean final temperature nadir occurred 9.6 hours later than the mean initial temperature nadir (14:53±0:32 vs. 05:19±0:23 hours; $P<0.0001$) (Fig. 2). The mean shift in the endogenous circadian temperature nadir between the first and sixth nights in the treatment group (−9.6±0.7 hours) was significantly greater than that in the control group (1.1±0.9 hours) ($P<0.0001$). Finally, the mean endogenous circadian temperature nadir on the sixth night occurred significantly later in the treatment studies than in the control studies (14:53± 0:32 vs. 03:31±0:56 hours; $P<0.0001$).

These differences between the control and treatment groups were also statistically significant even when the data for one control trial and one treatment trial for each of the first two men (who participated in both the treatment and control studies) were excluded from the analysis. Finally, there was no significant difference between the mean amplitudes of the initial and final temperature wave forms in either the control or the treatment studies. However, for one man in the treatment study the amplitude of the cycles for temperature and plasma cortisol concentration was attenuated during the first 24 hours of the final constant routine; when the constant-routine study was extended for an additional 24 hours, both the amplitude and phase shift of these variables were comparable with those of the other subjects in the treatment studies.

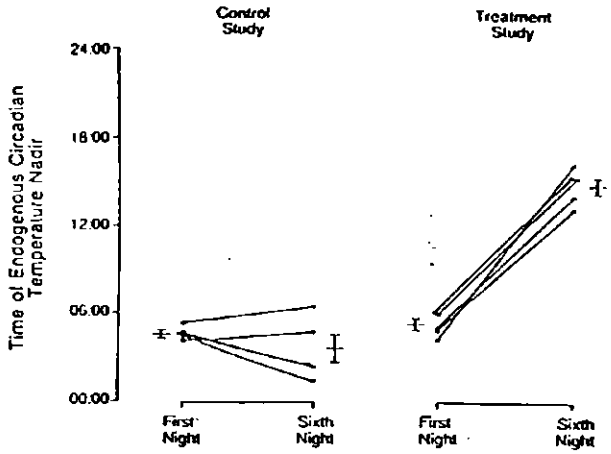

Figure 2. Shifts in Endogenous Circadian Temperature Nadirs between the First and Sixth Nights of Work in the Subjects in the Control and Treatment Studies.

The men in the control studies were exposed to ordinary indoor light on the second through fifth nights, and they slept at home on a free schedule during the day, whereas the subjects in the treatment studies were exposed to bright light during night work and to darkness during daytime sleep, which was scheduled for the period between 09:00 and 17:00 hours. Horizontal lines and vertical bars denote mean ±SEM values.

24-Hour Patterns of Physiologic and Behavioral Variables

The mean 24-hour patterns of core body temperature, subjective alertness assessments, cognitive performance, urinary excretion rate, and plasma cortisol concentrations during the initial constant routine in both the control and treatment studies had prominent circadian variations. The mean wave forms and timing for each of these variables during the initial constant routine were similar in the men who subsequently participated in the control and treatment studies and also resembled those reported previously[30,31,33,42] (Fig. 3). During the final constant routines, a persistent circadian rhythm was apparent in the average wave form for each variable in both groups. Furthermore, the internal temporal relation between these rhythms did not change during the final constant routine of the control and treatment studies. The relation of each of these average rhythms to the time of day did not change from the initial to the final constant

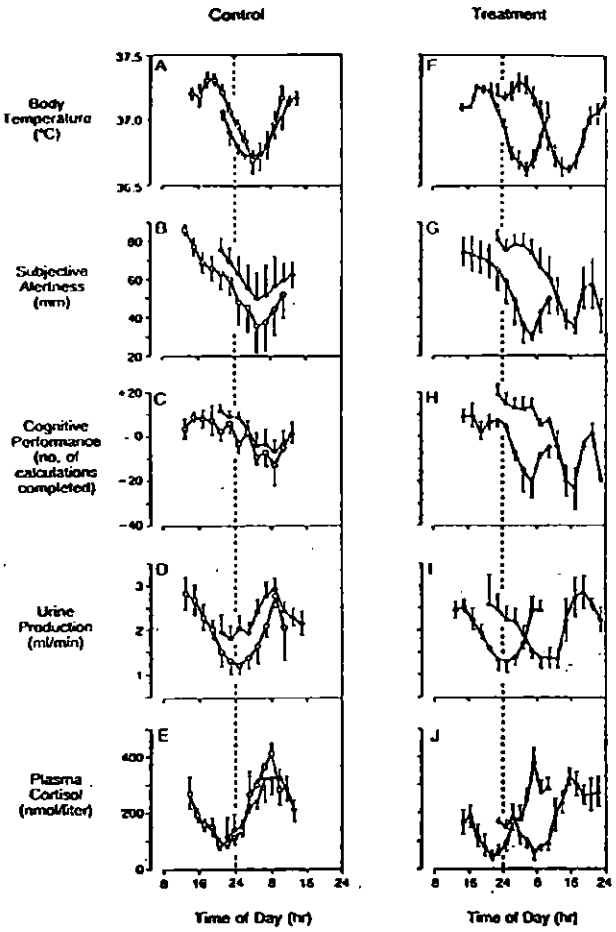

Figure 3. Shifts in Physiologic and Behavioral Measures during the First and Sixth Nights of Work in the Subjects in the Control and Treatment Studies.

Each point shows the mean ±SEM for each variable at a given hour during the initial (open symbols) and final (solid symbols) constant routines in the control subjects (left-hand panels) and the subjects in the treatment group (right-hand panels). Vertical dashed lines indicate the beginning of the night shift (midnight). Conditions during the control and treatment studies were as described in Figure 2. The values for cognitive performance are expressed as the deviation from the 24-hour mean.

routine in the control studies, but in the treatment studies the average curves were displaced to a later hour (Fig. 3). The average curves for the final constant routines of the treatment studies also occurred later than those of the control studies. The magnitude of the displacement was consistent with quantitative estimates of the shift of the endogenous circadian phase as derived from the temperature data.

Performance and Alertness Measures during the Night Shift

As shown in Figure 3H, the shift in the endogenous circadian phase observed during the final constant routine in the treatment studies was associated with significantly higher normalized levels of performance during the hours of the night shift (midnight to 08:00) after treatment than before treatment ($P = 0.041$). In the control studies, there was no significant difference in performance during the night-shift hours between the initial and the final constant routines (Fig. 3C). Similarly, the mean values for alertness were significantly higher during the night shift after the bright-light intervention in the treatment studies than they were before treatment ($P = 0.0009$) (Fig. 3G). Although the mean values for alertness during the night shift were also significantly higher in the control studies at the time of the final constant routine than at the time of the initial constant routine ($P = 0.009$) (Fig. 3B), the improvement was significantly greater in the treatment studies than in the control studies (31.5± 7.8 vs. 13.4±6.3 mm, respectively; $P = 0.004$).

Discussion

Despite the high prevalence of night work in modern society, the physiologic response of the circadian timing system to the reversal it occasions in the sleep–wake schedule is poorly understood. This is largely because night workers are exposed to conflicting synchronizing cues: their work schedule demands activity at night and sleep during the day, whereas all other periodic environmental cues (in particular the light–dark cycle) are oriented toward activity during the day and sleep at night. Although some laboratory experiments have indicated considerable adaptation to a week of simulated nighttime work,[12] those experiments were conducted in laboratories shielded from the environmental light–dark cycle to which shift workers are ordinarily exposed. Studies of shift workers exposed to normal periodic environmental cues have suggested that an incomplete adaptation to nighttime work occurs in persons who live at home and travel daily to work.[2-6,43,44]

In this study, we attempted to resolve the dilemma by evaluating endogenous circadian rhythms under controlled laboratory conditions on the first and sixth night shifts in men otherwise living at home. The physiologic and behavioral data that we collected in the control studies demonstrate that under field conditions the circadian timing system fails to adapt to an inversion of the daily routine even after a week of night work. In fact, three of the five men had small maladaptive advances of the endogenous circadian phase on the sixth night shift as compared with the first. The failure of the circadian timing system to adapt to night-shift work in persons working in ordinary room light at night and sporadically exposed to bright outdoor light during the day is probably a consequence of the direct and powerful biologic effect of light on the human circadian pacemaker.[28,29]

In contrast, in the treatment studies we found that four cycles of exposure to a properly designed regimen of bright light and darkness induced a complete physiologic adaptation to night work in the men living at home and traveling to and from work. The physiologic and behavioral adaptation to the night shift was evident with respect to all measured variables. The success of this experimental paradigm in inducing an ad-

aptation to an inversion of the sleep–wake schedule is consistent with the finding that travelers adapt more rapidly to a time-zone shift if they remain outdoors on arrival rather than in their hotel rooms[45,46] and with recent studies suggesting that bright light is an effective synchronizer of circadian rhythmicity in human subjects.[29,47-53] Our findings are comparable with the results of experiments conducted under conditions of 24-hour daylight in the Arctic, in which adaptation of the body-temperature cycle to a reversal of the activity–sleep schedule was achieved after only three to four days among subjects who concurrently reversed their exposure to the natural light–dark cycle by using blindfolds during daytime sleep.[54] However, it should be noted that the resetting effect of light on the circadian pacemaker is critically dependent on the timing, intensity, and duration of the light exposure. The desired phase shift may not be achieved even with the same amount of exposure to bright light[55] unless it is administered at appropriate times.[29]

The use of the constant-routine procedure allowed the extent of adaptation of both physiologic and behavioral variables to be evaluated in the control and treatment studies. The endogenous circadian rhythms of body temperature, plasma cortisol concentration, and urinary excretion rate all failed to adjust to the schedule of night work in the control studies, yet in the treatment studies they were all effectively synchronized with the night-work schedule. The indexes of alertness and performance remained at their lowest daily levels from midnight to 08:00 hours in the control studies, even after a week of nighttime work. In the treatment studies, these same indexes during the night were significantly improved, and there was a marked decline in alertness (or an increase in sleepiness) during the daytime, when night workers must attempt to sleep. This increase in daytime sleepiness is consistent with the shift in phase of the physiologic variables and may account for the significantly increased sleep time among the men in the treatment studies. Taken together, these data suggest that the schedule of light and darkness to which these men were exposed shifted a master circadian pacemaker that drives all these physiologic and behavioral rhythms.

Misalignment of the circadian phase and sleep deprivation are the principal factors contributing to the decrements in performance and increased accident rates associated with night-shift work.[9] Therefore, the ability of exposure to light and darkness to adjust the circadian phase and improve the sleep of night-shift workers could have important implications for both industrial productivity and safety. Furthermore, since circadian-phase misalignment, sleep deprivation, or both may add to the deleterious consequences for health that are associated with nighttime work (such as digestive, cardiovascular, and sleep disorders), the ability to induce physiologic adaptation to such a schedule could also have important consequences for the health of night workers.

Although this study is a step toward the development of a practical treatment for maladaptation to nighttime work, a number of important questions remain to be answered. They concern the relative importance of exposure to bright light during nighttime work as compared with darkness during daytime sleep, variability both between individuals and according to age and sex in the phase-shifting response to bright light, and the number, duration, and intensity of light exposures needed to induce and maintain optimal physiologic adaptation to nighttime work.

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Coping with the stress of shift work

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A large proportion of the American and European work-force is engaged in night and shift work. The aim of this brief article is to present those involved with some practical advice regarding how they might best cope. The advice is presented in terms of a theoretical framework involving a triad of mutually interactive factors.

Keywords: shift work, stress, sleep.

Introduction

Shift work very often involves the individual in having to sleep and work at 'unnatural' times of day. This break with the inherent human tendency to sleep at night and be active during the day may, or may not, be actually harmful to the person involved (Rutenfranz *et al.* 1977, Harrington 1978), but it is certainly a source of stress which must be actively coped with.

An individual's ability to cope with shift work is determined by a triad of inter-related factors (figure 1).

The biological clock factor comprises the endogenous timekeeping processes (actually several 'clocks') which are present in the brain, and drive circadian rhythms in many different aspects of physiology, mood and performance efficiency (Aschoff 1981). Under a normal (diurnal) routine, these rhythms set the stage mentally and physically for sleep at night and active wakefulness during the day. Unfortunately for the shift worker, the biological clock takes several days to readjust to a sudden change in schedule (Aschoff *et al.* 1975). While the resetting process is taking place, the individual will often experience jet-lag symptoms (Monk 1987), leading to sleep and stomach complaints, malaise, irritability and lapses in concentration (Rutenfranz *et al.* 1985).

There are two influences on the sleep factor of the triad. Exogenous influences come from a day-oriented society which expects the shift worker to be awake during the day. Thus, there are levels of noise and expected social commitments during the sleep period which would be considered intolerable in the equivalent sleep period of a day worker (Tepas and Monk 1987). However, endogenous influences will also limit the sleep of the shift worker (Tepas *et al.* 1981). Very often the biological clock will be 'expecting' wakefulness during day sleeps, thus reducing the sleeping individual's tolerance to noise.

Social and domestic factors come from the family and community tensions which can arise because of the shift worker's unusual work and sleep schedule (Walker 1985). Spouse and parenting roles can be compromised, and shift workers may feel themselves isolated from the rest of the community.

All three factors are heavily inter-related. Thus, for example, shift workers' sleep will be dependent upon the state of their biological clock and the tranquillity of their household, their biological clock upon the degree of fragmentation of their sleep and the domestic demands upon their daily routine, and their domestic harmony upon the degree to which they are continually sleep-deprived and/or 'jet-lagged'. It is important to note that a failure in any one of the three components of the triad can negate any advances that have been made in the other two. Thus, for example, a worker who has plenty of sleep and a perfectly adjusted circadian system will have failed to cope with shift work if those gains were won at the expense of domestic responsibilities, whose failure might be leading to an imminent divorce.

Biological clock coping strategies

Unless the shift worker is on a very rapidly rotating routine (e.g. the 2–2–2 rota of two morning shifts, two evening shifts, two night shifts and two days off) the aim will be to acquire the biological clock orientation most appropriate

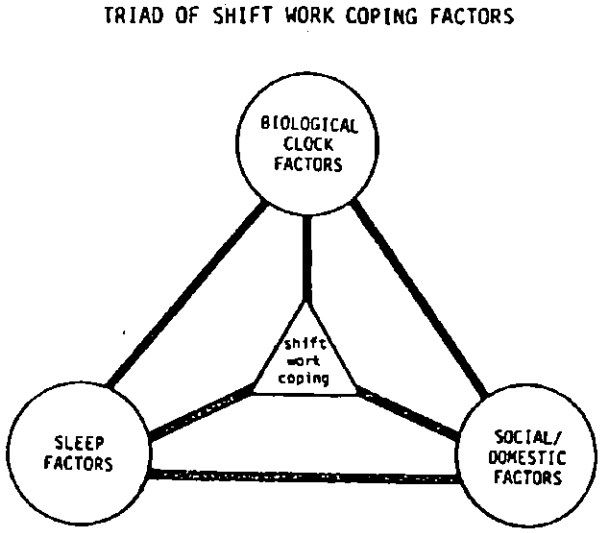

Figure 1. Schematic model of the triad of factors influencing shift work coping ability.

to the work shift as rapidly as possible, and to maintain that orientation throughout their spell of duty on that shift (Monk 1986).

Studies of jet-lag and laboratory phase shifts have suggested that phase delays are more easily accomplished by the biological clock than phase advances (Aschoff *et al.* 1975, Klein *et al.* 1972). Night workers should thus take their sleep straight after work, rather than waiting until the afternoon. This corresponds to a delay of about nine hours, a change that is easier for the biological clock to achieve than the *advance* of about nine hours required by an afternoon bedtime. Since excessive napping can interfere with the quality of the major sleep episode, afternoon naps should be used only as a 'topping up' device and should be limited to two hours or less.

Night workers should identify the time cues that are pulling their biological clock towards a nocturnal orientation and strengthen them, and identify those that are working against a nocturnal orientation and attenuate them. Time cues working in their favour will be a regular morning bedtime, three meals per 'day', with a proper lunch half way through the working night, and physical activity and social interaction through the night. Time cues working against them will be daylight on the journey home from work (perhaps warranting the use of sunglasses), sleep during the night shift and social or work commitments during the first half of the day (8 am to 4 pm).

Not everyone's biological clock properties are the same, and certain characteristics will influence how easy or difficult an individual finds it to cope with shift work. In particular, 'morning types' with an early phasing biological clock who like to be up with the dawn seem to experience extra shift work coping problems (Hildebrandt and Stratman 1979). Also at risk are those in their late forties or fifties whose biological clocks have become earlier phasing and less robust with age (Foret *et al.* 1981). For such individuals the change from successful shift work coping to significant sleep and well-being problems can be a precipitate one.

Sleep coping strategies

Shift workers should jealously guard the time set aside for their sleep. This time should be regular and predictable, and free from social or other commitments. During that time, telephones, doorbells and domestic appliances should be silenced. Heavy curtains and thick carpets should be used to help make the bedroom as quiet and as dark as possible. The bedroom should be used only for sleep and lovemaking. Caffeine should be avoided within five hours of bedtime, and alcohol should not be used as a sedative since subsequent sleep would then be light and disrupted. Because of problems of tolerance and withdrawal, sleeping pills should be used only very occasionally. Shift workers taking sleeping pills more than four times a week should consult a physician about tapering them off. Apart from being good health practice, this would mean that occasional use at a later date would be much more effective.

Coping with the stress

People who naturally function well can find hard to cope with. Ofte that all they do is 'work ... recreation and social i become so problemat daywork is called for.

Social and domestic copin

Few of the coping strat other two factors of the tri social and domestic m workers should seek understanding of their ... their support in coping should be forged with who are more likely tha be supportive and unde...

Particularly at risk fro view are those shift expected to run a hous children (Gadbois 1981) often 'working wives', realize that this can se time of the shift worke irritability and family t...

Shift work coping

- *Sleep immediately aft than before it.*
- *Keep to a regula avoiding excessive sn*
- *Keep a regular bedtim*
- *Avoid exposure to way home from sunglasses).*
- *Jealously guard one's telephones, doorl appliances.*
- *Keep the bedroom qu*
- *Only use the bedr lovemaking.*
- *Avoid caffeine withi*
- *Avoid the habitual u pills.*
- *Rally the support o you to cope.*
- *Keep the channels o open.*
- *Set aside special tim children.*
- *Forge links with families.*

People who naturally need a lot of sleep to function well can find shift work particularly hard to cope with. Often such individuals report that all they do is 'work and sleep', missing out on recreation and social interaction. This can become so problematical that a switch to daywork is called for.

Social and domestic coping strategies

Few of the coping strategies outlined for the other two factors of the triad will work unless the social and domestic milieu is supportive. Shift workers should seek to gain their family's understanding of their predicament and to rally their support in coping with it. Relationships should be forged with other shift-work families who are more likely than day-working friends to be supportive and understanding.

Particularly at risk from a domestic point of view are those shift workers who are still expected to run a household and look after the children (Gadbois 1981). These shift workers are often 'working wives', and husbands should realize that this can severely cut into the sleep time of the shift worker, and will thus increase irritability and family tensions.

Shift work coping strategies

- *Sleep immediately after a night shift, rather than before it.*
- *Keep to a regular three meals per day, avoiding excessive snacks.*
- *Keep a regular bedtime on each spell of duty.*
- *Avoid exposure to bright sunshine on the way home from a night shift (wear sunglasses).*
- *Jealously guard one's sleep time, silencing telephones, doorbells, and domestic appliances.*
- *Keep the bedroom quiet and dark.*
- *Only use the bedroom for sleep and lovemaking.*
- *Avoid caffeine within five hours before sleep.*
- *Avoid the habitual use of alcohol or sleeping pills.*
- *Rally the support of your family in helping you to cope.*
- *Keep the channels of family communication open.*
- *Set aside special times to be with spouse and children.*
- *Forge links with other shift-working families.*

Spouse and parenting roles may also be compromised, particularly on the evening shift, which has little impact on sleep or biological clock factors. Efforts should be made to ensure that other times are specifically set aside for the shift worker to spend time with the spouse and children. In general, the presence of a shift worker in the household, like that of a handicapped person, can either strengthen the family by drawing it closer together against the difficulties, or it can destroy the family with strain and disharmony. Working hard to keep the family lines of communication open is a vital component of the domestic coping strategy.

Conclusions

Shift work is a multifaceted problem requiring multifaceted solutions. Coping strategies that promote suitable behaviours in the social/domestic, sleep and biological clock domains can help alleviate some of the adverse symptoms that are experienced.

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Shift work, fetal development and course of pregnancy

by Tuula Nurminen, MSc[1]

NURMINEN T. Shift work, fetal development and course of pregnancy. *Scand J Work Environ Health* 1989;15:395—403. Information on 1475 mothers of infants with selected structural malformations and an equal number of mothers of "normal" babies was analyzed for a possible relationship between shift work and adverse pregnancy outcome or a complicated course of pregnancy. The primary data were obtained from the Finnish Register of Congenital Malformations supplemented by special interviews on the mothers' work conditions. No signs of a teratogenic risk were observed. The relationship between course of pregnancy and outcomes other than malformations was determined from the noncase mothers' experience. Threatened abortion and pregnancy-induced hypertension were not associated with rotating shift work alone, but in a noisy work environment moderate risks could not be ruled out. Rotating shift work was associated with a slight excess of babies small for their gestational age independently of noise exposure. The results suggest that further studies on the effects of different work schedules on pregnancy are worth consideration.

Key terms: birth defects, birthweight, length of gestation, malformations, occupation, pregnancy-induced hypertension, threatened abortion, vaginal bleeding.

Few investigations have been made on the possible relationship between shift work and fetal development or course of pregnancy. In a Japanese study (1) shift and night workers reported spontaneous abortion more frequently than day workers. Shift work in laboratories was related to a clearly higher rate of spontaneous abortion in a Swedish study (2). But this relation was not confirmed in a later investigation (3), and only a slightly increased risk was associated with work entailing irregular hours or rotating shifts as compared with day work only. In a study in Montreal (4) rotating or irregularly changing shift work was related to spontaneous abortion, and the association was confirmed in a second analysis of the same data. Shift work and night work was associated with preterm delivery in a French study (5). However, another French study (6) found no relation between preterm delivery or low birthweight and night work. In the Montreal study (7) changing shift work was related to preterm birth and low birthweight, but not consistently. Because of the large overlap between preterm birth and low birthweight, the data of the Montreal study were analyzed further, and gestational age was allowed for when birthweight was the outcome. The results suggested that shift work retarded fetal growth and increased the risk of preterm birth (8). The results of the later Swedish study (3) supported the hypothesis that irregular work schedules might have a negative influence on birthweight.

To investigate the effects of shift work on teratogenic risk, threatened abortion, pregnancy-induced hypertension, length of gestation, and birthweight, the present study scrutinized the experience of 1475 mothers of infants with selected structural malformations and an equal number of mothers of noncase babies. The study was part of a project whose original goal was to explore the possible role of occupational factors in the occurrence of birth defects (9).

Subjects and methods

Birth defects

The source information of the study was the Finnish Register of Congenital Malformations between June 1976 and December 1982. The data included 365 defects of the central nervous system, 581 orofacial clefts, 360 structural defects of the skeleton, 169 cardiovascular malformations, and 1475 noncase babies whose deliveries had preceded the case deliveries in the same maternity health care district (9). The mothers of the time- and area-matched case-noncase pairs of babies were interviewed by means of standard Register procedures about particulars of the latest and previous pregnancies, diseases, consumption of drugs and alcohol, smoking habits, etc (10). The Register data were supplemented with interviews on the mothers' work conditions. Two trained interviewers from the Finnish Institute of Occupational Health carried out the interviews. (For details, see references 9, 11, and 12.)

The special interview started with a question inquiring if the mother had worked during her pregnancy most of the time, only temporarily, or not at all. In addition to information on the employer, job title, and

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Table 1. Occupational classification of the mothers in shift work during early pregnancy.

Major occupational group[a]	Two-shift workers	Three-shift workers	Other type of shift workers	Tot
0 (technical, physical science, social science, humanistic and artistic work)	53	7	111	171
1 (administrative, managerial and clerical work)	13	2	—	15
2 (sales work)	8	—	2	10
5 (transport and communication work)	5	4	1	10
6/7 (manufacturing and related work)	43	18	2	63
8 (service work)	78	6	3	87
9 (work not elsewhere classified)	8	1	3	12
Total	208	38	122	368

[a] According to reference 14.

Table 2. Physical load of the mothers who did shift work and those who did nonshift work in the first trimester of their pregnancy.

Mean physical load[a]	Shift workers		Nonshift workers	
	N[b]	%	N[c]	%
Sedentary work	127	34.8	1114	57.5
Standing work	131	35.9	443	22.9
Work involving walking	81	22.2	106	5.5
Work with a moderate physical load	26	7.1	273	14.1

[a] See reference 15 for a description of the assessment of physical load.
[b] There were three mothers with missing data on physical load.
[c] There were 43 mothers with missing data on physical load.

time of employment, the mother was asked if she had worked in shifts. Of the mothers, 2073 had worked throughout most of their pregnancy, and 603 had not worked in the first trimester, the risk period for structural malformations (10). In all, 274 mothers had worked temporarily in the first trimester, and the reason for stopping work was the termination of employment for 47 % of these mothers, maternity leave or vacation for 10 %, and sick leave or overstrain for 18 %. The rest had other reasons or the reason was unknown. The mothers who did not work in the first trimester of pregnancy were excluded from the analyses when birth defects were studied.

Altogether, 368 mothers (16 % of those who had worked) had done shift work during early pregnancy, 41 temporarily and 327 regularly. In the shift work group, 57 % of the mothers had worked in two shifts, 10 % in three shifts, and 33 % had work arrangements that differed in some manner from normal daily work, mainly periodic work. In Finland, the individuals who work in shifts usually do rotating shift work in which the work schedule changes after every week in two-shift work and after 4 d in three-shift work, while in periodic work the cycle is two or three weeks (13). In the two-shift group almost 40 % had been in service work and about one-half had been in manufacturing or nursing work. Of the mothers working in three shifts, almost one-half had done manufacturing work. The mothers in other types of shift work were mainly in the nursing field. (See table 1.)

According to the classification of socioeconomic status of the Central Statistical Office of Finland (14), most of the mothers (96 %) in shift work during early pregnancy were lower-level employees with administrative and clerical occupations or manual workers whereas 84 % of the mothers in nonshift work belonged to these categories. None of the women in shift work had been employed in farming. Possible confounding was controlled for in additional analyses in which the subjects were restricted to nonagricultural workers in the two aforementioned socioeconomic classes.

The physical load of the occupational activities of the mothers was evaluated with a standardized method reflecting energy expenditure (15). The group in shift work included relatively more women in standing work and in work involving walking. Nonshift work was more often sedentary, but also moderate physical load was more common in nonshift work (table 2). Over one-half of the mothers in nonshift work with a moderate physical load had worked in agriculture.

Two industrial hygienists independently assessed exposure to noise blindly from a description of the mother's workday and a fixed question on noise exposure (12). In all, 17 % of the mothers in shift work in the first trimester of pregnancy had been exposed to an 8-h equivalent continuous A-weighted sound level ($L_{Aeq\ (8\text{-}h)}$) of around 80 dB or higher during early pregnancy, whereas the corresponding percentage was seven in the nonshift group.

Similarly, two industrial hygienists assessed the mothers' solvent exposure on the basis of the workday description and a fixed question on solvent exposure (16). A mother was considered exposed if the continuous concentrations had been at least one-third of the threshold limit values for chemical substances

Table 3. Background characteristics of the shift and nonshift workers who worked temporarily in the first trimester of their pregnancy and those who worked throughout most of their pregnancy.

Background characteristic	Temporary work		Regular work	
	Shift workers (N = 41) (%)	Nonshift workers (N = 233) (%)	Shift workers (N = 327) (%)	Nonshift workers (N = 1746) (%)
Maternal age ≥ 35 years	9.8	9.4	7.0	8.6
No previous pregnancy	41.5	41.4	39.0	37.6
Previous deliveries without an adverse pregnancy outcome	17.0	28.4	31.3	35.1
Previous adverse pregnancy outcome[a]	41.5	30.2	29.7	27.3
Menstrual irregularity	9.8	6.2	13.2	9.1
Regular smoking	21.9	14.6	12.3	12.4
Alcohol intake	39.0	43.4	43.9	42.8
Intake of drugs in the first trimester[b]	26.3	31.6	30.7	25.8
Common cold or fever in the first trimester	19.5	12.4	17.7	15.5

[a] Previous induced abortion, miscarriage, preterm delivery, malformed child, or stillbirth.
[b] Vitamins and tonics not included.

in workroom air (17) or peaks had been higher than the threshold limit value. Exposure to solvents did not differ much between the shift and nonshift groups.

When the relation between shift work and malformations was studied, physical work load, exposure to noise and solvents, and temporariness of employment were adjusted for in the analyses.

The mothers who had been in temporary shift work during early pregnancy had experienced more previous adverse pregnancy outcomes and were more often regular smokers than the mothers in temporary nonshift work or in regular work. More women in shift work had had menstrual irregularities than those in nonshift work. (See table 3.) Table 4 presents the maternal characteristics that were adjusted for in the analyses.

The matching procedure had not correlated the case and noncase series with respect to shift work, and therefore the data were analyzed as independent series to enhance efficiency (18, 19). Confidence intervals for the crude odds ratios were calculated with the modified Cornfield method (20, 21). The adjusted odds ratio estimates and their confidence intervals were calculated from results of unconditional logistic regression analyses, which were executed with the SAS software system (22). The independent variables were entered into the models as binary codes, or category indicators were used. Before the final models were fit, stratified analyses were performed to judge whether the stratum-specific estimates of the effect of shift work could be considered constant and to obtain estimates against which the modeling results could be checked.

Table 4. Matched odds ratio estimates of all birth defects pooled for maternal characteristics among all the 1475 case-noncase pairs.

Maternal characteristic	Odds ratio[a]
Maternal age ≥ 35 years[b]	1.0
Birth order greater than three[c]	1.2
Two or more previous induced abortions[c]	1.8
Previous miscarriage[c]	1.1
Previous stillbirth[c]	1.4
Previous malformed child[b]	3.8
Regular smoking during pregnancy[b, d]	1.5
Alcohol intake during pregnancy[b]	1.1
Intake of drugs in the first trimester[b, e]	1.6
Common cold or fever in the first trimester[b]	1.8

[a] Calculated from data matched on time and area.
[b] Source: the Register questionnaire.
[c] Source: the records of the maternity health care center.
[d] All regular smoking compared to nonsmoking or temporary smoking during pregnancy. The odds ratio was 0.9 for temporary smoking during pregnancy, 1.4 for regular smoking of less than five cigarettes daily, and 1.5 for regular smoking of five or more cigarettes daily as compared with not smoking during pregnancy. There were nine mothers who had smoked over 20 cigarettes daily during pregnancy regularly.
[e] Vitamins and tonics not included.

Birthweight and course of pregnancy

The second part of the present study, on birthweight and course of pregnancy, was based on the noncase mothers' experience. This procedure has been described in more detail elsewhere (23, 24). Information on the noncase mothers' pregnancies was obtained from the Register questionnaires and the records of the maternity health care center.

The mother was asked in the Register interview if she had experienced a threatened abortion and what symptoms she had had. In the analyses vaginal bleeding with or without lower abdominal pain was considered an indication of a threatened abortion but not lower abdominal pain only.

An increase of at least 20 mm Hg (3 kPa) in the mean arterial blood pressure between the mother's first visit to the maternity health care center and her last visit

before delivery was considered a sign of pregnancy-induced hypertension (25).

The length of gestation was calculated from the first day of the last normal menstrual period. The small size of the noncase series did not allow a study of rare outcomes like preterm birth (length of gestation less than 259 d), whose occurrence was 2.6 % (27 mothers) among those who had worked during most of their pregnancy. Instead, the occurrence of pregnancies that were shorter than 280 d was studied. The reference value for the definition of a small baby for his or her gestational age was the tenth percentile birthweight of the babies of the same sex born to mothers in nonshift work in the same gestational age group. The applied gestational age groups were <37 weeks, 37—39 weeks, 40—41 weeks, and ≥ 42 weeks. (For more details on these outcomes see references 23, 24, and 26.)

Seventeen of the 1475 noncase mothers had twin births, and for one woman information on the number of fetuses was missing. These 18 mothers were excluded from the second part of the study. Of the remaining mothers, 267 had not worked during pregnancy, 146 had worked only temporarily, and 1044 had worked regularly throughout most of their pregnancy. A total of 178 mothers had done shift work regularly and 22 temporarily. For the mothers who had been in shift work throughout most of their pregnancy, the median duration of gestation at the termination of work was 242 d with a lower quartile (Q1) of 223 d and an upper quartile (Q3) of 251 d, and in nonshift work the median was 248 (Q1 225, Q3 252) d, respectively. In regular shift work the reason for stopping was maternity leave for 39 % of the mothers, sick leave for 32 %, and the rest had other reasons, including vacation, or the reason was unknown. In nonshift work the respective percentages were 45 and 27.

When the occurrence of threatened abortion was studied, all the mothers who had worked were part of the analyses, but, when other aspects of pregnancy were under consideration, only mothers who had worked throughout most of their pregnancy were included. The mothers' socioeconomic class and agricultural work were controlled by the same restrictions that were used in the study of birth defects, and the same features of work were adjusted for in the analyses.

For threatened abortion the possible confounders maternal age, parity, outcome of previous pregnancies, history of menstrual irregularity, intake of drugs, alcohol consumption, and smoking were controlled in the analyses. For pregnancy-induced hypertension maternal age, parity, outcome of previous pregnancies, alcohol intake, and smoking were adjusted for. The models for length of gestation included the covariates maternal age, parity, outcome of previous pregnancies, history of menstrual irregularity, alcohol intake, and smoking. In the study of the occurrence of babies small for their gestational age maternal age, parity, outcome of previous pregnancies, maternal prepregnancy weight less than 50 kg, alcohol intake, and smoking were controlled for.

The estimates and confidence limits for the crude risk ratios were calculated according to the chi-square function procedure of Miettinen & Nurminen (21). The estimates of the adjusted risk ratios were calculated from the results of binomial regression analyses executed with the generalized linear interactive modeling (GLIM) program and the macros written by Wacholder (27). Independent variables were defined and analyses were performed that corresponded to the procedures used to study birth defects. The effect of shift work on vaginal bleeding and shortened length of gestation (less than 280 d) was not homogeneous when divided into strata according to noise exposure [test for heterogeneity of risk ratio (28) for vaginal bleeding $X^2=4.7$ ($P=0.03$) and for shortened length of gestation $X^2=5.8$ ($P=0.02$)], and some indication of corresponding heterogeneity was found for pregnancy-induced hypertension ($X^2=2.4$, $P=0.12$). Therefore the estimates of the effect of shift work on vaginal bleeding, pregnancy-induced hypertension, and shortened length of gestation were presented separately for strata according to noise exposure, and the concerned product terms were included in the models. No other noteworthy signs of heterogeneity were found in the data, the smallest P-value being 0.15.

Results

Malformations

When all the birth defects were pooled, the crude odds ratio for shift work in the first trimester of pregnancy was 0.9 with a 95 % confidence interval (95 % CI) of 0.7—1.2, and the adjusted analysis yielded similar estimates. The crude and adjusted odds ratios for the separate malformation groups under study were unity or very close to it (table 5). When analyzed using the groups restricted to the nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers, the adjusted overall odds ratio estimate was 0.9 (95 % CI 0.7—1.1). In addition, the estimates for the specific malformation groups were very similar to those obtained in the unrestricted analyses.

Vaginal bleeding (threatened abortion)

In the group of mothers who had done shift work during pregnancy, the occurrence of vaginal bleeding was 12 %, and in the nonshift group 9 % had experienced symptoms of threatened abortion (risk ratio 1.3, 95 % CI 0.8—1.9). The crude risk ratio for shift work and threatened abortion in the first trimester was 1.3 (95 % CI 0.7—2.1). When the mothers' occupations were considered, it was revealed that the mothers who had done shift work in manufacturing and related occupations had an elevated risk of vaginal bleeding when

compared with the mothers in nonshift work in manufacturing (table 6).

In manufacturing, 82 % of the mothers in shift work had been exposed to a noise level of around 80 dB $L_{Aeq\,(8\,h)}$ or higher as against 54 % of the mothers in nonshift work. Exposure to noise modified the relation between shift work and the occurrence of vaginal bleeding. The risk ratio for shift work among the mothers who had worked in a noisy environment was 3.0 (95 % CI 1.2—7.5), but the risk for shift work was not elevated in the case of noiseless work environments (table 7). When work conditions and maternal background characteristics were taken into account, the adjusted risk ratio for shift work in a noisy environment was 1.8 (95 % CI 0.7—4.6), and for shift work in a noiseless environment the adjusted risk ratio was 0.8 (95 % CI 0.5— 1.4). When the analysis was restricted to the nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers, the adjusted risk ratio for shift work in a noisy environment was 1.8 (0.7—4.8), and for shift work in a noiseless environment the corresponding value was 0.9 (95 % CI 0.5—1.5).

Pregnancy-induced hypertension

The occurrence of pregnancy-induced hypertension was 9 % among the mothers who had been in shift work and 7 % among those who had not worked in shifts (risk ratio 1.2, 95 % CI 0.7—2.0). The risk was elevated among the mothers who had done two- or three-shift work in a noisy environment; but, without noise exposure, the mothers in shift work had experienced no more pregnancy-induced hypertension than the mothers with normal daywork (table 8). The adjusted risk ratio for shift work in a noisy environment was 2.2 (95 % CI 0.7—6.5), and for noiseless shift work it was 1.0 (95 % CI 0.5—2.0). The restricted analyses yielded an adjusted risk ratio of 1.9 (95 % CI 0.6—5.6) for an association between shift work in a noisy environment and pregnancy-induced hypertension, and the adjusted risk ratio for shift work in a noiseless environment was 1.1 (95 % CI 0.6—2.3).

Length of gestation and birthweight

In all, for 39 % of the mothers in shift work, the length of gestation was less than 280 d, whereas the corresponding percentage in nonshift work was 44 %

Table 5. Mothers in shift work and those in nonshift work in the first trimester of pregnancy according to whether their baby was a case or noncase.

	Shift workers (N)	Nonshift workers (N)	Crude odds ratio[a]	Adjusted odds ratio[a]
Cases				
Central nervous system defects	44	237	1.0 (0.7—1.4)	1.0 (0.7—1.4)
Orofacial clefts	63	387	0.8 (0.6—1.1)	0.8 (0.6—1.1)
Skeletal defects	46	243	1.0 (0.7—1.4)	1.1 (0.7—1.6)
Cardiovascular defects	23	118	1.0 (0.6—1.6)	0.9 (0.6—1.5)
All cases pooled	176	985	0.9 (0.7—1.2)	0.9 (0.7—1.1)
Noncases	192	994		

[a] 95 % confidence interval in parentheses.

Table 6. Vaginal bleeding (threatened abortion) and shift work according to the mothers' occupations.

Major occupational group[a]	Number of mothers[b]	Vaginal bleeding N	Vaginal bleeding %	Crude risk ratio	95 % confidence interval
0 (technical, physical science, social science, humanistic, and artistic work) & 1 (administrative, managerial, and clerical work)					
Shift work	97	10	10.3	1.1	0.6—2.1
Nonshift work	473	43	9.1		
2 (sales work), 5 (transport and communication work) & 8 (service work)					
Shift work	59	5	8.5	0.8	0.3—1.8
Nonshift work	280	30	10.7		
6/7 (manufacturing and related work)					
Shift work	33	8	24.2	3.0	1.3—7.0
Nonshift work	113	9	8.0		
3 (agriculture, forestry, and fishing) & 9 (work not elsewhere classified)					
Shift work	9	—	0.0		—4.5
Nonshift work	122	9	7.4		

[a] According to reference 14.
[b] There were two mothers in shift work and two mothers in nonshift work with missing data on the symptoms.

Table 7. Vaginal bleeding (threatened abortion) among the mothers with and those without exposure to noise in shift or nonshift work during pregnancy.

	Number of mothers[a]	Vaginal bleeding		Crude risk ratio	95 % confidence interval
		N	%		
Noisy environment[b]					
Shift work					
Any shift work	34	9	26.5	3.0	1.2—7.5
Two-shift work	26	8	30.8	3.5	1.4—8.8
Three-shift work	6	1	16.7	1.9	0.3—8.7
Nonshift work	68	6	8.8		
Noiseless environment					
Shift work					
Any shift work	164	14	8.5	0.9	0.5—1.6
Two-shift work	95	7	7.4	0.8	0.4—1.6
Three-shift work	10	1	10.0	1.1	0.2—4.5
Other shift work	59	6	10.2	1.1	0.5—2.3
Nonshift work	920	85	9.2		

[a] There were two shift workers and two nonshift workers with missing data on the symptoms.
[b] Level of noise an 8-h equivalent continuous A-weighted sound level of around 80 dB or higher. Two mothers had been in another type of shift work, and they had not had vaginal bleeding.

Table 8. Pregnancy-induced hypertension and shift work among the mothers with and those without occupational exposure to noise throughout most of their pregnancy.

	Number of mothers[a]	Pregnancy-induced hypertension		Crude risk ratio	95 % confidence interval
		N	%		
Exposure to noise[b]					
Two- or three-shift work	28	6	21.4	2.4	0.8—6.4
Nonshift work	66	6	9.1		
No noise exposure					
Shift work					
Two- or three-shift work	92	6	6.5	0.9	0.4—1.9
Other shift work	55	4	7.3	1.0	0.4—2.5
Nonshift work	798	58	7.3		

[a] There were two shift workers and two nonshift workers with missing data on blood pressure.
[b] Level of noise an 8-h equivalent continuous A-weighted sound level of around 80 dB or higher. One mother had been in another type of shift work and had not had pregnancy-induced hypertension.

(crude risk ratio 0.9, 95 % CI 0.7—1.1). Table 9 shows the distributions of the gestational ages of the babies according to whether their mothers were in shift or nonshift work. In a noisy environment, 57 % of the mothers in shift work had a gestation shorter than 280 d, and for mothers in nonshift work this percentage was 37 (crude risk ratio 1.5, 95 % CI 1.0—2.4, and adjusted risk ratio 1.4, 95 % CI 0.9—2.1). For nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers the corresponding adjusted risk ratio was 1.3 (95 % CI 0.8—2.0).

The tenth percentile birthweight of the babies born to mothers who had been in two- or three-shift work was 2940 g; for the babies born to mothers who had done another type of shift work, the tenth percentile was 2900 g; and, for the babies born to mothers with normal daily work, the tenth percentile was 3000 g (table 9).

In a noiseless environment, the crude risk ratio for the mothers in shift work giving birth to babies that were small for their gestational age was 1.4 (95 % CI 0.9—2.2) (table 10). The restriction of the study group to nonagricultural workers in the socioeconomic categories of lower-level employees with administrative and clerical occupations and manual workers yielded an adjusted risk ratio of 1.5 (95 % CI 1.0—2.4).

Placental weight

The mean placental weight was 631 (SD 132) g for the mothers in shift work and 611 (SD 125) g for the mothers in nonshift work. In all, 5 % of the mothers in shift work had placentas weighing 400 g or less as against 4 % of the mothers in nonshift work (risk ratio 1.2, 95 % CI 0.6—2.5).

Discussion

The analyses produced no indication of a teratogenic risk in connection with shift work. In light of the study data twofold or greater risks appeared implausible for all of the examined structural malformations. (See table 5.)

One-fourth of the mothers who had been in two- or three-shift work were in manufacturing and related occupations. (See table 1.) In manufacturing, the crude risk of threatened abortion was elevated for shift work, but some 80 % of these mothers had also been exposed to noise at a level of around 80 dB $L_{Acq\,(8\,h)}$ or higher. In the study data, shift work alone was not related to the occurrence of threatened abortion, but, in a noisy work environment, the mothers in shift work showed indications of an elevated risk of both this outcome and of pregnancy-induced hypertension. In addition, shift work and noise together appeared to shorten the length of gestation, but the data did not allow an evaluation of the occurrence of preterm delivery.

The occurrence of threatened abortion or pregnancy-induced hypertension showed no associations with two- or three-shift work in environments in which the level of noise was clearly less than 80 dB $L_{Acq\,(8\,h)}$. The women in other types of shift work had mainly done periodic work in nursing occupations, and the level of noise in their work had been low. The risks of threatened abortion, pregnancy-induced hypertension, or shortened length of gestation were not elevated among these women. However, the study population was small, and the data were compatible with a broad range of possibilities.

The study mothers who had been in shift work had a slightly elevated risk of giving birth to babies that were small for their gestational age when the babies' birthweights were compared with the birthweights of the babies born to the mothers in nonshift work, and this excess of small babies was not necessarily related to exposure to noise. It is not unlikely that the work conditions during the last months of pregnancy are the most relevant with respect to birthweight. Therefore only mothers who had worked throughout most of their pregnancy were included when birthweight was studied. Half of the mothers in shift work had already stopped working around the middle of the 35th week (as calculated from the first day of the last normal menstrual period), while the mothers in nonshift work usually worked a little longer, half of them having stopped by the middle of the 36th week. At the time when the study data were collected, Finnish legislation stated that a pregnant woman should normally start her maternity leave 24 workdays (ie, around 29 days

Table 9. Birthweight by the gestational age of the babies according to whether their mothers were in shift or nonshift work.

Gestational age of the babies	Babies		Birthweight (g)	
	N[a]	%	Median	Tenth percentile
<37 weeks				
Shift work				
Two- or three-shift work	1	0.8	3000	.
Other shift work	2	3.6	2465	.
Nonshift work	24	2.8	2605	875
37—39 weeks				
Shift work				
Two- or three-shift work	45	37.8	3500	2770
Other shift work	20	35.7	3285	2625
Nonshift work	347	40.7	3400	2930
40—41 weeks				
Shift work				
Two- or three-shift work	59	49.6	3650	3020
Other shift work	29	51.8	3790	3000
Nonshift work	429	50.4	3660	3150
≥42 weeks				
Shift work				
Two- or three-shift work	14	11.8	3620	3250
Other shift work	5	8.9	4000	3700
Nonshift work	52	6.1	3750	3140
Total				
Shift work				
Two- or three-shift work	119	100	3570	2940
Other shift work	56	100	3620	2900
Nonshift work	852	100	3540	3000

[a] There were three shift workers and 14 nonshift workers with missing data on the length of gestation.

Table 10. Babies small for their gestational age and maternal shift work in a noiseless environment[a] among all the women who worked throughout most of their pregnancy and among those nonagricultural workers who worked throughout most of their pregnancy in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers.

Work group	Total number of babies	Babies small for gestational age	
		N	%
All mothers who worked throughout most of their pregnancy			
Shift work			
Any shift work	146	20	13.7[b]
Two- or three-shift work	91	12	13.2
Other shift work	55	8	14.6
Nonshift work	771	74	9.6
Nonagricultural lower-level employees and manual workers			
Shift work			
Any shift work	141	18	12.8[c]
Two- or three-shift work	87	10	11.5
Other shift work	54	8	14.8
Nonshift work	597	55	9.2

[a] An 8-h equivalent continuous A-weighted sound level of <80 dB.
[b] Crude risk ratio 1.4 [95 % confidence interval (95 % CI) 0.9—2.2], adjusted risk ratio 1.4 (95 % CI 0.9—2.2).
[c] Crude risk ratio 1.4 (95 % CI 0.8—2.3), adjusted risk ratio 1.5 (95 % CI 1.0—2.4).

when Sundays and holidays are included) prior to the estimated date of her delivery. More study mothers in shift work had stopped working before the beginning of maternity leave than those in nonshift work.

Only a few of the mothers in shift work were in the categories of own-account (ie, self-employed) workers or upper-level employees with administrative, managerial, professional and related occupations according to the used socioeconomic classification (14). Moreover, none of the mothers in shift work had been involved in farming, which explained the fact that the group in nonshift work included relatively more mothers with a moderate physical work load. (See table 2.) In addition to comparing the groups of all mothers in shift and nonshift work, further analyses were restricted to nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers. The use of these selection criteria aimed at comparisons in which occupational aspects, other than work in shifts, would be more similar and, hence, the categories of work more comparable with respect to potential determinants of risk. In addition, possible selection for certain types of employment is a cause for concern. In the restricted analyses the compared mothers would be expected to have more similar pregnancy outcomes if they had not had different work schedules. (Compare reference 29.) The restricted analyses produced results similar to those obtained with the more heterogeneous data.

In Finland, shift work usually involves rotating work schedules (13). The employee in rotating shift work must adapt each time that the schedule changes, and many bodily functions and systems which are circadian in nature can be disturbed (30). The study mothers in shift work reported more irregularities in menstruation (see table 3), but the possible relation between circadian rhythm and reproduction is not well understood (3).

The published studies provide some evidence of adverse effects of shift work, especially rotating shift work or irregularly changing work schedules, on pregnancy (1—5, 7, 8), but the results include inconsistencies. The analyses of the present study produced indications that rotating shift work could be harmful for pregnancy. Altogether, the available research data are not ample. Thus further studies on the possible effects of different work schedules on pregnancy are needed.

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Travailler la nuit? Mais dans quelles conditions?

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La démarche présentée dans cette note consiste, à partir d'un état des lieux, à analyser les difficultés rencontrées par les travailleurs postés dans l'exercice de leur activité ainsi qu'à expliciter les conséquences du travail en horaires inhabituels.

De la confrontation de ces diverses données, il apparait qu'il n'existe pas de solution unique, ni même un catalogue de bonnes solutions où il serait possible de trouver la réponse au cas particulier de chaque entreprise. Aussi, les aménagements proposés pour chaque paramètre sont présentés sous forme d'options analysées en termes d'avantages et d'inconvénients, permettant d'élaborer des compromis en connaissance de cause.

Working at night: but how?

On the basis of an initial inventory, this data sheet analyses the difficulties encountered by shift workers in the exercise of their activity and explains the consequences of working at unusual hours.
Comparison of the various data indicates that there is no single solution, nor even a catalogue of satisfying solutions in which each company would find the answer to its particular problem. The arrangements suggested for each parameter are presented in the form of options, the advantages and disadvantages of which are analysed to help the user strike the correct balance advisedly.

Plus de 17 millions des salariés de l'industrie et des services de la Communauté économique européenne étaient en 1978 des travailleurs en équipes successives alternantes. Cette forme particulière d'organisation du travail (travail posté) concernait en France, à cette date, environ 21 % des travailleurs des secteurs secondaire et tertiaire. Le recours au travail posté, après avoir connu une forte progression entre 1950 et 1973 environ, s'est stabilisé jusqu'au début des années 80. Sa croissance reprend depuis 5 ou 6 ans. Ainsi, de 11 % de l'ensemble des salariés français en 1981, le poids des salariés en équipes successives est passé à 12,6 % en 1984. 60 % de ces personnes travaillent en 2 équipes et 40 % en 3, 4, 5 équipes et plus. A l'heure actuelle on estime, en France, que près d'un million de salariés sont directement touchés par la nécessité de travailler, de manière plus ou moins régulière, la nuit.

L'augmentation du travail de nuit (+ 3 à 4 % des salariés en équipes entre 1981 et 1984) résulte au moins d'un double mouvement : d'une part, l'accentuation du poids des contraintes économiques et sociales, d'autre part, la diffusion vers de nouveaux secteurs épargnés jusqu'à présent (agro-alimentaire, organismes d'information, construction électronique par exem-

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ACTIVATION (et son contraire la désactivation) : notion caractérisant le niveau de fonctionnement du système nerveux central sous l'influence de structures cérébrales diffuses. L'intervention de ces structures affecte à la fois les parties hautes du cerveau et les systèmes de contrôle de l'activité motrice.

ALGORITHME : description de la succession organisée des décisions élémentaires conduisant à la réalisation d'une séquence de travail ou à la résolution d'un « problème ».

ASTREINTE : ce terme est utilisé en ergonomie et en organisation du travail. Dans le premier cas, il évoque les effets (le coût) d'une contrainte (d'une exigence) sur les opérateurs. Dans le second cas, il fait référence au temps pendant lequel un salarié doit rester à la disposition de l'entreprise à son domicile afin de rejoindre son poste très rapidement sur simple appel.

BIORYTHMES : voir Rythmes biologiques. A ne pas confondre avec les pseudo-rythmes (dont l'existence n'est nullement démontrée) postulés sans justification scientifique par certains auteurs. Ils rendraient compte de certaines prédispositions (!) certains jours.

CONTINU (travail posté continu) : fonctionnement d'une installation ou d'un service sans interruption ni la nuit ni en fin de semaine. Très souvent, ce mode de travail est qualifié de 3 × 8 ou de 4 × 6 en référence au nombre de postes sur 24 heures.

CYCLE DE ROTATION : nombre de jours séparant le début d'une séquence de travail posté et le retour à cette même séquence. Par exemple, dans un système régulier comportant la succession de 2 après-midi - 2 matinées - 2 nuits et 3 jours de repos, la durée du cycle est de 9 jours.

DÉSACTIVATION (ou déactivation) : voir Activation.

DISCONTINU (travail posté discontinu) : fonctionnement d'une installation ou d'un service avec arrêt en fin de journée et en fin de semaine. Très souvent, ce mode de fonctionnement est qualifié de 2 × 8 en référence au nombre d'équipes par 24 heures.

ÉQUIPE : groupe d'opérateurs effectuant leur travail aux mêmes heures et prenant leur repos les mêmes jours.

ÉQUIPES ALTERNANTES : cas où les travailleurs d'une même équipe sont affectés alternativement aux différents horaires, par exemple × matinées puis × après-midi puis × nuits.

ÉQUIPE DESCENDANTE : équipe qui termine son travail.

ÉQUIPES FIXES : cas où les travailleurs d'une même équipe travaillent toujours à un même horaire (un même poste). Cette situation, assez rare en France en ce qui concerne le travail de nuit, s'observe surtout dans le secteur hospitalier ou dans la presse.

ÉQUIPE MONTANTE : équipe qui vient prendre son travail.

ÉQUIPES SUCCESSIVES : voir Travail posté.

ÉTAT DES LIEUX : première étape indispensable de toute démarche ergonomique. Description préliminaire et globale de la situation rencontrée dans une entreprise. Cet état est fondé sur l'inventaire des paramètres caractérisant les situations de travail et sur l'analyse des relations qui les unissent. Au-delà d'une simple « photographie », il permet de comprendre pourquoi les lieux sont en l'état actuel.

FACTION : voir Poste. Intervalle de temps pendant lequel doit s'effectuer le travail d'une équipe donnée. Très souvent les 24 heures sont découpées en 2, 3 voire 4 factions égales (2 × 12, 2 × 8, 3 × 8, 4 × 6 ...). Il s'agit-là d'un choix purement organisationnel sans justification technique.

MODE OPÉRATOIRE : ensemble organisé d'opérations visant à l'exécution d'une tâche donnée, c'est-à-dire toute action organisée en vue d'obtenir un résultat précis.

NYCTHEMERE : espace de temps comprenant 1 jour et 1 nuit.

O.T.T. (organisation temporelle du travail) : définition de l'emploi du temps compte tenu d'une durée hebdomadaire du travail.

POSTE : peut désigner : 1) l'emplacement où se trouve divers appareils et où se déroule le travail (poste de conduite automobile par exemple); 2) la fonction confiée à une personne (poste de rondier, de chef d'équipe...); 3) enfin, l'intervalle de temps pendant lequel s'effectue le travail pour une équipe (poste de nuit, poste de matinée...). Dans ce dernier cas, « poste » est synonyme de quart ou de faction (voir ce terme).

QUART : synonyme de faction ou de poste.

REPÈRE : ensemble d'options permettant à chacun de se situer au regard des connaissances et des pratiques, et par là d'envisager les transformations en connaissance de cause.

TRAVAIL POSTÉ (ou travail en équipes successives) : forme d'organisation du travail dans laquelle des équipes distinctes se succèdent pour assurer la continuité d'une production ou d'un service.

RELÈVE : moment (et durée) pendant lequel l'équipe montante et l'équipe descendante se transmettent les consignes.

ROTATION COURTE : cas où le nombre de factions identiques est égal à 1, 2 ou 3; exemple : 2 après-midi puis 2 matins puis 2 nuits.

ROTATION INVERSE : affectation successive d'une équipe dans les différents postes selon l'ordre anti-horaire; exemple : travail le matin puis la nuit puis l'après-midi.

ROTATION IRRÉGULIÈRE : cas des systèmes de rotation présentant un nombre variable de factions successives; exemple : 5 matinées, 2 nuits, 5 après-midi, 3 nuits.

ROTATION LENTE : cas où le nombre de factions identiques successives est supérieur à 4; exemple : 7-7-7.

ROTATION NORMALE : succession des postes (matin, après-midi, nuit) dans le sens horaire. Un travailleur fera d'abord les après-midi, puis les nuits puis les matinées.

ROULEMENT (système de...) : voir Cycle de rotation.

RYTHME BIOLOGIQUE : variation systématique d'une fonction biologique ou physiologique montrant une tendance à se reproduire dans un intervalle de temps défini (sa période). Par extension, toute variation similaire d'une fonction psychologique ou d'un comportement. Parmi les rythmes biologiques, ceux dont la période est voisine de 24 heures (rythmes circadiens) sont les plus étudiés (et sans doute les plus perturbés chez les travailleurs postés).

SEMI-CONTINU : fonctionnement d'une installation ou d'un service 24 h sur 24 h, avec arrêt en fin de semaine.

SYNDROME : ensemble des symptômes qui caractérisent une affection, un état pathologique.

TOLÉRANCE (au travail posté) : concept vague faisant référence à une acceptation du travail posté par un travailleur en l'absence de troubles décelables ou mal supportés.

TOURNANTE : voir Cycle de rotation.

ULCÈRE (gastro-duodénal) : plaie de l'estomac ou d'une partie de l'intestin (duodénum), fréquemment rencontrée chez les travailleurs postés après quelques années en poste. L'ulcère doit être distingué des autres troubles gastro-intestinaux résultant de l'irrégularité des repas.

ple). Par ailleurs, de nouvelles catégories de personnel sont touchées (ou risquent de l'être dans les toutes prochaines années), or les connaissances actuelles concernant ces « nouveaux postés » sont bien souvent très insuffisantes. De ce seul point de vue, la levée des restrictions concernant le travail de nuit du personnel féminin est très inquiétante dans la mesure où, à côté de justifications dites égalitaristes, se dessinent des raisons plus profondes concernant la recherche d'une main d'œuvre généralement peu qualifiée, moins onéreuse et très fréquemment soumise à des tâches répétitives. Cette évolution, non seulement pose avec force le problème du travail de nuit, mais elle en modifie aussi les conditions d'exécution (main d'œuvre différente, introduction des technologies de traitement de l'information, conditions socio-économiques particulières).

Le travail de nuit reste donc, hélas, un problème d'actualité et les pronostics les plus optimistes n'envisagent ni sa suppression ni même sa stricte limitation aux besoins collectifs indispensables ou à la sauvegarde des systèmes de production. Dans un tel contexte, le problème est donc de rechercher les conditions les moins défavorables, sachant toutefois qu'aucune solution ne peut être réellement satisfaisante puisque le travail de nuit comporte de nombreuses variables dont les effets sont contradictoires. Ceci n'implique pas pour autant que toutes les solutions se valent. Certaines accentueront les effets indésirables, d'autres tendront à limiter les conséquences les plus négatives. Il nous a donc paru important de fournir aux entreprises et aux partenaires sociaux un cadre de référence au sein duquel l'élaboration des conditions du travail posté dans une entreprise particulière pourra se situer.

Nous avons alors été conduits à élaborer une démarche fondée sur la recherche de « repères » permettant d'éclairer les choix, objets de négociations entre les partenaires sociaux concernés. Cette expérience a donné lieu à la publication d'un ouvrage « Repères pour négocier le travail posté » (4) qui a deux objectifs :

- comprendre les conséquences du travail posté et notamment analyser les mécanismes qui produisent la surfatigue, les effets physiologiques, psychologiques et sociaux étant souvent non évidents parce que non immédiats;

- repérer ce qui est aménageable dans la situation du travail posté, éclairer les choix possibles et proposer une démarche négociatrice pour atténuer les conséquences négatives et obtenir le meilleur compromis possible à un moment donné de la vie d'une entreprise.

Le texte présenté ici est un condensé de cet ouvrage, condensé ayant comme ambition de fournir quelques éléments de réflexion sur l'aménagement (ou le réaménagement) du travail posté, en invitant le lecteur plus directement concerné à se reporter au texte intégral.

Dans l'entreprise où s'est réalisée cette expérience, le travail des postés comporte essentiellement des tâches de surveillance; cet aspect, privilégié dans les exemples, ne doit pas faire oublier que d'autres types d'activités sont également souvent effectués en horaires postés.

INTRODUCTION

Des questions primordiales

De quoi parle-t-on?

- Des systèmes de rotation?
- Des équipes, de leur nombre, de leurs effectifs?
- De la qualification et de la polyvalence?
- De la conception des dispositifs techniques, des tâches?

Qui parle et au nom de qui?

- Les acteurs concernés?
- Le projet de transformation de chacun des groupes?
- Le rôle de chacun dans la démarche?

Qu'entendre par recommandations?

- Des normes?
- Des propositions générales?
- Des repères?

Pour quel usage?

- Une prescription?
- Un outil de réflexion pour les travailleurs?
- Un outil de dialogue entre les partenaires sociaux?

L'organisation du travail en équipes successives

Propositions :

- pas de solution unique;
- pas de solutions toutes faites.

Pour éclairer, présenter des options :
- renvoyant aux connaissances scientifiques et aux pratiques;
- prenant en compte les caractéristiques et les souhaits des personnes concernées.

Des choix :

- susceptibles d'entraîner des transformations des conditions de vie au travail des postés;
- que les acteurs auront à élaborer, mettre en œuvre et évaluer;
- selon les modalités qu'ils auront à définir.

Compte tenu de notre objectif, à savoir élaborer des repères pour éclairer des choix, plusieurs itinéraires peuvent être empruntés. C'est le rôle de la démarche que d'indiquer un (ou plusieurs) chemin(s) possible(s) et d'envisager les moyens à mettre en œuvre. La démarche, quoique précisée dans ses grandes lignes dès le départ, n'est jamais définie une fois pour toutes. Elle fait l'objet de réajustements permanents tout en conservant sa fonction essentielle de « guidage ». La démarche oriente le déroulement :

- au niveau de la nature, de l'ordre et des modalités de recueil des informations;

- au niveau de l'analyse, de la restitution et de la présentation des résultats.

Elle met en œuvre un ensemble de règles dont elle contrôle le respect : anonymat, contrôle de l'information par celui qui l'émet, restitution des résultats à tous les acteurs concernés, avec présentation, à la fin de chacune des étapes, de l'état d'avancement des travaux pour procéder aux réajustements nécessaires.

Ce texte s'organise autour de quelques étapes indissociables au travers desquelles se dessine la démarche.

(4) Ouvrage édité par le Service des publications, Université de Toulouse – Le Mirail (56, rue du Taur – 31000 Toulouse), 1985.

Ces étapes permettent en outre de se doter d'outils méthodologiques afin de répondre aux questions primordiales pour entamer un processus de transformation des conditions du travail posté répondant au mieux aux attentes des personnes concernées. Ainsi formulé, le problème implique donc de :

1° décrire l'état des lieux pour comprendre la diversité des situations tant du point de vue des horaires de travail et du travail effectif que de celui des caractéristiques des personnes. Il est nécessaire d'évaluer l'impact des horaires en tenant compte, d'une part, du travail à faire comme de ses fluctuations et, d'autre part, des modalités réelles de fonctionnement des opérateurs humains compte tenu de leurs caractéristiques individuelles;

2° présenter et discuter les aménagements sous forme d'options pour chacun des critères pouvant faire l'objet de choix en énonçant quelques conditions à réunir pour que ces repères soient susceptibles d'être suivis par des actions transformatrices;

3° recenser les principales conséquences du travail en équipes successives, tant dans la vie de travail que dans la vie hors de l'établissement, à partir des diverses recherches qui ont été menées depuis une cinquantaine d'années par de nombreux organismes dans la plupart des pays.

1. ÉTAT DES LIEUX

Cette première étape a pour objet d'identifier le (ou les) mode(s) d'organisation dans l'unique objectif d'avoir un inventaire le plus exhaustif possible des caractéristiques de chacune des situations de travail dans l'entreprise, tant du point de vue du temps de travail et des tâches que du point de vue de la structure des équipes ou des caractéristiques du personnel.

Il s'agit d'un préalable indispensable. En effet, si les caractéristiques propres à chacun des services s'avèrent différentes, alors cela implique qu'une solution unique ne peut être envisagée.

Une telle étude de l'existant permet de cerner les points communs mais aussi les différences entre les services. Elle permet en outre de disposer d'une base d'informations commune et objective.

Celle-ci sera alors restituée aux différents partenaires qui, dans la grande majorité des cas, ne connaissent pas avec exactitude la situation réelle de leur entreprise, voire de leur propre service.

Au-delà de la « photographie » des lieux, cette première partie a aussi pour objet de comprendre pourquoi les lieux sont en l'état actuel. Ceci implique que la description s'accompagne nécessairement d'une analyse des déterminants de la (ou des) situation(s) rencontrée(s), c'est-à-dire des objectifs poursuivis lors de l'adoption de telle ou telle organisation temporelle. La description doit également comporter des éléments sur les modalités d'élaboration de chaque solution retenue. Ainsi, le choix d'un système de rotation donné a répondu, à un moment donné, à un ou plusieurs objectifs et a pu être imposé (par qui?) ou négocié.

Il s'agit, au-delà de l'anecdote, d'esquisser un *guide méthodologique* permettant de cerner les principales caractéristiques d'un travail en équipes successives et de restituer la diversité, dans une entreprise donnée, des situations impliquant un recours au travail posté.

Il convient enfin de connaître l'opinion des personnes qui ont à supporter le travail posté et, au-delà, de dresser le bilan des attitudes vis-à-vis des solutions organisationnelles en place.

S'agissant d'un premier repérage, les informations recueillies ne pourront donner qu'une image globale de la situation. Cet ensemble de repères permettra cependant d'orienter les recueils et l'analyse ultérieurement.

Les informations peuvent être regroupées selon quatre axes principaux :

a) les informations relatives à l'organisation temporelle du travail, c'est-à-dire à l'organisation de l'emploi du temps, service par service;

b) les informations concernant l'organisation temporelle des équipes, c'est-à-dire le mode d'insertion des hommes dans l'emploi du temps;

c) l'évaluation du travail posté par les personnes concernées. Les attitudes et opinions des postés à l'égard des solutions existantes sont autant de repères qu'il conviendra de prendre en compte lors de la préparation de nouvelles modalités;

d) les informations caractérisant le travail à réaliser, c'est-à-dire non seulement les tâches prévues mais aussi les activités réellement déployées sur les lieux du travail et notamment les éventuelles différences entre le travail de jour et le travail de nuit.

Ce découpage en quatre domaines est arbitraire. Chacun n'acquiert toute sa signification qu'en le reliant avec les autres. Néanmoins, compte tenu des objectifs de cette phase, il se dégage une première vision des caractéristiques principales d'une situation de travail impliquant d'occuper les postes à des heures inhabituelles. Dans la majorité des cas, il ne s'agit pas d'un simple catalogue, certes utile pour guider le recueil d'informations, mais bien d'un ensemble de repères pour faciliter la compréhension des facteurs qui structurent la dimension temporelle du travail.

Ce recensement permet de dégager quelques problèmes que peut poser l'articulation entre la logique d'utilisation des dispositifs techniques dans un contexte organisationnel donné avec la (les) logique(s) de fonctionnement des opérateurs humains.

Enfin, il est important de respecter ici trois impératifs :

a) recueillir les informations dans tous les services impliquant directement ou indirectement du travail posté, continu ou discontinu;

b) combiner plusieurs méthodes d'obtention des données et notamment prendre en compte le point de vue des personnes vivant dans ces situations, mais aussi rechercher dans les archives (CE, CHSCT...) les éléments susceptibles d'éclairer la situation présente à partir de son histoire;

c) restituer l'information recueillie auprès de tous les acteurs et confronter les réactions pour arriver progressivement à un bilan aussi exact que possible.

1.1. Organisation temporelle

1.1.1. Organisation temporelle des services

Pour chaque service, l'organisation temporelle du travail peut être saisie à partir de deux indicateurs : la durée du travail et les horaires de travail. Quel que soit le mode d'organisation, continu, semi-continu ou discontinu, l'objectif d'un service est d'assurer

une production ou une prestation dans les meilleures conditions possibles. Au cours de la période de fonctionnement des dispositifs, le service doit donc assurer ses fonctions dans des conditions de sécurité, de fiabilité et de production optimales.

Les opérateurs humains devront alors maintenir ces conditions, en dépit d'événements plus ou moins aléatoires. Le travail sera déterminé, en ce qui concerne le temps, d'un double point de vue :

– il se déroule sur la base d'une durée fixée,

– les conditions d'utilisation du temps sont définies par diverses caractéristiques organisationnelles.

Ainsi, les 39 heures hebdomadaires actuelles peuvent être effectuées uniquement de jour, avec ou sans interruption entre 12 et 14 heures, ou bien en 2 x 8 ou encore en continu. Des pauses peuvent intervenir, ou non, pendant le travail... En ce qui concerne le travail en équipes successives, la réalité se révèle souvent bien complexe car les notions de jour, de semaine... ne signifient pas toujours la même chose. De même, il est parfois difficile d'identifier ce que la notion de durée du travail recouvre.

1.1.2. Organisation temporelle des équipes

Pour une durée hebdomadaire de travail (moyenne) déterminée et des conditions temporelles définies, l'organisation temporelle des équipes va imposer les modalités d'insertion des travailleurs dans l'emploi du temps. Nous examinerons successivement les différentes options mises en œuvre puis les caractéristiques des personnes impliquées.

Deux options de base vont déterminer la situation du personnel. La première concerne le mode d'occupation des factions. La seconde a trait au choix des systèmes de roulement (ou tournantes ou cycles de rotation). Par ailleurs, diverses dispositions, souvent négligées dans l'approche du travail posté, vont faciliter ou au contraire aggraver les conditions de travail et de vie des travailleurs en équipes.

a) Mode d'occupation des factions

Une équipe peut soit occuper en permanence une même plage horaire (équipe fixe), soit, au contraire, être affectée successivement aux différentes factions (équipe alternante).

b) Les notions de rotation, roulement ou tournante, se réfèrent « à la succession des diverses phases de travail de nuit, de matin, d'après-midi et de repos dans le cadre d'un travail posté » (FUC – CFDT – Sommeil à vendre? 1982).

Par exemple, les trois grands types de rotation régulière (tableau I) ont été observés dans l'entreprise étudiée :

– des rotations lentes, puisque, dans ce cas, les postés restent 7 jours dans la même faction ①.

– des rotations peu rapides puisqu'elles font rester le posté 4 jours ② dans la même faction;

– des rotations très rapides puisqu'elles ne font rester le posté que 1 jour dans la même faction du matin, d'après-midi ou de nuit ③.

Par ailleurs, des rotations plus complexes, dites irrégulières, se rencontrent également dans l'entreprise étudiée ④.

En résumé, l'organisation temporelle du travail répartit les travailleurs à l'intérieur de l'enveloppe préalablement définie. Elle fixe le mode d'insertion de chaque individu dans ce cadre, détermine les obligations de service et délimite la gestion personnelle du temps par les travailleurs postés. Il va de soi qu'aucune de ces dispositions n'est indépendante des autres : l'emploi du temps nécessite pour être mis en œuvre une organisation temporelle des équipes et celle-ci ne s'établit qu'à l'intérieur d'une enveloppe de temps donnée. Si certains paramètres comme la durée du travail sont imposés de l'extérieur, d'autres font l'objet de choix et de négociations. A ce niveau, de très importantes marges de manœuvre existent.

TABLEAU I

Quelques exemples de roulement pour des services fonctionnant en continu dans l'entreprise étudiée

			Heures de début et de fin	Durée des factions
①	MMMMMMM AAAAAAA NNNNNNN RR RRR R RRRRR HAHAHA	(sur 5 sem.)	04 h 30-12 h 30 12 h 30-20 h 30 20 h 30-04 h 30 08 h 00-16 h 00	08 h 00 M 08 h 00 A 08 h 00 N 08 h 00 HA
②	NNNN NNNN RRRR RRRR RR RR JJJJ HA		18 h 30-06 h 30 06 h 30-18 h 30	12 h 00 N 12 h 00 J
③	M M M M M M M A A A A A A A N N N N N N N RR RR RR RR RR RR RR		07 h 30-12 h 30 12 h 30-20 h 30 20 h 30-07 h 30	05 h 00 M 08 h 00 A 11 h 00 N
④	1re semaine, 35 h M R R R N N N 2e semaine, 45 h R A A N R R R 3e semaine, 36 h N N N R A R R 4e semaine, 42 h 30 HA HA HA HA HA R R 5e semaine, 43 h 30 R ou HA M M A R A A 6e semaine, 37 h 15 A R R M M M M		07 h 00-14 h 15 14 h 00-22 h 15 22 h 00-07 h 15 08 h 00-16 h 30	07 h 15 M 08 h 15 A 09 h 15 N 08 h 30 HA

A : après-midi; HA : journée horaire « administratif »; J : journée (horaire non « administratif »); M : matin; N : nuit; R : repos.

1.2. Personnes concernées par le travail posté

1.2.1. Caractéristiques du personnel

La définition d'un emploi du temps et l'insertion des équipes dans cet organigramme concernent des individus précis et non des « travailleurs », terme vague recouvrant une réalité hétérogène. Le poids du travail, et notamment du travail posté, ne sera pas ressenti de manière identique d'un travailleur à l'autre et les conséquences en seront différentes. L'âge, la pratique des 3 x 8 depuis de nombreuses années, en particulier, jouent un rôle important dans la tolérance au travail posté.

De même, la composition des équipes dépend pour partie de l'expérience professionnelle de chacun de ses membres. Enfin, pour prendre un dernier exemple, la qualification attendue peut conduire à prévoir dans l'emploi du temps des possibilités de formation (continue ou complémentaire).

Les quelques cas évoqués ci-dessus conduisent donc à décrire, aussi précisément que possible, les caractéristiques du personnel travaillant dans un contexte temporel déterminé (tableau II).

TABLEAU II

Fiche sur les caractéristiques du personnel posté : informations devant être recherchées

1. Age.
2. Sexe.
3. Nombre d'années passées en travail continu, semi-continu, à la journée.
4. Date d'embauche.
5. Ancienneté dans le service et au poste de travail occupé actuellement.
6. Principaux services fréquentés auparavant (nombre d'années).
7. Formation initiale.
8. Formation acquise en cours d'emploi (et temps nécessaire).
9. Qualification estimée, reconnue, mise en œuvre.
10. Y a-t-il eu dépôt de demande de mutation? Si oui : quand, pour quelles raisons, quelle est la réponse donnée...?
11. Le contrat d'embauche comportait-il une clause concernant l'acceptation, en cas de besoin, de travailler en continu?
12. En cas de promotion, le nouveau poste implique-t-il un travail posté?
13. Situation familiale (âge des enfants).
14. Distance (et temps) pour se rendre du domicile à l'entreprise.
15. Type de logement (maison individuelle, collectif...).
16. Y a-t-il une chambre insonorisée ou, tout au moins, calme?
17. Problèmes de santé.

Remarque

> Dans notre étude, les données recueillies montrent une hétérogénéité des caractéristiques de l'âge dans un même service et dans l'entreprise. Ainsi, dans un service donné, les travailleurs postés les plus jeunes avaient 26 ans et les plus âgés 56 ans.

1.2.2. Opinions du personnel sur l'organisation du travail posté

Il ne saurait être question de reproduire ici, ni même d'aborder, tous les thèmes évoqués par les travailleurs postés, mais aussi l'encadrement ou les chefs de service. A titre d'exemple nous reprendrons ci-dessous quelques thèmes rencontrés.

Si l'on se réfère aux déclarations les plus fréquentes des opérateurs de l'entreprise étudiée, on retrouve avantages et inconvénients.

• *Les avantages déclarés* apportés par certaines tournantes portent sur :

– les heures d'embauche qui se rapprochent le plus des horaires familiaux,
– les possibilités de conserver les heures habituelles de repas,
– des périodes de repos assez longues,
– le fait d'avoir choisi les horaires,
– les facilités de circulation.

Sur un plan plus général, les avantages de ce type d'horaires sont :
– une certaine liberté,
– des avantages financiers.

• *Les inconvénients signalés le plus souvent sont :*

– le nombre insuffisant de week-ends,
– le nombre de nuits consécutives,
– l'alternance qui est pour certains plus perturbante que la régularité des postes,
– le recyclage lors de la réadaptation aux horaires postés après vacances, week-ends, travail en horaire administratif,
– la sensation d'un temps « haché »,
– les difficultés pour la vie familiale, pour avoir des loisirs réguliers,
– les problèmes de formation,
– la marginalisation : « on est un peu à part »,
– la difficulté de faire le travail compte tenu des effectifs.

Certains craignent que l'âge affaiblisse leurs facultés de récupération. Pour d'autres, l'âge ne semble pas poser de problème particulier. Ils sont conscients d'une sélection de fait : « c'est ceux qui supportent qui restent ».

Enfin, pour la plupart, le travail selon ce type d'horaires doit pouvoir n'être qu'une étape dans la vie professionnelle, à la fois pour des raisons de santé et de vie personnelle.

Par delà l'inventaire de points particuliers, l'accent a été mis sur des *aspects primordiaux pour les opérateurs*. Ainsi, a été clairement exprimée la nécessité :

• *d'associer le personnel à l'élaboration des choix :*

– « le tour le meilleur sera toujours celui qu'on aura élaboré »;
– « si le changement est impératif, que ce soit nous qui l'amenions »;
– il faut « réfléchir ensemble aux modifications ».

• *de tenir compte de chacune des situations de travail :*

« Le système (horaire) doit être adapté à la condition opérationnelle du service ». Cette remarque est de toute première importance car elle indique aussi, en raison d'un travail différent

d'un service à l'autre, qu'il serait dangereux de vouloir imposer le même type d'organisation des horaires.

• *de pouvoir évaluer les solutions retenues :*

– « le tour le meilleur sera toujours celui qu'on peut modifier »;
– le système de rotation convient à ceux qui y sont soumis parce que ce tour « a été élaboré par les postés..., les anciens l'ont rodé ».

Apparaît donc l'idée que, quelle que soit la solution, il faudra l'expérimenter pour l'évaluer : cela signifie qu'il faut avoir la possibilité de faire évoluer les choix puisqu'au cours des années les évaluations peuvent changer.

1.3. Le travail à réaliser en horaires postés : activités et conditions d'exercice

Les descriptions précédentes, relatives à l'organisation du cadre temporel et à l'insertion du personnel dans ce cadre, doivent être complétées par un examen des caractéristiques du travail à réaliser. En effet, les effets du travail, pour des opérateurs donnés, sont étroitement dépendants des exigences du travail et de la nature des activités mises en œuvre. Ces activités résultent des conditions externes de réalisation du travail (nature des tâches, moyens matériels...), des conditions d'exécution (cadre temporel, espace de travail, ambiances physiques, contraintes de temps et/ou de précision, quantité et qualité de la production...) et enfin des conditions internes, propres aux opérateurs, que celles-ci soient d'ordre biologique (âge, état de santé...), psychologique ou socioprofessionnel.

On peut définir des options au plan de l'emploi du temps : choix du mode de travail (discontinu, semi-continu, continu), du nombre de factions, des modalités d'occupation de ces factions (fixes, alternantes), de leur durée, de leur localisation ou de leur succession. Mais, comment analyser chacune de ces options sans connaître le travail qui se déroule dans ce contexte, sans avoir étudié l'activité réelle de ceux qui travaillent dans ce contexte?

L'objet ici est donc d'inviter ceux qui ont à structurer l'enveloppe temporelle du travail, à réfléchir, avant toute décision, sur la manière dont le travail est réalisé concrètement et sur les conditions réelles d'une activité impliquant d'être actif de nuit.

Cette étape vise à apporter, non des réponses précises, mais au moins des éléments de réflexion pour que ceux qui auront à élaborer, négocier, mettre en œuvre ces choix, le fassent à partir de cette réflexion préalable.

Celle-ci s'articule autour de trois niveaux indissolublement liés.

a) Il s'agit, tout d'abord, du travail *demandé* (qui diffère d'un service à l'autre), des tâches et des moyens techniques utilisés ainsi que de l'organisation du travail et de son environnement physique.

b) Le travail à faire est en général défini par les responsables en termes d'objectifs à atteindre, de tâches à remplir, éventuellement de procédures, d'algorithmes à suivre. Mais, pour l'opérateur, la question est de savoir comment il va pouvoir remplir ces objectifs : quelles sont les informations dont il a besoin? Quelle décision doit-il prendre? Quels modes opératoires va-t-il employer? Quel contrôle du résultat de son activité va-t-il rechercher?

Il s'agit donc de connaître les *activités réellement effectuées* pour exécuter le travail par les opérateurs et non celles qui sont prescrites par les consignes et plans de travail. De nombreux travaux ont montré, en effet, des différences notables entre ces deux facettes et qu'en général, il existait une grande méconnaissance, entre autres, des difficultés réelles de la tâche pour l'opérateur. L'évaluation de ce qu'il est convenu d'appeler la « charge de travail » (c'est-à-dire le coût pour l'opérateur de la mise en œuvre des fonctions nécessaires à l'exécution de la tâche) ne peut se faire valablement à partir de la définition théorique des tâches, mais seulement à partir de la façon dont elles sont réalisées : procédures opératoires utilisées, processus mentaux sous-jacents dont on sait qu'ils varient d'un opérateur à l'autre mais aussi chez un même opérateur.

Mettre l'accent sur cette connaissance est important surtout dans une phase d'évolution telle que la connaissent à l'heure actuelle bon nombre d'établissements. Les transformations à la fois techniques (nouvelles fonctions – nouveaux matériels) et organisationnelles entraînent des modifications des tâches habituelles. Celles-ci ne sont pas faciles à percevoir et nécessitent la mise en œuvre d'outils d'analyse qui restent à élaborer et à mettre à la disposition des intéressés eux-mêmes.

Ces caractéristiques des tâches déterminent les activités physiques, perceptives, mentales par lesquelles les opérateurs réalisent le travail, en fonction de leur propre état.

Ces trois classes d'activité ne sont pas indépendantes les unes des autres, elles fonctionnent en interaction (l'activité physique retentit sur l'activité mentale), mais elles fonctionnent également en dépendance (l'activité mentale organise et commande l'activité physique et perceptive). Aussi, il importe de ne pas perdre de vue, dans toute analyse, les liens entre ces différentes composantes. Or, pour l'observateur extérieur, seul le geste est visible (mouvement, parole, etc.), c'est-à-dire le résultat de l'activité mentale préalable qui a été nécessaire pour aboutir à l'action mais qui, elle, est non perceptible, donc méconnue la plupart du temps. Ceci conduit à des préjugés tenaces dans l'appréciation de la charge de travail : par exemple il est courant d'entendre dire que dans les tâches de contrôle et de surveillance où (sauf en cas d'incident – on reviendra sur cette notion) il ne se passe rien, tant que l'opérateur n'a rien à faire, « il ne fait rien ».

Cette conviction est d'autant plus forte qu'avec les progrès de l'informatisation, la plupart des procédures sont automatisées et le travail de l'opérateur semble négligeable sinon inutile.

Une telle méconnaissance amène parfois à confier des travaux annexes à l'opérateur qui effectue le contrôle de qualité des produits dans l'industrie, par exemple. Celui-ci se trouve alors en conflit permanent de priorité entre les différentes tâches. Cette situation comporte des risques à la fois pour le travail (erreurs, oublis) et pour l'état mental de l'opérateur (situation anxiogène).

Enfin, le travail demandé s'effectue dans des *conditions particulières de réalisation*. Ces conditions influent sur les exigences du travail et sur l'état des opérateurs : mode d'organisation particulier et conditions matérielles spécifiques.

Les liens entre activité des opérateurs et horaires de travail révèlent donc des relations complexes que le contexte de travail semble moduler.

c) Il s'agit, enfin, des *effets de cette activité sur les opérateurs*, effets dont la variabilité dépend à la fois des caractéristiques de chacun et des tâches à réaliser.

1.4. L'état des lieux : un préalable enrichissant

Au cours de la première partie ont été explorés divers domaines concernant, d'une part, l'organisation temporelle du travail et des équipes, d'autre part les aspects relatifs aux travailleurs postés (caractéristiques du personnel concerné, opinions et attitudes vis-à-vis des modalités organisationnelles existantes), enfin les caractéristiques des tâches et des activités de travail.

Cette première étape visait à caractériser « l'état des lieux » tant d'un point de vue technique et organisationnel que d'un point de vue humain. Un tel repérage conduit : a) à répertorier les critères pertinents du point de vue de la description de la situation de travail; b) à identifier les liens qui unissent ces critères et qui tissent la trame du contexte temporel du travail des postés; c) enfin, à dégager les grands thèmes de réflexion sur lesquels il conviendra maintenant d'insister.

Cette première approche se révèle très fructueuse car elle permet : a) de constituer un ensemble de connaissances communes servant de base de référence lors de l'élaboration des recommandations; b) de mieux saisir la réalité et l'étendue des problèmes ayant conduit à la formulation d'une demande d'intervention; c) de dégager les pistes prioritaires pour l'analyse ultérieure; d) de dessiner déjà les grandes orientations pour la mise en œuvre des transformations souhaitées. Dans bien des cas, cette « mise à plat » de la situation conduira, d'une part, à préciser la demande et, d'autre part, à clarifier les objectifs et les moyens à développer pour les atteindre. Par là, ce premier repérage oriente la méthodologie des étapes suivantes. Dans l'étude de cas sous-jacente ici, il apparaît une *diversité* des situations de travail tant sous l'angle de l'organisation du travail que sous celui des tâches ou encore des caractéristiques du personnel. Cette diversité, au-delà de son caractère anecdotique, révèle que l'organisation du travail posté n'est ni rigide ni totalement contrainte. Des choix existent qu'il conviendra d'examiner plus attentivement. Mais, cette diversité témoigne aussi du fait qu'il n'existe pas *une seule* solution et qu'aucune des solutions n'est totalement satisfaisante : il s'agit toujours de *compromis* reposant sur la recherche, souvent implicite, d'un équilibre, plus ou moins atteint, entre aspects positifs et aspects négatifs.

Il y a (au moins) 5 domaines (fig. 1) concernés par les horaires; ils ont chacun des exigences qui peuvent se

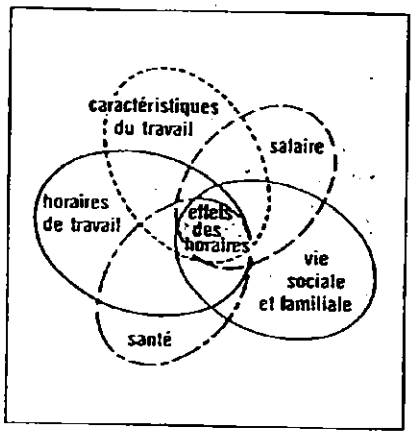

Fig. 1. Domaines concernés par les horaires.

révéler contradictoires entre elles; il faut donc choisir un compromis « en connaissance de cause » à partir de deux catégories de données (terrain, scientifiques), dans les différents domaines concernés; il faut enfin rassembler toutes les connaissances pertinentes en les structurant.

2. LA RECHERCHE DES AMÉNAGEMENTS

2.1. Objectif

La dernière phase de la démarche a pour objet d'éclairer les choix en proposant, pour chacun des paramètres pouvant faire l'objet d'aménagements, des *options*. L'idée d'option traduit le fait qu'il n'y a pas de solution unique mais bien des alternatives. Le choix de telle ou telle option appartient aux acteurs concernés.

> Les options présentées devraient permettre à chacun de se situer par rapport aux connaissances et aux pratiques existantes et par là d'envisager les transformations en connaissance de cause.

L'ensemble de ces indications constitue ce que nous appellerons *repères*.

2.2. Principes sous-jacents à l'élaboration des repères

Les repères reposent sur un ajustement au contexte scientifique et technique mais aussi au contexte social. Ils sont élaborés compte tenu de l'état des connaissances à un moment donné et de l'évolution des techniques. L'évolution probable de chacun de ces champs impose de considérer ces repères comme relatifs et susceptibles de transformations. De même, la nature du contexte social peut agir sur les stratégies d'acceptation ou de contestation du travail en équipes successives. Des modifications dans ces stratégies risquent, si ce n'est de rendre obsolètes ces repères, tout au moins d'en accentuer certains aspects et d'en diminuer d'autres. Les repères présentés portent donc les limites des connaissances acquises et de l'usage social qui les rend possibles, voire nécessaires. Ils ont été élaborés sur la base de quelques *principes* relatifs à l'organisation temporelle du travail (OTT) présentés ci-dessous.

Il n'existe pas de solution unique d'OTT acceptable par ceux qui y sont soumis

S'agissant d'OTT impliquant d'être actif la nuit, ce principe est de toute première importance : il indique qu'il n'y a pas de bonne solution pour organiser le travail posté. Dans le meilleur des cas, le caractère anormal du travail de nuit se traduira par une « transformation » des personnes considérées comme bien « adaptées ».

Il n'y a pas de déterminisme absolu de la technologie sur l'OTT

De manière générale, on peut dire que l'extension du travail en équipes successives relève d'une augmentation des durées d'utilisation des matériels. A même technologie correspondent des modes d'OTT différents. La technologie dans son état actuel peut influencer le *mode* d'OTT non les *modalités* pratiques.

L'OTT fait l'objet de choix

Ces choix concernent essentiellement 3 domaines :

– l'organisation de l'enveloppe temporelle (durée et horaires), donc l'emploi du temps;
– les modalités d'affectation des opérateurs humains dans cet emploi du temps;
– la conception du fonctionnement des installations et du travail à faire.

Il n'y a pas de domaine séparé mais interaction entre domaines

Il est impossible de définir une option dans un domaine particulier sans en envisager les conséquences sur les divers paramètres des autres domaines.

L'OTT peut renfermer des contradictions

Toute mesure est susceptible de se révéler positive d'un certain point de vue mais négative par ailleurs. Il conviendra donc d'évaluer conjointement les avantages et les inconvénients.

L'OTT se traduit par des compromis à négocier et évaluer

Ces compromis doivent être élaborés, négociés, mis en œuvre, évalués avec ceux qui auront à vivre dans le contexte de travail ainsi défini. Les repères présentés n'ont d'autre objectif que d'aider les acteurs concernés à élaborer ces compromis : ils sont donc ***préparatoires*** à la mise en œuvre des compromis. Ils doivent aussi permettre, ultérieurement, d'évaluer les conséquences des choix effectués.

L'ensemble des compromis constitue des indications provisoires

Ils devront faire l'objet d'une évaluation de leurs résultats ou de leurs difficultés d'utilisation. Leur révision s'ajustera aussi en fonction de l'évolution des connaissances et des pratiques sociales concernant l'organisation temporelle du travail.

2.3. Domaines des solutions

Trois principaux domaines ont donc été explorés :

– les aménagements se rapportant à l'organisation temporelle du travail et des équipes;
– les aménagements se rapportant aux personnes;
– les aménagements se rapportant au travail et à ses conditions d'exécution.

Ces repères sont présentés sous forme de fiches pour en faciliter l'usage. Celles-ci sont conçues comme un *outil de travail* permettant aux acteurs concernés d'élaborer des choix.

Les repères sont abordés à la fois du point de vue de leur objet, des alternatives qui peuvent être associées, et du point de vue de leurs implications pour les opérateurs humains. Ces implications sont envisagées sous l'angle des avantages et inconvénients qu'elles suscitent. Enfin, chaque repère est associé aux principaux autres repères susceptibles de l'influencer.

Un tel usage des fiches suppose néanmoins qu'un ensemble de conditions soient remplies pour que la recherche des aménagements soit suivie d'actions concrètes transformant positivement les conditions de vie et de travail du personnel posté.

2.4. Mode d'utilisation des repères : la démarche

Il va de soi que la notion même de repère implique de ne pas utiliser de solutions préétablies : il appartient aux acteurs sociaux de préciser leurs priorités en fonction de leurs propres stratégies et d'y associer les moyens nécessaires. Il ne s'agit donc pas de recettes toutes faites qu'il suffirait d'appliquer.

Il ne s'agit pas non plus d'un simple catalogue de critères dont la seule juxtaposition permettrait de les rendre cohérents. Les repères énoncés nous semblent devoir être insérés dans une démarche d'ensemble qui fait donc aussi l'objet de quelques repères sans lesquels l'utilisation des informations présentées risquerait de contredire les objectifs définis ci-dessus (cf. conclusion § A).

Il n'est pas possible de présenter l'ensemble des fiches dans le cadre de cet article. Aussi nous en donnons la liste (2.5.)(5) qui elle-même peut être enrichie et deux exemples illustratifs se rapportant le premier (2.6.A) à l'organisation temporelle des horaires, et en particulier « les heures de début et de fin de poste », le second (2.6.B) à l'organisation temporelle des équipes et en particulier « les effectifs par équipe ».

2.5. Liste des thèmes abordés

A. Aménagements se rapportant aux horaires de travail

A1 : mode de travail.

A2 : postes ou factions (nombre et durée).

A3 : recouvrement de postes.

A4 : pauses.

A5 : repas.

A6 : heures de début et de fin de poste.

B. Aménagements se rapportant aux équipes et aux personnes

En ce qui concerne *les équipes :*

B1 : le mode d'occupation des factions : fixe ou alternant.

B2 : le système de rotation : très rapide, rapide ou lent.

B3 : l'intervalle entre deux factions occupées par une équipe.

B4 : enfin, la localisation des équipes sur les factions.

Alors devront être envisagées les caractéristiques de l'équipe :

B5 : nombre d'équipes : faut-il se limiter à 5 équipes?

B6 : effectifs par équipe : combien de personnes par équipe?

En ce qui concerne *les personnes :*

B7 : les repos consécutifs à plusieurs factions et ceux de fin de cycle.

B8 : les modalités de remplacement pour faire face à une absence.

B9 : la polycompétence et la mobilité au sein de l'équipe.

B10 : la formation : peut-on suivre une formation quand on est posté?

B11 : le reclassement : comment réinsérer ceux qui ne peuvent plus travailler en horaire continu?

B12 : la prolongation des factions : comment assouplir les contraintes de présence?

B13 : les trajets : peut-on limiter les risques liés aux trajets?

B14 : les congés : peut-on prendre ses congés lorsqu'on le souhaite, quand on est posté?

(5) Nous conservons ici la numérotation de l'ouvrage de référence, pour faciliter la recherche d'informations de ceux qui voudraient s'y rapporter, bien qu'elle ne corresponde pas tout à fait à la présentation exposée ici.

B15 : participation à la vie de l'entreprise : les postés ne sont-ils pas marginalisés, voire exclus de la vie sociale et culturelle de l'entreprise?

B16 : la retraite : peut-on prévoir des modalités de diminution progressive de l'activité à partir d'un âge à définir, quand on a été travailleur posté?

...

C. Aménagements se rapportant au travail et à ses conditions d'exécution

C1 : les horaires ne peuvent être aménagés qu'en référence au travail réel qui se déroule dans ce contexte temporel.

C2 : le travail doit être conçu et organisé en fonction de son caractère continu.

C3 : le travail et ses horaires doivent être aménagés en tenant compte des conditions particulières d'environnement la nuit (bruit, toxiques, température, etc.).

C4 : le travail et ses horaires doivent être aménagés en fonction des personnes qui auront à développer leurs activités.

2.6. Exemples de fiches « repères »

A. AMÉNAGEMENT DES HORAIRES

Thème A6 - **Heures de début et fin de poste**

1. OBJET

Elles délimitent :

– d'une part l'heure à laquelle les équipes se succèdent,
– d'autre part le début et la fin du travail et le début et la fin de la vie hors de l'entreprise.

Remarques

Le choix du début et de la fin d'un poste a des incidences :

– sur le sommeil,
– sur le moment et le lieu de la prise des repas,
– sur le transport (moment du trajet pour se rendre au travail ou en sortir),
– mais aussi sur la fiabilité humaine.

2. OPTIONS

– 3 types de situations se présentent pour la fin de poste et le début du poste suivant dans l'entreprise étudiée :

Exemple 1	Exemple 2	Exemple 3
3 h - 11 h - 19 h	4 h - 12 h - 20 h	6 h - 14 h - 22 h

– Prise des repas à domicile et conservation de durées de sommeil quasi normales sont des exigences difficilement conciliables pour des durées égales de chaque poste.

– Même en travail posté, l'aménagement d'*horaire variable* pour tout ou partie de l'équipe est possible.

3. ANALYSE DES OPTIONS

Exemple 1 : 3 h - 11 h - 19 h	Exemple 2 : 4 h - 12 h - 20 h	Exemple 3 : 6 h - 14 h - 22 h
a) Inconvénients		
• Perturbation du sommeil au poste de nuit (19 h - 3 h) et au poste du matin (3 h - 11 h). • Repas pris sur le lieu de travail au poste d'AM et parfois au poste de N. • Matinée de repos précédant le poste d'AM raccourcie. • Temps de transport peut être plus long après le poste d'AM. • Transport collectif public peu probable la nuit	• Perturbation du sommeil au poste de nuit (20 h - 4 h) et au poste du matin (4 h - 12 h)	• Forte perturbation du sommeil au poste de nuit; moindre perturbation au poste du matin. • Repas pris sur le lieu de travail pour les postes du M et d'AM. • Soirée supprimée après le poste d'AM.
b) Avantages		
• Soirée après poste d'AM intacte.	• Moindre décalage des heures de repas à domicile avant ou après les postes de M et d'AM. • Soirée presque normale après poste d'AM.	• Longue matinée libre avant poste d'AM • Transport public envisageable.

La durée inégale des postes peut permettre d'obtenir dans les 3 exemples une plus grande souplesse pour la prise des repas à domicile et pour minimiser les perturbations (au poste du matin) du sommeil.

4. AUTRES THÈMES A CONSULTER

– Mode de travail.
– Nombre et durée des factions.
– Pauses.
– Mode d'occupation des factions.
– Système de rotation (normal-inverse).
– Localisation des équipes.
– Effectifs par équipe.
– Polycompétence.
– Prolongation des factions.

B. AMÉNAGEMENTS SE RAPPORTANT AUX ÉQUIPES

Thème 86 – **Les effectifs par équipe**

1. OBJET

Il s'agit, en fait de deux problèmes :

– du nombre de postes de travail au sein de l'équipe,
– et du nombre de personnes affectées à ces postes de travail.

En théorie, pour 2 postes par équipe, il faut 2 personnes, soit 10 au total dans le cas de 5 équipes.

Remarques

Il n'est pas possible de fixer a priori le nombre de postes de travail que doit comporter chacune des équipes, toutefois :

a) le calcul des effectifs doit se faire en connaissant très précisément *la nature du travail réel* : celui-ci n'est pas la moyenne de situations stables et de situations perturbées (avec incidents). L'irrégularité des exigences du travail impose d'analyser ce que cela implique pour l'activité des opérateurs;

b) la fiabilité du système dépend des conditions permettant aux opérateurs de développer une réponse appropriée;

c) les effectifs doivent tenir compte du fait que tout salarié dispose de congés, de possibilités de formation ou d'activité syndicale, qu'il peut être absent pour maladie ou autre (convenance personnelle, etc.).

2. OPTIONS

Trois types de situation mériteraient un examen approfondi :

a) cas où le nombre de personnes et de postes de travail sont identiques d'une équipe à l'autre;

b) cas où les effectifs sont réduits au cours de certaines factions, notamment la nuit;

c) cas où une mobilité de la répartition des effectifs par équipe est introduite.

Exemple 1
Une équipe est renforcée de façon occasionnelle lors d'un démarrage ou d'une étape complexe, ou bien pour former des collègues;

Exemple 2
Une faction est renforcée, celle de nuit, alors que la faction d'après-midi est réduite.

3. ANALYSE DES OPTIONS

Avantages

a) Effectifs constants
– Stabilité des équipes.

b) Effectifs réduits la nuit
– Moins de personnes faisant les postes.

c) Répartition mobile des effectifs (exemple 2)
– Possibilité de s'adapter aux aléas.
– Possibilité de diminuer le coût du travail posté pour ceux qui le subissent (transfert-report du travail au sein de l'équipe).

Inconvénients

a) Effectifs constants
– Rigidité face à des perturbations.
– Difficultés de distribution mobile du travail.

b) Effectifs réduits la nuit
– Dans ce cas, réduction de la capacité d'intervention de l'équipe, alors que des perturbations peuvent tout autant apparaître au cours des 3 factions et que, la nuit, les opérateurs ont une capacité fonctionnelle réduite.
– Problèmes de la solitude de nuit.

c) Répartition mobile des effectifs
– Plus de personnes sollicitées pour un travail de nuit.

4. AUTRES THÈMES A CONSULTER

– Pauses.
– Heures de début et de fin des factions.
– Localisation des équipes sur les factions.
– Polycompétence.
– Formation.
– Reclassement des travailleurs postés.

3. L'INDISPENSABLE APPORT DES CONNAISSANCES POUR EFFECTUER LES CHOIX

Nous venons de voir que l'aménagement du travail posté implique de retenir des options, parfois contradictoires, et de rechercher le meilleur compromis possible dans une situation concrète (atelier, service, entreprise). Ces choix reposent sur un ensemble de données dont certaines proviennent des nombreuses recherches effectuées dans ce domaine. Il convient donc ici de les expliciter succinctement.

3.1. Un problème de fond : la rythmicité circadienne des capacités humaines

Il n'est pas pensable de parler du « travail posté » sans en aborder les conséquences pour le travailleur et sa famille. Il convient cependant de ne pas négliger les problèmes inhérents à l'exécution du travail lui-même. Dire que « le travail de nuit c'est pénible » ne suffit pas à comprendre pourquoi. On réduit par ailleurs les difficultés dues à de la fatigue supplémentaire et on sous-estime le coût réel du travail nocturne ou les risques encourus par les hommes et les installations. C'est sur cette sous-estimation qu'est bâti le travail posté. En effet, l'organisation du travail en équipes successives se relayant tout au long des 24 heures repose, sans le dire, sur l'idée que des équipes différentes assureront à des heures différentes le même travail, de la même façon. En d'autres termes, on suppose que l'homme est stable, aussi performant et aussi efficace, quelle que soit l'heure du jour ou de la nuit. Sans nier l'existence de la fatigue ou le caractère pénible de l'activité nocturne, ces modèles considèrent que les opérateurs peuvent « prendre sur eux » et réaliser correctement les tâches qui leur sont confiées : ne sommes-nous pas capables de conduire notre voiture à 4 heures du matin? Oui, mais à quel coût et avec quels risques?

Dans cette perspective, la réponse du monde du travail consiste, dans la majorité des cas, à monnayer les inconvénients du travail de nuit, mais aussi de week-end ou de jour férié comme si une heure de travail l'après-midi du 14 juillet équivalait aux 2/3 d'une heure de travail la nuit. De plus en plus, ces inconvénients sont négociés non en avantages financiers, mais plutôt en réduction d'horaire de travail. Si cette dernière solution, quand elle est bien conduite (réduction du nombre et/ou de la durée des vacations, abaissement de la durée hebdomadaire du travail et non augmentation systématique des congés annuels par exemple) représente une réponse positive aux difficultés rencontrées, elle ne doit cependant pas masquer les problèmes de fond.

L'homme, comme tout être vivant, est soumis à des *rythmes biologiques* (voir encadré « Chronobiologie ») qui affectent le fonctionnement de son organisme. Ces rythmes confèrent aux êtres vivants une véritable structure temporelle dont les perturbations ne sont pas sans danger.

La rythmicité du fonctionnement humain se répercute bien évidemment sur les activités de travail. De ce fait, elle contredit le travail posté dans ses fondements et notamment dans ses postulats de stabilité et de fiabilité permanentes de l'homme. Nous aborderons donc les conséquences du travail en continu et nous illustrerons brièvement l'impact des rythmes circadiens sur les activités de travail et leurs résultats.

La Chronobiologie

La chronobiologie est l'étude des rythmes biologiques.

L'observation d'un animal pendant un temps assez long permet de constater l'alternance de moments de forte activité contrastant avec des moments de faible activité. Ces variations ne se distribuent pas au hasard. Elles se reproduisent à intervalles réguliers. Nous dirons que l'animal présente des cycles d'activité. Il s'agit là d'une première manifestation des rythmes biologiques. Ceux-ci sont présents chez tous les êtres vivants, l'homme y compris.

Les rythmes biologiques possèdent trois *caractéristiques* principales : *1)* ils affectent toutes les cellules, toutes les fonctions d'un organisme et par là modulent ses capacités fonctionnelles à tout moment; *2)* ils sont assimilables, en première approximation, à une fonction sinusoïdale dont il est alors possible de caractériser les paramètres et notamment la période. Celle-ci évalue l'intervalle de temps entre deux passages à un état identique : quelques minutes, un jour, un mois, une année ...; *3)* ils peuvent affecter une même fonction selon des périodes différentes. Ainsi, la température du corps varie, chez l'homme, au cours des 24 heures (on parle alors de rythme circadien), mais aussi au cours de l'année (rythme annuel).

L'existence de telles rythmicités a deux *conséquences* essentielles : *1)* toutes les fonctions biologiques (régulation de la température du corps ou des paramètres sanguins, secrétions hormonales, capacités cardiaque et respiratoire...) et les fonctions psychophysiologiques (sensibilité à la douleur, vitesse et précision des gestes, force, mémoire, détection de signaux...) en étant affectées, nos capacités à effectuer une certaine activité (y compris un travail donné) sont essentiellement variables. Ainsi, à certaines heures, nos réponses seront peut-être rapides mais pas forcément exactes; alors qu'à d'autres heures nous réagirons moins vite mais avec une plus grande exactitude; *2)* toute perturbation dans le déroulement normal des rythmes s'accompagnera d'une désorganisation de notre fonctionnement et d'un coût supplémentaire pour maintenir une activité même apparemment modérée. Ces difficultés sont à l'origine d'une pathologie reconnue (voir dernière partie) en cas de décalage horaire comme c'est notamment le cas dans le travail posté.

3.2. Horaires de travail et organisation de l'activité

Nous avons vu précédemment que le travail réellement effectué n'était pas identique au travail théoriquement prévu, que ce dernier n'était pas toujours le même de jour ou de nuit, enfin que les capacités humaines variaient au cours des 24 heures. On ne saurait cependant en rester à une conception simpliste de la diminution nocturne des capacités humaines. En effet, si, dans diverses situations, on constate une réduction de l'activité nocturne (surveillance moindre, lecture abrégée, conversations moins nombreuses, changements de posture limités...), en réalité, cette modification quantitative se double de modifications qualitatives. En d'autres termes, le travailleur de nuit n'est pas simple-

ment un individu qui travaille moins, c'est surtout un individu qui travaille autrement. Dans ces conditions, il convient de s'interroger sur la fiabilité de l'opérateur humain dans un système complexe et sur les aménagements indispensables pour faire face aux fluctuations de l'état des opérateurs et pour « empêcher » les conséquences négatives ... (voir encadré « Chronobiologie et ergonomie »).

3.2.1. Structuration de l'activité

Assimiler l'être humain à un « moteur » ou à une « machine » conduit à au moins deux simplifications dangereuses. La première consiste à faire comme si la « machine humaine » pouvait être mise en route à tout moment. La seconde suppose que les capacités de la machine sont fixées une fois pour toutes (usure ou « transformations » mises à part). En fait, les données accumulées depuis une vingtaine d'années sur le fonctionnement rythmique des êtres vivants conduisent à l'idée d'une véritable « structure temporelle ».

Les différentes aptitudes humaines ne sont pas toutes maximales à une heure donnée et minimales à une autre heure. Autrement dit, il peut y avoir plus de différence chez un même sujet entre la nuit, le matin ou l'après-midi qu'entre des sujets différents.

Cette recombinaison permanente des capacités peut alors conduire les opérateurs à utiliser préférentiellement telle ou telle manière de travailler selon les heures. On peut constater que les opérateurs mettent en œuvre de nombreux mécanismes de régulation. Celle-ci peut concerner l'activité d'un opérateur pris isolément ou encore affecter une équipe de travail.

En l'absence de perturbations graves, les activités des opérateurs sont dictées moins par les exigences de la tâche que par la recherche de stratégies compatibles avec leur capacité fonctionnelle du moment. Ainsi, l'analyse de l'activité de surveillance chez des opérateurs assurant, en salle de contrôle, la régulation de processus de fabrication en continu, révèle une importante réduction de l'activité en période nocturne et une activité maximale l'après-midi. Cette variation n'est liée ni aux fluctuations de la production ni aux modifications du contexte organisationnel (absence ou présence de la hiérarchie, des services d'entretien...) (fig. 2).

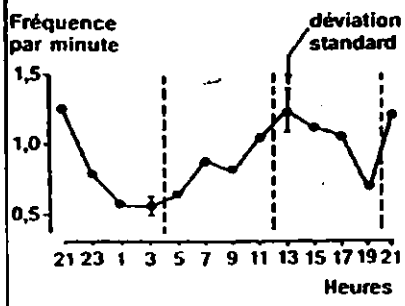

Fig. 2. Variations de l'activité de surveillance (évaluée par la fréquence des changements de direction du regard) chez des contrôleurs de processus continu (secteur de la chimie). Les changements d'équipe ont lieu à 4 heures, 12 heures et 20 heures (d'après De Terssac et coll., 1983).

Dans une industrie chimique, l'étude détaillée de 38 incidents a révélé que l'apparition d'un incident se traduit, au poste de nuit (20 h - 4 h), par une élévation brutale et durable des prises d'information visuelle (leur fréquence triple durant les 5 minutes qui suivent la signalisation de l'incident). Au contraire, au poste d'après-midi (12 h - 20 h), la survenue d'un incident ne provoque qu'une faible réponse passagère (moins d'une minute). Enfin, sans entrer dans le détail des résultats concernant la distribution des regards vers les différentes sources informationnelles, on peut néanmoins préciser que l'apparition d'un incident s'accompagne, la nuit, d'une profonde réorganisation de leur localisation, mais que ceci n'est pas aussi vrai l'après-midi (fig. 3).

Ces exemples posent par ailleurs un certain nombre de questions concernant la pertinence des indicateurs de performance. En effet, celle-ci n'est pas toujours un bon critère. De nombreux travaux ont montré que, pour maintenir une « bonne performance », les opérateurs modifient leur activité et mettent en jeu des mécanismes de régulation coûteux. *En d'autres termes, le coût humain du travail n'est pas toujours visible au travers de la performance.* Dans bien des cas, les travailleurs atteignent un niveau de charge de travail élevé sans pour autant qu'il y ait variation de la performance. Ceci est déjà vrai de jour. La nuit, en raison de la réduction des aptitudes humaines et de la moindre résistance aux contraintes de la situation, les opérateurs pour fournir un même travail doivent faire un effort supplémentaire. Les conséquences sont alors à rechercher au niveau de l'homme et non au niveau du seul rendement. Ce *coût supplémentaire* du travail est aggravé d'une part par la moindre qualité d'un sommeil de

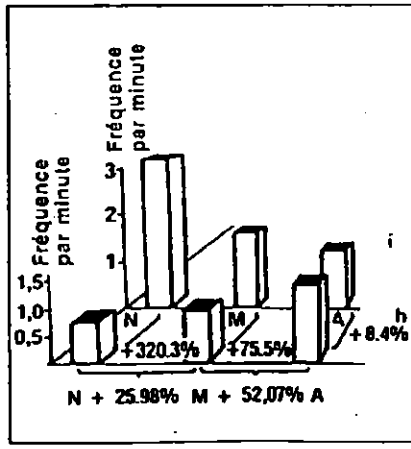

Fig. 3. Variations de l'activité de surveillance de contrôleurs de processus, cinq minutes avant (h : situation habituelle) et cinq minutes après (i : incident) l'apparition d'un incident (d'après Queinnec et De Terssac, 1984).

jour et d'autre part du fait de la conjonction de plusieurs facteurs dont les effets peuvent se renforcer mutuellement. Ainsi, la nuit, la privation de sommeil mais aussi les perturbations du fonctionnement de la mémoire, l'allongement des temps de réponse ou la plus grande difficulté à fixer son attention accroissent la pénibilité du traitement d'informations, d'autant que, bien souvent, ce type de travail implique d'être assis et de lire des listings, un écran... (« et les yeux piquent »). Cette immobilité facilite la somnolence d'où la nécessité « pour tenir le coup, la nuit, de bosser physiquement » et donc d'accroître les contraintes de la situation. Dans ces conditions, il convient de permettre aux opérateurs de « décrocher » à la faveur de véritables pauses; ce qui nécessite, outre la réalisation de salles de repos confortables et fonctionnelles, un nombre suffisant de personnes par équipe pour autoriser, surtout la nuit, une « gestion mobile » des activités. Cette tendance au renforcement des équipes de nuit apparaît actuellement, pour des raisons de sécurité, dans les centrales nucléaires. Nous avons nous-mêmes constaté, dans la chimie, le bénéfice apporté par la présence d'un équipier supplémentaire à une équipe de deux contrôleurs de processus hautement automatisé.

Un opérateur humain ne peut donc traiter de l'information et/ou réagir aussi rapidement et aussi efficacement à toute heure du jour ou de la nuit.

Le dramatique incident de la centrale nucléaire de Three Mile Island confirme, s'il en était besoin, que le fonctionnement différent de l'homme le jour ou la nuit ne permet pas toujours de prévoir les modalités exactes que mettront en œuvre des opérateurs mal préparés à agir et dont les capacités se trouvent modifiées du fait de la durée et/ou des horaires de travail. Attribuer un incident à une « défaillance humaine », justifier une catastrophe par le « facteur humain » ... n'explique rien et ne permet guère de se préparer à éviter la catastrophe suivante. Ni fatalisme, ni culpabilisation des contrôleurs, des pilotes, des conducteurs ne sont à mettre en avant; il s'agit d'insister plutôt sur la recherche de conditions techniques et organisationnelles permettant l'exécution correcte de la tâche confiée. Ce n'est sûrement pas en rajoutant un « cadran » de plus ou des consignes plus strictes que l'on réglera tous les problèmes de la fiabilité humaine.

3.2.2. Les réactions aux conditions de l'environnement

Un opérateur ne supporte pas non plus de la même façon les diverses conditions de son environnement de travail. Ainsi, une climatisation appréciée dans la journée devient gênante la nuit. De même, le bruit d'un avertisseur sonore peu gênant de jour est vécu comme agressif la nuit, etc. On connaît encore très mal les effets interactifs des conditions générales du travail. L'exemple de la variation de la sensibilité de l'organisme à l'apport de produits chimiques permet d'illustrer ce dernier point. Des premières expériences réalisées sur des animaux ont montré que l'injection d'un produit toxique pouvait se traduire par le décès de 80 % ou de 20 % de la population selon l'heure d'administration du produit. Chez l'homme, la sensibilité d'un organe à la prise de médicaments varie selon l'heure.

L'effet global d'un produit présente donc une nette rythmicité circadienne. Par exemple, la prise d'alcool le matin peut, si la quantité est suffisante, se traduire par un alcootest positif mais ne pas entraîner d'ébriété alors que l'inverse sera vrai le soir. Ces quelques données issues du développement de la chronopharmacologie posent avec force le problème de l'impact des conditions externes du travail sur l'opérateur à horaires inhabituels. En effet, les normes d'acceptation d'une nuisance (physique, chimique...) restent fixées à partir et pour des travaux effectués de jour. En l'absence de données précises en ce qui concerne les heures de nuit, il convient d'être particulièrement attentif aux conditions du travail de nuit.

3.3. Travail posté, état de santé et vie personnelle

Les études consacrées au travail posté sont particulièrement nombreuses et diversifiées tant sur le plan des objectifs (économique, psychosociologique, médical...) qu'au niveau de la méthodologie retenue (enquêtes de plus ou moins grande envergure; bilans de santé, analyses quantitatives et qualitatives du travail; recueils de divers indices physiologiques soit indirectement – analyse d'urine ou de sang –, soit directement – télémétrie ou autorythmométrie notamment; reconstitutions en laboratoire de postes en horaires alternants...). Il ne saurait donc être question ici de présenter de façon exhaustive l'ensemble des données accumulées dans ce domaine depuis une trentaine d'années mais plutôt de rappeler les principales conclusions tirées des connaissances actuelles sur les relations entre le mode de fonctionnement de l'organisme d'une part, et les contraintes qui lui sont imposées par ce type d'horaires de travail d'autre part.

Le bilan provisoire que nous pouvons établir concerne les répercussions plus ou moins nocives que le système de travail en équipes alternantes a sur les travailleurs.

Ce système de travail en équipes illustre la contradiction entre deux logiques hétérogènes : la logique économique qui pousse à l'extension de ce type d'horaires et la logique sociale qui est bien autre chose que l'expression monétaire des nuisances sociales : les coûts socialement reconnus sont en effet bien inférieurs aux charges réellement supportées par ceux qui subissent cette organisation du travail sans l'avoir voulue.

La charge supplémentaire résultant du travail en équipes se traduit pour les travailleurs par une *majoration* de l'astreinte puisqu'ils doivent effectuer des tâches en période de désactivation et par une *moindre récupération* dans le sommeil puisqu'ils doivent dormir en période d'activation. D'où l'existence d'une *surfatigue* chez le travailleur posté : cette surfatigue est illustrée notamment par les relations entre travail posté et variation de certains indices professionnels : rendement, sécurité...

En ce qui concerne la santé, le bilan actuel, bien que partiel, constitue à lui seul un réquisitoire suffisamment éloquent contre le travail en équipes alternantes.

Les symptômes révèlent une intolérance au travail posté, intolérance qui trouve son explication à deux niveaux :

– au niveau psychophysiologique, la perturbation de la structure rythmique des diverses fonctions de l'organisme et la quasi-impossibilité de s'ajuster parfaitement à la rotation des quarts rendent compte des nombreux troubles observés chez les postés.

Les conséquences de ces altérations sont d'autant plus graves que les sujets sont âgés ou qu'ils pratiquent les 3 x 8 depuis de nombreuses années (fig. 4).

Chronobiologie et ergonomie

L'image simpliste du travailleur, jouet de ses rythmes biopsychologiques, actif le jour et sans grande efficience la nuit, ne correspond qu'à une partie des apports considérables de la chronobiologie. Il ne s'agit pas de sous-estimer la dimension chronobiologique humaine, mais, bien au contraire, d'en saisir toute la complexité pour mieux cerner les inconvénients et exploiter au maximum les avantages. On entend trop souvent un discours ambigu qui consiste à supposer que, certes, l'homme n'est pas fait pour travailler la nuit mais qu'en cas de besoin urgent, un travailleur de nuit pourra « vaincre ses rythmes » et passer outre. Ainsi, on confie à des automatismes estimés plus fiables des tâches de plus en plus complexes en reléguant – théoriquement – l'opérateur au rang de « pompier de service ». Cependant, dans le même temps, et ceci justifie déjà sa présence, les fonctions qui lui sont dévolues en font un « calculateur de secours » devant rapidement et efficacement intervenir en cas de défaillance des automatismes comme si l'opérateur humain n'avait pas besoin de se préparer en permanence à l'éventualité de ses interventions, comme s'il était « programmé » pour faire face, à tout moment, à toutes les situations.

Les quelques données présentées ici constituent une étape dans la description des modalités réelles du fonctionnement des opérateurs dans une situation concrète de travail, étape qui a pour résultat non seulement de montrer l'existence d'une surfatigue lors d'un travail en période de désactivation et la variabilité des comportements des opérateurs, mais aussi d'attirer l'attention sur le problème de fiabilité posé par la réduction de l'activité la nuit.

Cette surfatigue résulte du fait que l'opérateur se trouve placé en situation de surcharge de travail, la nuit, par son état de vigilance bas alors que, pour effectuer le même travail, il pourra être en sous-charge de travail lors du poste de l'après-midi, compte tenu de son haut niveau de vigilance. Ces deux situations, toutes deux défavorables, contribuent à accroître fortement l'astreinte de l'opérateur en 3 x 8 soumis à des contraintes théoriquement stables. En effet, en deçà et au-delà d'un niveau optimum de vigilance, le coût pour l'opérateur de la réalisation de son activité augmentera rapidement.

Diverses données montrent que la nuit n'est pas seulement une période de moindre activité, mais que le ralentissement de l'activité consécutif à la réduction de la capacité fonctionnelle des opérateurs s'accompagne d'une réorganisation de l'activité : cela suppose que la conception des systèmes de travail permette cette flexibilité et qu'elle intègre un modèle de l'opérateur humain qui ne soit pas celui d'un homme stable et invariant au cours du nycthémère, mais un modèle d'opérateur réel, c'est-à-dire instable et organisant son activité en fonction des fluctuations de ses capacités fonctionnelles.

La normalisation des procédures opératoires, la définition rigoureuse du chemin, parfois unique, qu'il faut suivre pour résoudre un incident, entraînent une rigidification dans la façon de travailler des opérateurs dont l'analyse révèle qu'ils réajustent en permanence leur façon de procéder au vu des données nouvelles de la situation. La conception des systèmes doit laisser à l'opérateur la possibilité de changer de procédure de travail, de modifier le mode opératoire qu'il utilise. Enfin, si la démarche de conception des systèmes complexes doit être repensée de façon à intégrer les connaissances sur le fonctionnement de ceux qui en assureront la conduite et la surveillance, la mise en œuvre de ces systèmes ne doit pas s'appuyer sur des interprétations hâtives concernant le fonctionnement des opérateurs humains : dans les aménagements des systèmes complexes se dégage actuellement une tendance à la réduction des effectifs, notamment la nuit, et à l'allégement des tâches des postés soit par transfert de tâches de la nuit vers le jour, soit par automatisation des tâches en fonction de critères souvent liés aux possibilités technico-économiques. Outre que la validité de telles mesures n'est pas bien vérifiée, il y a lieu de s'interroger sur cette tendance à la réduction des effectifs et du volume d'activité, la nuit, qui va dans le sens d'un renforcement des difficultés auxquelles sont soumis les postés notamment la nuit.

Travail posté et santé

La contradiction entre la rythmicité du fonctionnement humain et l'organisation du travail posté se traduit par une altération de la santé. En dépit de l'insuffisance des connaissances (petit nombre d'enquêtes de grande envergure, manque d'approche synthétique, problèmes méthodologiques), tous les spécialistes de la question, quels que soient leur pays et leur voie d'approche, sont d'accord pour reconnaître que :

1) les effets ne sont pas toujours faciles à mettre en évidence en raison de la sélection de fait qui frappe les postés : les sujets les plus malades quittent le régime du travail posté et échappent ainsi aux enquêtes;

2) les effets ne sont pas tous immédiats mais peuvent se révéler à long terme, même après l'abandon du travail posté (surmortalité précoce après la retraite par exemple);

3) les effets résultent de la multiplication de contraintes : horaires, type de travail et conditions d'exécution, ancienneté...;

4) les écarts entre travailleurs de jour et travailleurs postés se creusent au cours de la vie (fig. 4).

Ces quelques remarques préalables font craindre une sous-estimation systématique des conséquences pathogènes du travail en équipes. Néanmoins, il est possible de dresser un premier tableau du « syndrome du travailleur posté ». Outre le vieillissement prématuré ou la mortalité précoce, les symptômes les plus clairement démontrés concernent : a) les perturbations des fonctions biologiques avec réduction des défenses immunitaires; b) les troubles gastro-intestinaux et notamment les ulcères; c) les maladies cardio-vasculaires; d) les troubles du sommeil (réduction de sa durée et altération de sa composition); enfin, e) un ensemble de troubles nerveux encore mal répertoriés.

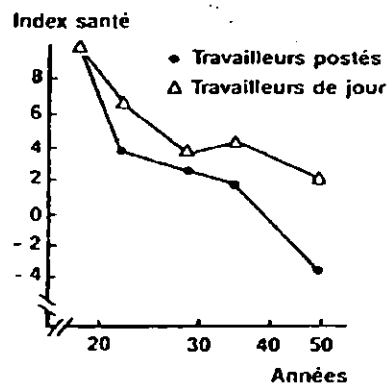

Fig. 4. Détérioration de la santé avec l'âge des travailleurs postés et des travailleurs de jour (d'après Haider et coll., 1980).

En outre, divers symptômes de l'atteinte subie par les travailleurs peuvent être soit reportés à l'extérieur du travail (contamination de la vie hors travail), soit différés (réduction de l'espérance de vie). Ce dernier point a été bien illustré par les recherches conduites dans la presse (6) puisque les auteurs rapportent un écart quant à l'espérance de vie des rotativistes (travailleurs de nuit) vis-à-vis de leurs collègues correcteurs ou typographes-monteurs (travailleurs d'après-midi et de soirée). Il est encore trop tôt pour faire la part de ce qui ressort du travail de nuit et de ce qui résulte des autres conditions de travail. Il est cependant certain que ces différents paramètres de la situation se renforcent mutuellement;

– au niveau psychosocial, le travail posté est un mode d'organisation du temps qui met en contradiction les rythmes du travail et ceux de la vie sociale, assurant du même coup une opposition de plus en plus mal ressentie entre la vie de travail et la vie sociale. De ce fait, le travail posté rencontre l'hostilité d'un nombre croissant de travailleurs, même si certains de ses avantages sont reconnus (*cf.* § 1.2.2. sur les opinions).

Au total, ce mode de travail est médicalement nocif et comporte d'importantes perturbations de la vie sociale.

C'est pourquoi aucun aménagement organisationnel ne paraît susceptible, à lui seul, de supprimer la nocivité du travail posté. Comme on l'a déjà souligné, il ne peut s'agir que d'un compromis entre diverses exigences contradictoires.

CONCLUSION

Globalement on peut dire qu'aménager les horaires de travail, c'est élaborer des solutions, les mettre en œuvre, les évaluer de façon à faire évoluer les choix.

L'élaboration des solutions d'aménagement doit prendre en compte le fait que les actions d'aménagement sont *interdépendantes*. Cela signifie non seulement qu'aucune mesure ne peut être prise isolément mais aussi qu'une action développée dans un secteur peut avoir des effets négatifs dans d'autres. D'où l'idée qu'à un objectif donné correspondent des alternatives : le choix résulte nécessairement d'un compromis.

La mise en œuvre de ces actions doit être *pragmatique* et s'appuyer sur une expérimentation tenant compte des *souhaits et avis des personnes concernées* : concertation et discussion sont indispensables pour une telle mise en œuvre.

L'évaluation des choix retenus est une étape capitale dans la mesure où, d'une part, elle permet de vérifier la validité des solutions et où, d'autre part, elle permet aussi de faire évoluer ces choix. Toute solution n'est que *partielle et provisoire*. Selon les objectifs du moment, on accordera plus d'importance à tel événement. Tout compromis à un instant t pourra ne plus être accepté à l'instant t + 1. A l'inverse, une solution inacceptable maintenant pourra devenir acceptable dans quelques années.

Pour que de tels aménagements puissent avoir lieu, nous suggérons trois propositions qui doivent être rendues opérationnelles sous quatre conditions.

A) Propositions concernant la démarche

- ***Mise en place d'un dispositif de suivi des effets du travail sur les opérateurs humains***

Ce dispositif aurait pour objet d'étudier les difficultés rencontrées par les opérateurs dans la réalisation de leur travail, d'en comprendre les causes, d'en déterminer les effets sur la santé.

L'idée sous-jacente est que toute modification nécessite d'être évaluée par ses effets et ceci de façon permanente. Des effets cachés peuvent n'apparaître qu'à *moyen et long terme* et non à court terme. La nature et l'ampleur des conséquences du travail posté évoluent au cours du temps; de plus, les conditions de la production se modifient, notamment du point de vue technique.

Toute solution n'est que *provisoire* : son évolution dépend de la connaissance de ses effets sur la santé des opérateurs. Un tel dispositif pourrait être animé en étroite relation avec les structures paritaires ayant compétences et attributions pour analyser ces problèmes, comme le CHSCT. Il appartient donc aux partenaires sociaux d'en définir les objectifs et les modalités de fonctionnement; le recours à des personnes ou organismes extérieurs à l'entreprise ne pourrait qu'être partiel. N'appartient-il pas à l'entreprise de développer ses propres compétences, par exemple en se dotant d'un service ergonomique disposant de moyens à la hauteur de sa tâche?

- ***Formation des acteurs à l'analyse des situations de travail***

Quelle que soit la structure que se donnerait l'entreprise pour assurer un tel « suivi », il est important que les *acteurs* y soient associés, qu'il s'agisse des membres des structures représentatives (CE, CHSCT), des opérateurs eux-mêmes ou des responsables de service. Pour que cette association des acteurs au suivi soit efficace et pertinente, il est indispensable d'organiser un programme de formation à l'analyse des situations de travail.

Un suivi permanent ne s'improvise pas par quelques entretiens avec les opérateurs, quelques observations ou quelques mesures : il est indispensable que cette collecte d'informations et son analyse soient réalisées par les acteurs eux-mêmes. Encore faut-il leur en fournir les moyens.

Il appartient aux partenaires sociaux de définir la ou les structure(s) de travail pertinente(s); quelle qu'en soit la structure, il est indispensable que des personnes (membres du CHSCT, opérateurs, encadrement) aient les connaissances, les méthodes nécessaires, pour assurer un tel suivi. Rappelons qu'il en va aussi de la fiabilité du système tout entier.

Cette formation serait un moyen de mettre en œuvre un dispositif permanent de suivi et de contrôle puisque l'on aurait alors un ensemble de personnes compétentes.

- ***Développement des études*** permettant de mieux comprendre la nature du travail et ses exigences, les effets de l'activité dans le travail mais aussi en dehors. Il s'agit en fait de se donner des moyens pour que les mesures prises soient basées sur une connaissance précise du travail réel.

Plusieurs thèmes de réflexion ont été développés au cours de la seconde partie. Ils pourraient servir de base pour élaborer des propositions afin de mieux cerner :

– les problèmes de fiabilité humaine et l'évolution de l'activité au cours des 24 h;

– les modalités exactes de résolution d'incidents;

(6) TEIGER C. et coll. – Les rotativistes – Changer les conditions de travail – Paris, ANACT, 1982, 344 p.

– les processus mentaux mis en œuvre pour surveiller les installations;

– les effets de l'interaction vieillissement, activité;

– les effets de l'interaction entre la vie extra-professionnelle (sommeil, santé, activités sociales et familiales, etc.) et la vie professionnelle, etc.;

B) Quatre conditions

• ***Une politique claire d'amélioration de la vie des travailleurs postés***

Pour procéder aux aménagements évoqués, il faut qu'une décision soit prise par la direction pour définir les objectifs de cet aménagement et les moyens à y associer. Si l'objectif même d'améliorer la vie des travailleurs postés n'est pas affirmé et si les moyens ne sont pas mis en œuvre pour réaliser un tel objectif, alors il devient illusoire de croire que des aménagements seront probables.

• ***Une démarche négociée***

Toute recherche de solution passe par la voie de la discussion et de la négociation. Tout d'abord le personnel concerné par le travail en équipes successives doit être associé à l'élaboration, à la mise en œuvre et au suivi des solutions retenues. Ensuite, il appartient aux partenaires sociaux, à leurs instances représentatives qui ont compétence et attribution pour cela de négocier les aménagements tels qu'ils auront été définis avec le personnel concerné, de suivre leur mise en œuvre, de les évaluer. Précisons ici qu'il appartient maintenant aux partenaires sociaux de définir les zones d'aménagement : personne ne peut se substituer à eux pour faire l'inventaire de ce qui peut faire l'objet d'un aménagement ou pour établir des priorités.

• ***Il n'y a pas un mode d'organisation unique mais des solutions adaptées aux situations concrètes***

Les mesures d'aménagement doivent être adaptées aux caractéristiques de la situation de travail dont la première est la diversité. Cela signifie que toute mesure visant à imposer un mode d'organisation unique est a priori inacceptable. En effet, la diversité des tâches, des moyens et méthodes de travail rend caduque toute solution unique d'aménagement. On voit mal comment des horaires pourraient être identiques alors que le travail réel varie d'un service à l'autre.

Cette condition d'adaptation des choix aux situations concrètes n'exclut pas, tout au contraire, que des principes communs soient affichés. Néanmoins les modalités de mise en œuvre resteraient à élaborer, service par service, avec les opérateurs concernés.

• ***Enfin, toute recherche de solution doit comporter un coefficient de flexibilité***

Il est indispensable de ne pas ridigilier l'aménagement de la vie des postés par des mesures dont on connait peu le bien-fondé ou bien dont on n'a pu vérifier la pertinence à long terme. Toute mesure doit être accompagnée d'une certaine flexibilité permettant son évolution.

En résumé, ces quatre conditions accompagnant les trois propositions sont elles-mêmes interdépendantes et doivent être remplies simultanément; loin d'être exhaustives, elles constituent des éléments de la démarche à laquelle des moyens devraient être associés. Les différentes étapes de cette démarche sont schématisées sur la figure 5.

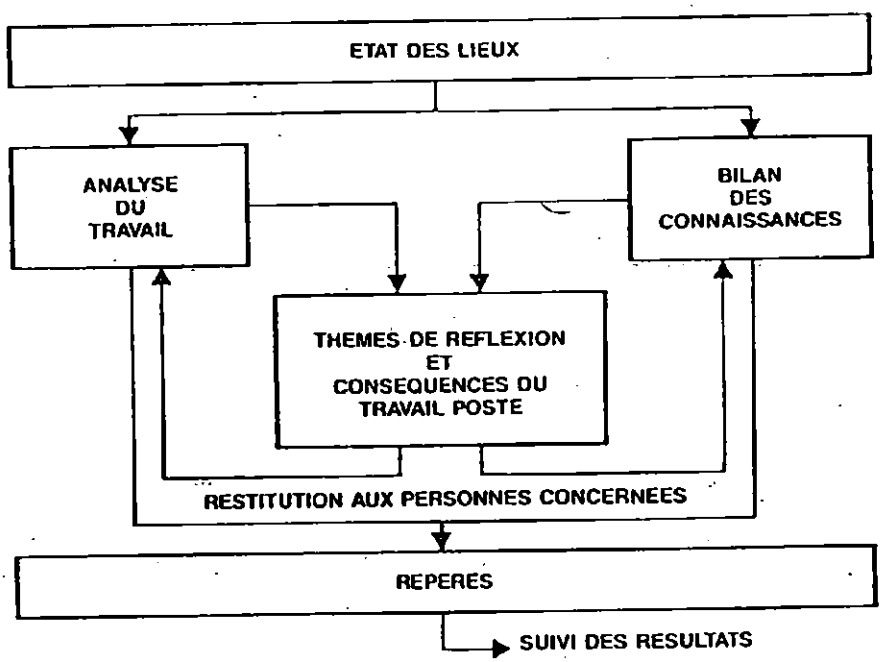

Fig. 5. La démarche d'aménagement du travail posté.

Bibliographie

Une bibliographie importante, présentée par thèmes, figure dans notre ouvrage. Pour en savoir plus, le lecteur pourra consulter les ouvrages généraux suivants.

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Shift Work

Joseph Rutenfranz, M.D., Ph.D.

Prof. Dr. Peter Knauth

According to the 1977 Bureau of Labor Statistics, approximately 18% of the U.S. labor force had to work in shift systems,[35] i.e., at "unsocial" or "unphysiologic" working times. The main reasons for the introduction of shift work are:

1. Technologic reasons.—Some technologic processes, e.g., in steel and chemical industries, need more time than a normal day worker has to work or may even require continuous production.

2. Economic reasons.—High costs of capital equipment and high demands of the market tend to increase shift work.

3. Social reasons.—Medical health care workers, safety personnel (e.g., police, fire protection), suppliers of energy and water, those in the travel, communication, and information industries (e.g., telephone, TV, newspapers), as well as the purveyors of cultural events and entertainment maintain our "quality of life."

Although many shift workers have problems (as will be discussed later), some shift workers seem to have no essential problems caused by shift work. Only a few, around 10%, like shift work, 20%–30% do not like it, and the majority tolerates it.[31]

The fact that different shift workers vary widely in their tolerance of their unnatural way of life is taken into consideration in the model of stress and strain of shift workers. Colquhoun and Rutenfranz[19] describe this model as follows: The objective stress resulting from the disruption of physiologic rhythms by shift work, and from the slow rate of re-entrainment of these rhythms to the changed wake/sleep cycle, induces a state of subjective strain in the shift worker that can potentially affect his working efficiency, his physical and psychologic health and well-being, and his family and social life. The magnitude of the effects observed in any individual will be influenced by a number of "intervening variables" acting separately, or in combination. Important intervening variables are particular characteristics of the shift worker, such as his age, his personality, his rhythmic "type," his physiologic adaptability and social circumstances such as marital status, number and age of children, or domestic situation such as housing conditions.

STRESS OF SHIFT WORKERS

One kind of stress in connection with shift work—in particular, night work—results from the discrepancy between the time structure of behavior (work, sleep) and the daily variations of physiologic functions. Biologic rhythms with a periodicity of approximate 24 hours are called "circadian rhythms" (from the Latin "circa diem," i.e., "about a day"). For more than 100 human physiologic functions and organs the existence of a circadian rhythm has been shown.

According to Aschoff,[8] the circadian rhythm is based on an endogenous component, which can be detected if all "Zeitgebers" are excluded. Zeitgebers,[7] or synchronizers[29] are periodic factors in the environment which are able to synchronize endogenous rhythms. The period of the spontaneous rhythm which occurs under free-running conditions (without Zeitgeber) may deviate from 24 hours. Wever[97] has shown that the average period of rectal temperature of 147 subjects in free-running experiments was 25 ± 0.5 hours.

In human beings, the endogenous rhythms are synchronized to a period of 24 hours, in particular by cognitive and social Zeitgebers, i.e., the knowledge of the time of day as well as the daily experience that the family and the society has another rhythm of wakefulness and sleep than the shift worker. In contrast to transmeridian flights, these Zeitgebers are not phase shifted for normal shift workers. It cannot be expected that the circadian rhythms of a shift worker adapt completely to night work, when important synchronizers are conflicting. In laboratory and field studies with data covering the 24 hours, only a partial adjustment of the circadian rhythm of body temperature to night work was found.[17, 38, 44, 71, 80, 91]

Although the partial adjustment to night work is more advanced in connection with more consecutive night shifts than in shorter periods of night shifts, the re-entrainment always remains incomplete. Furthermore, different physiologic functions adjust with different velocity to night work which causes a dissociation between these physiologic functions. This dissociation is smallest at the day of the first night shift. In summary, when only a few

consecutive night shifts are worked (i.e., only one or two), less disturbance of circadian physiologic function is observed and fewer days of recovery are needed.

From studies concerning tolerance to shift work, Reinberg et al.[73, 74] conclude that the subject tolerant to shift work for many years is likely to have a large amplitude of the circadian rhythm and is likely to adjust slowly to the "new" schedule during the night shift. These studies of rotating shift-work systems suggest that features of the circadian rhythm of temperature associated with minimal re-entrainment are also linked to a greater tolerance of shift work.

In addition to the stress caused by the phase-shift of working and sleeping times, shift workers seem to suffer more often from unfavorable environmental conditions than day workers. However, our knowledge about the combined effects of shift work and unfavorable environmental conditions is rather poor.[37, 64, 67, 79, 96]

STRAIN OF SHIFT WORKERS

Since the circadian rhythms do not adjust completely to night work, effects on performance and on well-being have to be expected, e.g., fatigue, sleep difficulties, and disturbances of appetite.

Performance

The daily variations of performances, which have been known for a long time,[11, 50] are based on physiologic functions[34] as well as on psychic processes.[27, 33]

Some field studies have shown that performance was lowest during night time (midnight to 6 a.m.) and/or during the "post lunch dip," i.e., 1 p.m. to 3 p.m.[12, 32, 68] These performances were related to simple immediate processing tasks, e.g., vigilance tasks and sensorimotor tasks.

However, different types of memory processes may show different trends over the day.[23] The precise timing of the peak depends on the level of the memory load involved as Folkard et al.[24] have shown in laboratory experiments. In a field study, process controllers with a high short-term memory-loaded task performed better at night than at day.[58]

Fatigue and Sleep Loss

Sleep difficulties are a major problem for shift workers, in particular for shift workers who have to work in night shifts. Studies concerning sleep disturbances of day and shift workers were reviewed and classified according to the type of shift by Rutenfranz et al.[76] and Knauth[37] of 18,352 persons, 10%–40% with day work, 5%–30% with rotating morning and afternoon shifts, 10%–95% with rotating shift systems including night work, and 35%–55% with permanent night shift who complained about sleep disturbances. However, the two studies mentioned above differed considerably concerning the population (age, shift experience, marital status, age of children), workers' housing conditions, and the regularity of the shift system. Complaints about sleeping difficulties refer both to the duration of sleep and to the quality of sleep. To analyze the duration of sleep dependent on the type of shift, 1,230 workers were asked to fill out diaries during one week.[40] The mean duration of day sleep between two night shifts was about six hours, i.e., significantly shorter than the night sleep. However, it was not only the night shift that created problems of sleep duration. The shortest night sleep was found before morning shifts (about seven hours). This sleep is reduced particularly when the morning shift starts early and when the time needed to travel to work is long.

Comparisons of studies with contradictory results of permanent and rotating or slowly and quickly rotating shift systems do not allow the drawing of firm conclusions.[39, 56, 71, 80, 81, 85]

There are two reasons why the day sleep after night shifts is shortened. First, many shift workers complain that the day sleep is more disturbed by noise, in particular the noise of children and traffic noise, than the normal night sleep. Secondly, the night worker has to sleep during an unphysiologic time of day.

The day sleep is not only a phase-shifted night sleep, but it also has a different sleep structure. Most electroencephalographic studies comparing night and day sleep have shown a shorter REM-latency, and a shorter amount of REM and stage-2 sleep, as well as a different distribution of REM-periods over the sleep in day sleep.[15, 26, 54, 87, 90, 95]

If a shift worker has to work several night shifts in succession, an accumulation of sleep deficits may be expected. Kiesswetter et al.[36] studied police officers with a weekly rotating shift system. They compared the quality of night sleep with the quality of the first and last day sleep in the week with night shifts. Mean sleep duration was longest in the night, shorter after the first night shift, and shortest after the last night. REM-sleep percentages were reduced in the first and last day sleep of the night shift week. Only the slow-wave sleep percentages (not the absolute amount) increased from the night sleep up to the last day sleep. Regarding the subjective ratings of sleep quality, the restorative effect of sleep was rated lowest after the last day sleep. Neglecting the increase of slow-wave sleep percentages, all other findings supported the hypothesis that there is an accumulation of sleep deficits within a week of night shifts.

In two studies of shift workers who had changed from a slowly rotating to a rapidly rotating shift system with maximal two or three night shifts, the shift workers experienced reduced fatigue in the new system.[94, 99]

Disturbances of Appetite

Besides problems with sleep, some shift workers complain about disturbances of appetite. In particular, night shifts may cause a change of the sequence and frequency of meals. Reviewing studies[37, 76] which referred to altogether 11,258 persons, the following frequencies of complaints about disturbances of appetite were found: 5%–30% with day work, 5%–20% of persons with morning and afternoon shifts, 20%–75% of persons with rotating shift systems including night shifts, and 40% of persons with permanent night shift.

Vinit et al.,[97] Debry et al.,[21] and Reinberg et al.,[72] however, showed that the disturbances of appetite did not lead to a reduction of total caloric intake. The disturbances of appetite may be influ-

enced by the dislike of having to eat at unusual times outside the preferred social environment and by the fact that during nighttime cold food is often consumed.

Gastrointestinal Complaints

Gastrointestinal complaints may be long-term effects of irregular food intake. However, the causes for this complex of symptoms are manifold. Therefore, it is not surprising that in a review of studies referring to 22,693 persons, the groups of day workers and shift workers with and without night work did not differ clearly with respect to the frequency of gastrointestinal complaints.[37, 76]

Comparing the illness reports of 12-hour shift workers and day workers, those shift workers who changed from shift work to day work had a higher incidence rate of gastrointestinal diseases than the other shift workers and the day workers.[6]

DANGER TO HEALTH

The studies cited above show that not all types of shift work are similarly problematic, but rather that mainly shift systems that include night work are a risk factor to health. If the unavoidable disturbance of biologic rhythms caused by night work is combined with very unfavorable personal or situational factors, it might be expected that in such cases the human organism may not be able to adapt and that an increased frequency of diseases or even an excessive mortality rate should show up.

Studies of Mortality

A careful epidemiologic mortality study of shift workers and day workers has been carried out by Taylor and Pocock.[83] They analyzed the 1,578 deaths occurring in a 13-year period in 8,603 male manual workers. The results did not show a significant overall excess mortality among shift workers. The standard mortality rate of ex-shift workers was 118.9, compared with 101.5 for current shift workers.

Hannunkari et al.[30] compared 4,347 engineers, i.e., drivers of locomotives and their assistants, with two reference groups of 1,575 trainmen and 1,224 railroad clerks in a retrospective follow-up survey on invalidity and mortality over 18 years. The observed number of deaths per person years was 5.3 in the groups of engineers, 4.6 in the group of railroad clerks, and 4.1 in the group of trainmen. In an additional questionnaire study, the locomotive engineers complained about irregular working hours (including night shift), noise, vibration, draft, and poor seats. However, there is no information about the working conditions and working hours of the two reference groups.

The combination of shift work and adverse environmental effects also seems to play a role in the study of Teiger,[84] who analysed data from a professional retirement fund of four occupational groups in daily newspaper companies: 972 rotary printers (permanent night workers), 248 plate makers (permanent evening workers), 1,481 compositors (afternoon and evening workers), and 208 correctors (afternoon and evening workers).

The working conditions of the first two groups are characterized by physical load, time pressure, noise, toxic exposure, and heat. Compositors and especially correctors have better environmental conditions. Analyzing the decrease in percent of living population between ages 55 and 70, Teiger found a significant difference at age 70 between the rotary printers (63.5% survivors) compared with the other groups combined (plate makers: 66.9%, compositors: 70.5%, and correctors: 74.3%). Furthermore, there was four times as much early retirement for rotary printers (43.0%) than for correctors (10.8%); the reason for most of the early retirements was medically attested working incapacity.

Gastrointestinal Diseases

Reviewing investigations of various authors concerning ulcer incidence in a total of 34,047 persons with day or shift work, we[76] found ulcers occurring in 0.3%–7% of persons with day work, 5% of persons with morning and afternoon shifts, 2.5–15% of persons with rotating shift systems including night work, and 10%–30% of persons who had given up shift work, probably for health reasons.

The incidences of ulcer in day and shift workers are overlapping. Shift work is only one of many potential factors which may contribute to ulcers. Wolf et al.[100] reported on 17 factors that increase the probability of duodenal ulcer. Careful epidemiologic studies by Aanonsen[1] and Angersbach et al.[6] showed a much higher incidence of ulcers in former shift workers compared with other shift workers and day workers.

In the retrospective cohort study of Angersbach et al.,[6] covering a study period of 11 years, the process of self-selection in the shift workers cohort seemed to be still incomplete, because the relative risk of suffering from a gastrointestinal disease for the first time was higher in the last years of the investigation.

Cardiovascular Diseases

Only a few careful epidemiologic studies have been carried out on the possible effects of shift work on cardiovascular diseases. Aanonsen[1] observed ten times more absence attributable to cardiovascular disease in day workers compared with shift workers. No significant difference between day workers and night workers concerning cardiovascular mortality was found by Taylor and Pocock.[83] In the study by Angersbach et al.,[6] those shift workers who had changed from shift work to day work (mostly because of medical reasons) had a higher incidence rate of cardiovascular diseases compared with other shift workers and day workers. Koller et al.[49] compared day workers and "drop-outs" from a shift worker cohort, the drop-outs having a significantly higher rate of cardiovascular complaints which had occurred during the time when they had worked on shift. A Swedish cohort study of 394 subjects, the risk ratio of cardiovascular diseases was shown to increase with the years exposed to shift work.[63] After 20 years, the risk ratio dropped, probably because of self-selection.

Summing up, there is not enough evidence to conclude that cardiovascular disease is more prevalent in shift workers. More long-term studies, in particular, investigating ex-shift workers, are needed.

Other Diseases

In a review of studies concerning neurotic reactions and psychosomatic disorders, Koller et al.[41] state, "no clear conclusions about different frequencies of psychiatric disorders in shift and day workers can be drawn."

EFFECTS ON SOCIAL LIFE

The working times and leisure times of shift workers are out of sync with the "normal" social environment. This discrepancy may create problems within the family and concerning other social activities.

It is difficult for the shift worker, when working in afternoon shifts, to keep contact with the children who go to school.[60] However, rapid rotation of shift systems enables the workers to have more contact with their children than slowly rotating shift systems.[35]

In regard to the organization of household work, greater problems may occur when the spouse of the shift worker is also working outside the home, when female shift workers have to take care of small children, and when two members of the family have different shift systems.[78]

It is difficult for a shift worker to have regular contact with day working friends or to participate in regular social activities and in continuing education courses, which are often fixed to evening hours and to the weekend. Therefore, permanent evening shifts and continuous shift systems are particularly unfavorable for social contacts.[9, 10, 60]

SPECIAL HEALTH MEASURES FOR NIGHT WORKERS

Based on the recommendations by Rutenfranz,[75] special health provisions for night workers should include:

1. Pre-employment selection of workers
2. Regular health checks
3. Preventive health care
4. Additional free days
5. Provision of proper meals at night
6. Sleeping allowances during night shifts
7. Construction of shift schedules based on objective physiologic, psychologic, and social criteria
8. Reduction of unnecessary night work

Although all shift workers working in the same shift system at the same working place are exposed to the same stress, the individuals react in very different ways to shift work.

Selection of Workers

It would be desirable to have positive selection criteria at hand allowing one to predict which persons will have fewer health problems when working in particular shift systems. However, our actual knowledge only allows us to make a listing of negative criteria for the selection of night workers. According to Collier[16] and Rutenfranz,[75] the following persons should be excluded from shift work if possible:

1. People with a history of digestive tract disorders. Shift work produces special psychophysiologic problems and also involves unusual meal times, both of which may affect gastric functions.[2, 16, 22, 57, 86]

2. Diabetics and those with thyrotoxicosis. Regular food intake and correct therapeutic timing can be difficult to maintain under shift work conditions.[20, 52]

3. Epileptics. Reduction of sleep increases the incidence of fits.[20, 52]

4. People with severe mental derangements involving the whole personality. Depression is particularly important here, because this disease often starts with sleep disturbances, which indicate disruption of the sleep-wakefulness cycle and other circadian rhythms.[88]

5. All persons suffering from chronic sleep disturbances (allegedly caused by e.g., traffic noise).[52]

6. Patients with heart diseases who exhibit a significant reduction of physical performance capacity.

7. Active and extensive tuberculosis patients.

8. Alcoholics and other drug addicts.

9. Persons with marked hemeralopia, or visual impairment that is too severe for effective compensation to be possible. Illumination of many parts of factories is normally reduced at night; therefore these persons may have a particularly high risk of accidents.

Concerning positive criteria for the selection of night workers, it is not yet possible to put forward recommendations. However, there are many factors which have already been taken into consideration or which should be studied in more detail:

1. Rigidity[25, 101]
2. Extraversion/introversion[13]
3. Neuroticism[18]
4. Circadian phase position, morningness/eveningness[14, 59, 62, 65]
5. Amplitude of circadian rhythms[3, 4, 73, 74]
6. Sleep cycle properties
7. Liability to internal desynchronization[70]

Furthermore, situational factors seem to be of importance for the adaptability to shift work. In studies of chemical workers, train drivers, and air traffic controllers, 55%–80% complained about their sleep being disturbed by noise on the day after the night shift.[12, 61, 77] Shift workers reported that traffic noise and noise of children disturbed their day sleep most frequently. These kinds of noise may deteriorate the quality of sleep, as has been shown by Knauth and Rutenfranz,[41] Williams,[78] and Griefahn et al.[29] Shift workers whose day sleep was often or always disturbed by noise complained more frequently about neurovegetative and gastrointestinal symptoms than shift workers with undisturbed or rarely disturbed day sleep.[37, 51]

Another situational factor, which has not yet been studied in detail, is the attitude of the family of the shift worker toward shift work in general or toward particular negative aspects of a shift system. If, for example, the night work of a shift worker is not accepted by his or her spouse, it may be expected that this shift worker will have more problems coping with night work than a colleague who is supported by a more positive attitude from his or her spouse.

Regular Health Checks

The standard medical examinations before starting work have only limited predictive value for sickness-absence.[82] Therefore, it has been proposed that a second health examination be carried out not later than one year after starting shift work.[53] Between the two examinations the shift worker has found out what his or her most important problems concerning shift work are, and how shift work affects the worker's sleep, family, and social life.

A committee of German occupational health practitioners and scientific experts has proposed the following procedure:[75]

1. All persons working at least six hours on a regular shift system or at least five hours on an irregular shift system during the hours from 10 p.m. to 6 a.m. should have regular health checks.

2. The preplacement medical examination should exclude all persons from night work who meet the above-mentioned negative health criteria.

3. There should be a second health check 12 months, at the latest, after starting night work, and regular health checks, depending on the age of the worker, at the following intervals: aged under 25 years, 24 months; 25–50 years, 60 months; 50–60 years, 24–36 months; and over 60, 12–24 months.

Preventive Health Care

Since most problems of the shift worker are caused by the discrepancy or mismatch between the time structure of the social sphere and the work sphere, it seems to be desirable, occasionally, to give the shift workers the chance to live under normal conditions with respect to circadian rhythms. Some large German plants and communities have therefore begun to offer regular treatment for shift workers older than 50 years old in specialized hospitals for two to three weeks at two- or three-year intervals. By following a regular sleep-wake routine with proper mealtimes, these workers may normalize their circadian rhythms. Furthermore, a general health check and physiotherapeutic measures are offered. However, there are no long-term experiences with such treatments. Another way of reducing the problems of shift workers is realized by a French plant with a special organization of working time: three weeks of shift work are followed by four weeks of non-shift work, i.e., normal day work or a continuing education or holidays.

Additional Free Days

The medical reason for recommending additional free days for those who work in continuous shift systems is the same as mentioned before, namely, to give the shift workers the chance to have more "normal" days to allow the circadian system to renew. However, since there are up to now no epidemiologic longitudinal studies, nothing is known about the efficiency of these extra rest days for health.

Providing Proper Meals at Night

Complaints about disturbances of appetite are relatively frequent, particularly in connection with night work. Therefore, in France, a law obliges the industry to provide the night workers with facilities to warm up meals during nighttime. Reinberg et al.,[72] who studied the eating habits of shift workers of an oil refinery in 1974, observed five years later that the consumption of carbohydrates was reduced.[69] This change may be caused by the introduction of a cafeteria which offered warm, light meals, whereas in 1974 much bread had been consumed during night shifts. The meals should not be eaten too late in the night shift (e.g., not later than 1 a.m.). Beverages that contain caffeine should be drunk only many hours before bedtime.

Sleeping Allowances During Night Shifts

Since sleep is a major concern of night workers, any measure that will improve their sleep is important. Occupational health practitioners and scientists who have studied the problems of nightworkers know that in some work places illegal naps are taken during nighttime. Kogi[36, 47] reports that 43% of day-night (two-shift) workers and nearly half of regular (three-team or four-team) three-shift workers took naps in the form of short anchor-sleep-like sleep during midnight or early-morning hours. Many plants in Japan seem to have such more or less legalized sleeping allowances during night work and many of the nappers even had the chance to use a bed in the factory.

The main reasons for naps are prevention of fatigue and improvement of efficiency and safety.[5, 47] Problems may arise if the night worker has difficulties in falling asleep or if he has to react correctly immediately after being woken up, e.g., by an alarm bell. The nighttime nap seems to influence the following daytime sleep. Torsvall et al.[69] found that nappers had a shorter main sleep compared with non-nappers. Matsumoto et al.[55] observed that the stage-4 sleep in the subsequent day-sleep was decreased in proportion to how late the preceding nap was taken.

Constructing Shift Schedules Based on Objective Criteria

Based on the criteria concerning physiologic adjustment, performance and accidents, well-being, health, and personal and social problems, Knauth and Rutenfranz[43] have put forward nine recommendations for the construction of shift systems:

1. A shift system should have few night shifts in succession.
2. The morning shift should not begin too early.
3. The shift change times should allow individuals some flexibility.
4. The length of the shift should depend on the physical and mental load of the task, and the night shift should be shorter than the morning and afternoon shifts.
5. Short intervals of time between two shifts should be avoided.
6. Continuous shift systems should include some free weekends, with at least two successive full days off.
7. In continuous shift systems, a forward rotation should be preferred.
8. The duration of the shift cycle should not be too long.
9. Shift rotas should be regular.

In summary, the reasons for the first and most important recommendation are that re-entrainment of physiologic functions to night work seems to remain incomplete even after many night shifts in succession, and least disturbance of circadian physiologic functions is observed in connection with few consecutive night shifts.[37]

An accumulation of sleep deficits and fatigue has been observed in the course of longer periods of consecutive night shifts. Furthermore there are hints in the literature that the probability of accidents may increase after the second night shift.

In studies of groups which had changed from slowly to rapidly rotating shift systems, the majority of shift workers reported an overall preference for the new shift system[45, 66, 93] or had a higher level of job satisfaction.[99]

Reduction of Unnecessary Night Work

Since night work may be regarded as a risk factor for health and often results in negative effects on the well-being and social contacts of shift workers, ideally, the best measure would be to eliminate night work in general. However, this is an unrealistic approach. Therefore, the second-best measure would be to reduce unnecessary night work. When asking the management of a plant if some activities could be removed from the night shift and placed in morning or afternoon shifts, in general the first answer will be "that is not possible." However, if the activities are studied in more detail, in some cases it will be possible to reduce the amount of work done during the nighttime.

As an example, we gradually reduced (in cooperation with the management and the occupational health practitioner) the number of persons needed during nighttime (2–6 a.m.) for loading and unloading aircrafts from 104 to 66 in a first step, and in a second step to 38 persons.[39]

To sum up, occupational health measures for night workers and shift workers are necessary to prevent lowering of well-being and occurrence of job-related diseases. These measures should also include activities of the occupational health practitioner outside the workplace, such as advising workers on coping strategies, e.g., for organizing the social life, for sleeping and eating behavior, or supporting the amelioration of housing conditions.

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4 - PROBLÈMES MUSCULO-SQUELETTIQUES

L'industrie alimentaire est particulièrement à risque pour les lésions musculo-squelettiques. Les tâches impliquant des soulèvements et des gestes répétitifs sont très nombreuses. Les abattoirs de bétails et de poulets, les boucheries, les poissonneries et les entreprises de conserves de fruits et de légumes comptent parmi les plus à risque. En plus de la transformation primaire des produits il faut ajouter l'empaquetage et l'empilage avant l'expédition.

Les soulèvements de charge varient beaucoup en fréquence et en poids soulevés. On peut rencontrer des soulèvements non fréquents de sacs de grains ou de farine dont le poids dépasse 40 kg, des soulèvements de palettes, des transferts de quartier de viande de 100 à 300 livres etc. Beaucoup de clients d'abattoirs ou de charcuterie ne sont pas équipés pour recevoir des quartiers de boeuf de sorte que les accidents lors du transfert du camion à l'entrepôt du client sont fréquents.

Surveillance médicale et prévention

L'approche générale pour les lésions musculo-squelettiques repose sur une bonne documentation des accidents de travail et des maladies musculaires et tendineuses. Ces lésions sont le plus souvent associées aux gestes répétitifs et au soulèvement. A partir de ces données on peut déterminer les sites anatomiques les plus souvent touchés et préciser quels sont les gestes, postures et tâches en cause. Par la suite, on peut procéder à des évaluations ergonomiques et suggérer des solutions. La rotation des tâches quand elle est applicable peut s'avérer utile, mais les modifications du poste sont préférables. Le traitement précoce des travailleurs symptomatiques peut prévenir des lésions plus sévères. Le repos ou l'arrêt de travail est difficilement accepté par le milieu de travail, quoique ce soit le traitement initial le plus souvent utile.

Nous avons brossé un tableau général des problèmes musculo-squelettiques dans l'industrie alimentaire mais il n'est pas possible de couvrir entièrement le sujet dans ce document. Nous avons inclus une liste des références utiles selon les industries ou métiers pour lesquels les risques sont bien décrits.

Problèmes musculo-squelettiques

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Work-Related Injuries in the Meatpacking Industry

Carol Conroy

National Institute for Occupational Safety and Health (NIOSH) surveillance efforts are directed towards identifying and studying high-risk industries. This research describes injuries and worker characteristics and suggests how these injuries may be prevented in one industry – the meatpacking industry. This industry has maintained the third highest injury rate among all U.S. manufacturing industries from 1976 through 1985. According to NIOSH data, 25 workers died from work-related injuries during 1980–1985. Injury data from the Bureau of Labor Statistics Supplementary Data System show that 76% of injured workers suffered strains, sprains, lacerations, contusions, or abrasions. The two major types of injury are: Struck by or against objects (25%) and overexertion including lifting, pulling, and throwing (31%). Handtools are involved in almost one half of all injuries. The occupations of over half of all injured workers are meat cutter (49%), butcher (2%), and packer and wrapper (4%). These findings suggest aiming preventive efforts towards workers in these jobs. However, more comprehensive and detailed surveillance systems are needed to further study workers at risk and evaluate preventive efforts.

The National Institute for Occupational Safety and Health (NIOSH) surveillance efforts are directed towards describing industries in which there is a high risk of injury. Although national information on work-related injuries is limited, what is available can be used to identify injury trends and target areas for further study. This paper provides information on work-related deaths in one industry (meatpacking) by using a new source of national fatality data. It also updates information from an earlier NIOSH report (Pezaro, Leffingwell, & Mahaffey, 1985) which identified meatpacking as a high-risk industry.

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DATA SOURCES

Three data sources were used to investigate fatal and nonfatal injuries in the meatpacking industry. The National Traumatic Occupational Fatality data base (NTOF) (Division of Safety Research, NIOSH, 1988) provides data on work-related deaths. The Bureau of Labor Statistics (BLS) Annual Survey of occupational injuries and illness in the U.S. (1982, 1983, 1984, 1985) and Supplementary Data System (1982, 1983, 1984) both provide information on injuries in specific industries. These data sources can be

used to describe potential risk factors for injury to workers in the meatpacking industry.

The NTOF provides new national information on work-related traumatic deaths in the United States. Death certificates are used as a source for this data base. Death certificates are included in the system if they meet the following criteria: "Injury at work" item on death certificate is checked yes, underlying or contributory cause of death (International Classification of Diseases, 9th Revision) is external, and age at death is 16 years or older. Occupation is coded by the 1980 Census Index of Industries and Occupations, industry is classified by the 1972 Standard Industrial Classification (SIC) (Office of Management and Budget, 1972), and external cause of death is categorized by injury description.

The BLS annual survey provides incidence rates based on a national stratified random sample of approximately 280,000 private-sector establishments in the United States. Workers in companies that have less than eleven employees, public-sector employees, and self-employed workers are excluded from this sample. All injuries recorded on each company's OSHA 200 log (required by the Occupational Safety and Health Administration) are supposedly reported; by definition, these include injuries resulting in medical treatment beyond first aid, loss of consciousness, lost work time, or restricted job activities. The BLS defines occupational injuries as injuries "which result from a work accident or from exposure involving a single incident in the work environment." Injury rates are calculated based on employees working 40-hour weeks and 50 weeks per year, but are reported as rates per 100 employed persons. Rates are reported by industry and are not specific for occupation or other worker characteristics.

The SDS provides information on nature of injury, external cause, occupation, and body part injured. The SDS uses the Census codes for occupation of worker, the SIC codes for industry, and the American National Standards Institute Z16.2 standard (ANSI, 1962) for injury characteristics.

SDS data are obtained from states that voluntarily supply workers' compensation claim information to the BLS. In most states all public-sector employees and self-employed persons who are injured are excluded. Definitions of injury and reporting criteria vary from state to state as shown in Table 1.

RESULTS

A descriptive analysis of these data sources yielded the following profile of occupational traumatic injuries in the meatpacking industry.

Incidence

The meatpacking industry (SIC 2011) has the third highest injury rate among all U.S. manufacturing industries; this rank has persisted from 1976 through 1985. The annual BLS survey shows an average incidence rate of 27.6 injuries per 100 workers per year during 1982–1985. This rate is slightly lower than the rate (31.4 per 100 workers per year) reported for 1976–1981 (Pezaro et al., 1985). The average annual incidence rate for lost-work-day injuries is also lower (13.5 per 100 workers) than during 1976–1981 (15.0 per 100 workers). During 1982–1985 an average of 145,000 people were employed in the meatpacking industry each year.

Mortality

Information for fatally injured workers is limited to death certificate data included in the NTOF. Twenty-five such deaths were identified for the meatpacking industry during 1980–1985. The average annual rate is almost 3 deaths per 100,000 workers. The distribution of death varies by occupation: meat cutters account for 13%; meat packers, 13%; maintenance workers, 28%; truck drivers, 13%; and truck loaders, 4%. The causes of death include one electrocution, three falls, two unintentional stabbings, three intentional firearm wounds, and eight motor-vehicle-related deaths. Other deaths are primarily caused by blunt force trauma resulting in crushing injuries. There is no pattern by age distribution, and only one woman died.

Morbidity

The findings on nonfatal injuries are based on the workers' compensation infor-

TABLE 1
CRITERIA FOR RECORDABLE WORKERS' COMPENSATION CLAIMS IN STATES PARTICIPATING IN SUPPLEMENTARY DATA SYSTEM, 1982–1984

State	Criteria
Alaska	Death or injury
Arizona	All injuries
Arkansas	Death or injury
California	Death or "serious injuries" or 1 day lost time or more than first-aid required
Colorado	Death or injury with 3 or more lost-time days
Delaware	Death or injury
Hawaii	Death or at least 1 lost work day
Indiana	Disability of 1 day or more
Iowa	Disability of more than 3 days
Kentucky	Disability of 1 day or more
Maine	All injuries (did not participate in 1984)
Maryland	Disability of more than 3 days
Michigan	Death or disability of at least 1 week, "specific losses"
Minnesota	Death or serious injury or disability of at least 3 days
Mississippi	Disability of 1 day or work shift
Missouri	Death or injury with 3 or more lost-time work days in 1982–1983; changed to death or injury in 1984
Montana	All injuries
Nebraska	Death or injury
New Mexico	All injuries
New York	All injuries
North Carolina	Disability of 1 day or more
Oregon	"Serious" injuries
Tennessee	Disability of at least 1 week
Utah	All injuries
Vermont	Disability of at least 1 day and requiring medical care
Virginia	All injuries
Washington	All injuries requiring medical attention
Wisconsin	Disability of more than 3 days
Wyoming	All injuries

mation reported by states and included in the SDS. During 1982–1984, the 29 states listed in Table 1 participated in the SDS.

The data show that 86% of the injured workers are men. The two primary types of injuries (struck by/against objects and overexertion) vary according to gender. About 28% of women are injured by an object compared to 45% of men. However, almost 44% of injured women have overexertion injuries compared to only 29% of men. This difference may reflect different work-related tasks.

The distribution of injuries by age reveals that 55% of the injured workers are between 20 and 34 years of age. Almost 23% are 20 to 24 years old, and only 5.3% of injured workers are over 54 years old. Age is unknown for 9% of all injured workers. There is no significant difference between men and women in the age distributions of injured workers.

The occupation of injured workers is important to consider when studying work-related injuries. Over half of all injuries reported during 1982 to 1984 occurred to butchers (2%), meat cutters (49%), and meat packers and wrappers (4%). Material handlers (7%), laborers (9%), and operatives (7%) account for almost one quarter of injuries. Because certain occupations account for proportionately more injuries, meat cutters, butchers, packers, and wrappers are evaluated in more detail. Thirty-one percent of the injuries to these workers are lacerations. Butchers receive lacerations for almost 55% of their injuries; cutters, 40%; wrappers, 21%; and packers, 9%. Strains and sprains account for 34% of all injuries to this occupational group. Strains and sprains accounted for 21% and 26% of all injuries to butchers and cutters compared to 45% for meat wrappers and packers.

Injury characteristics are important to evaluate in terms of treatment and secondary prevention. Table 2 shows the distribution of nature of injury. Strains, sprains, lacerations, contusions, and abrasions are the most frequent injuries (76%). Inflamed joints account for almost 9% of reported injuries, and only about 5% of injuries are fractures or dislocations. The nature of injury patterns are similar to those reported for 1976–1981, except for "inflamed joints" which previously accounted for only 5% of all injuries (Pezaro et al., 1985).

TABLE 2
PERCENTAGE DISTRIBUTION OF NATURE OF INJURY REPORTED BY WORKERS IN THE MEATPACKING INDUSTRY, SUPPLEMENTARY DATA SYSTEM, 1982–1984

Nature of Injury	%
Strain/sprain	32.7
Laceration	30.9
Contusion/abrasion	13.0
Inflamed joints	8.6
Dislocation/fracture	4.8
Burn (chemical/scald/welder flash)	2.5
Multiple injuries	1.4
Hernia rupture	1.3
Amputation	0.6
Concussion	0.2
Electric shock/cold injury/heat stroke	0.1
Not classified/other	3.9
Total	100.0

The distribution of injury by body part is shown in Table 3. The body parts involved in 50% of all injuries are the arm, hand (including fingers), and back. Over 22% of all injuries involve fingers. The back is involved in 15%.

Because of their serious and permanent nature, amputations are evaluated in detail. The reports show that over 93% of amputations involve fingers (although three hands, one arm, two toes, and two feet were also lost). Meat cutters and butchers account for over 30% of all amputations in meat packing workers; machinists account for over 10%; operatives for over 8%; and heavy equipment mechanics for over 7%.

Lacerations and strains/sprains are also

TABLE 3
PERCENTAGE DISTRIBUTION OF BODY PART INJURED REPORTED BY WORKERS IN THE MEATPACKING INDUSTRY, SUPPLEMENTARY DATA SYSTEM, 1982-1984

Body Part	%
Finger	22.5
Back	15.5
Arm	11.7
Leg/hip (excluding knee)	9.4
Hand	8.6
Wrist	7.2
Shoulder	5.2
Multiple	4.6
Abdomen/trunk	3.6
Knee	2.8
Eye	2.6
Head/brain (excluding eye)	2.3
Chest	2.2
Neck	1.1
Not classified/other	0.7
Total	100.0

evaluated in more detail because they constitute a major proportion of all injuries. Lacerations involve arms, wrists, hands, and fingers about 83% of the time. In almost 55% of all lacerations, fingers are involved. For strains and sprains, 42% involve the back and 10% involve the shoulder; in fact, 87% of all reported back injuries are sprains or strains.

Table 4 shows the distribution by type of accident (external cause). Of all injured workers, 44% are struck by or against an object and 33% are injured by lifting, pulling, throwing, or overexertion. The "source of injury" also varies. Hand tools are associated with 47% of injuries with known sources; knives (a type of handtool) alone account for about 19% of all injuries. Over 6% of injuries are associated with the "floor or ground". "Animals and their products" are involved in over 6% of all injuries.

DISCUSSION

The occupations associated with the most injuries in the meatpacking industry are butcher, meat cutter, meat wrapper, and packer. One reason may be the large proportion of these workers employed in this industry. The majority of their injuries are strains, sprains, lacerations, and contusions; the body parts commonly injured are the wrist, hand, and finger. These clinical findings are consistent with their job tasks—using hand tools, especially knives, and manipulating large animal carcasses. This information suggests preventive efforts should be targeted at decreasing injury occurrence among these workers.

In the meatpacking industry, contact

TABLE 4
PERCENTAGE DISTRIBUTION OF ACCIDENT TYPE REPORTED BY WORKERS IN THE MEATPACKING INDUSTRY, SUPPLEMENTARY DATA SYSTEM, 1982-1984

Accident Type	%
Struck by/against object	44.4
Overexertion/lifting/pulling/throwing	32.6
Working surface	5.0
Caught in/under collapsing material	2.3
Falls	2.2
Temperature (hot or cold)	1.6
Motor-vehicle-related	0.8
Electricity	0.1
Not classified/other	11.0
Total	100.0

with handtools – especially knives – appears responsible for causing a large proportion of all injuries (Myers & Trent, 1988). However, the ANSI system of injury coding does not identify the external cause of injury. As a proxy, "accident type" is used to identify the event resulting in injury or how the object (source of injury) contacts the person. Another limitation is that the ANSI "nature of injury" categories include energy agents and injury outcomes (such as loss of function) in addition to injury descriptions. These attributes of the ANSI coding system inhibit descriptions of external cause or nature of injuries based on work-related injuries reported in the SDS.

In the meatpacking industry, the external cause associated with fatal injury differs from nonfatal injury; motor vehicle-related injury is more often a cause of death than a cause of nonfatal injury. This may occur because there is a greater magnitude of energy concentration with motor vehicle-related injuries, resulting in more severe injuries not compatible with life. Motor vehicle-related deaths may even be underreported in the NTOF because of the criteria for death certificate inclusion (Broberg, 1984). A prevention program designed to reduce injuries in the meatpacking industry may not decrease the deaths because the external causes vary for nonfatal and fatal injuries. This should be considered when developing injury prevention programs in meatpacking plants.

Although the BLS surveillance systems can be used to evaluate time trends, they have some limitations in this area as well. The data show an apparent decrease in injury rate incidence during 1982 to 1985 compared to 1976 to 1981. However, the annual survey is sensitive to reporting variation and the decrease may reflect changes in reporting. One incentive for underreporting is the change in OSHA policy that prevents inspections if an employer has an injury rate below average for its three-digit SIC. Other limitations of using data collected for OSHA are addressed by a report supported by the Department of Labor (Pollack & Keimig, 1987).

Similarly, the states in the SDS participate voluntarily and may change their reporting criteria, compensation criteria, and information collected over time. It is unlikely that all injuries are reported voluntarily. Worker's compensation claims are collected not for injury research, but in response to economic concerns of employers, legal responsibility to provide a safe work environment, and worker recognition of risk (Bale, 1988). Another researcher (Robinson, 1988) has noted that economic factors such as hiring rate, productivity, and labor and management relations affect injury rates in manufacturing industries. SDS data are restricted to participating states. If injury incidence varies by geographic location of plant, then these data may not be representative of all meatpacking plants.

It is not possible, using these surveillance systems, to evaluate the impact of nonfatal injuries upon a worker's quality of life or work production. For example, a worker suffering finger amputation would have a *moderate* injury based on the Abbreviated Injury Scale (American Association for Automotive Medicine, 1985). Although some states participating in the SDS include extent of disability information as a proxy for injury severity, there are limitations to these data. First, it is only reported by states submitting "closed cases" to the BLS. In the meatpacking industry, during 1982–1984, only 25% of injury claims had this information. Second, extent of disability is not an accurate measure of injury severity; it is influenced by the worker's job requirements, company policy, and other variables besides the anatomical or functional severity of the injury.

In conclusion, this study confirms earlier research (Broberg, 1984; Carlsson, 1984; Pezaro et al., 1985) suggesting that injury prevention efforts in the meatpacking industry should be directed towards butchers, meat cutters, meat packers, and wrappers. These workers either use knives or handle heavy pieces of meat during work. This research provides clues as to which injuries occur most often. Because the meatpacking industry has remained a high risk industry over the past 10 years, it deserves to be a high priority industry to initiate preventive programs. However, on-site surveillance sys-

tems (Klauche, Buehler, Thacker et al., 1988) are needed to further study workers at risk and evaluate preventive efforts.

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CHAPTER 7

HOW TO
Prevent occupational overuse injuries

Today's workplaces are pushing employees to the limits of their physical endurance, resulting in a dramatic increase in overuse injuries such as repetitive strain. But these can be prevented. By Don Couch

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Have you ever felt worn out after a hard day's work, like you've worn yourself to the bone? If you're like most people, you'll answer yes. But chances are that you've never really been worn out, never really worked yourself to the bone — unless you've suffered from occupational overuse.

Occupational overuse conditions — also known as repetitive strain injuries (RSI), cumulative trauma disorders (CTD), and cervico-brachial disorders — is a generic term used to describe a whole family of soft tissue disorders. Although the collective terms leave the impression that there is a single disease with a single cause and cure, nothing could be further from the truth. Ranging from tennis elbow to carpal tunnel syndrome, these painful and often debilitating ailments manifest themselves in many parts of the body, most commonly in the neck, shoulder, hand, wrist and forearm, as well as in the back and legs.

Overuse conditions should not be confused with overexertion injuries. Overexertion occurs when the body or body part is not adequately conditioned to perform or sustain a task. Overexertion can occur because of changes in method or rate of work, or simply because an employee returns to the same job after an extended absence.

Overuse, on the other hand, is usually a chronic condition caused by the wearing down or deterioration of tissues that aid in the body's movement. This wear and deterioration is brought about by the prolonged holding of an unnatural position or by repetitive and stressful motions over long periods of time. Improperly designed tools, inadequate working space, anatomically unsuitable work practices and poor workstation design are known causes of occupational overuse. Other conditions, such as cold and vibration, will promote the development of overuse symptoms, as will less concrete factors like psychological and emotional stresses.

Because of these intangible stresses, overuse symptoms may appear in one worker while another, performing the same tasks, experiences none. This has led to complaints symptomatic of these disorders being treated as hypochondria, neurosis, and even malingering. Often misdiagnosed as arthritis or muscle strain, occupational overuse went practically unnoticed for decades.

But in the last 10 years, reported incidences of the condition have risen sharply. Indeed, occupational overuse appears to be 'fashionable.' There are some good reasons for the increase. There is a greater awareness that many of these painful conditions can be attributed to work; conditions that were previously diagnosed as sprains or arthritis are now being more accurately assessed; a poor economic climate and changing technology are putting increased demands on people and productivity; and limited job opportunities are dissuad-

ing occupational overuse sufferers from seeking alternative employment.

The increase in reported incidences of occupational overuse has brought with it an increase in research. Light is now beginning to be shed on the proper treatment and prevention of this very real and very serious workplace disorder.

Countless workers vulnerable

Proper preventive measures for occupational overuse must begin with a basic understanding of the disorder from a clinical point of view. Overuse conditions usually arise from the inflammation and swelling of tendons, tendon sheaths, ligaments, epicondyles or bursae *(see figure on page 32)*. Symptoms include chronic pain, numbness, tingling, weakness and problems holding and grasping objects.

Put simply, tendons connect muscles to bones, and ligaments are the bands of connective tissue that unite the joints. Some tendons run through smooth lubricating casings called synovial sheaths. Overuse of tendons can cause the inflammation of the tendons and/or synovial sheath, resulting in tendinitis or tenosynovitis. Epicondyles are two boney bumps found at the lower corners of the humerus bone at the elbow. Overuse of these tissues is called epicondylitis, more popularly known as tennis elbow. Bursitis, another condition caused by occupational overuse, is the swelling or deterioration of the bursae — protective cushions or smooth lubricating sacs found at the shoulder joint and other locations where tendons rub against bones, ligaments or other tendons.

At the wrist — a frequent site of occupational overuse — nerves, blood vessels and tendons are bound together with a large band of tissue. This bundle of fibres runs from the wrist to the hand through a route bordered by several small bones. These are called the carpal bones and the route is called the carpal tunnel. Carpal tunnel syndrome is a common overuse disorder that develops when repetitive motions cause excessive and prolonged compression of the median nerve that runs through the carpal tunnel. Other common overuse conditions include ganglions (fluid-filled lumps over tendon sheaths or joints) and non-specific conditions such as 'process workers arm.'

Workers from a wide array of occupations fall victim to these disorders. Particularly susceptible are those who perform repetitive tasks or tasks involving close or delicate work. Victims of occupational overuse are frequently clerical workers, data process operators, and clothing, textile and electrical workers.

Four factors determine occurrence

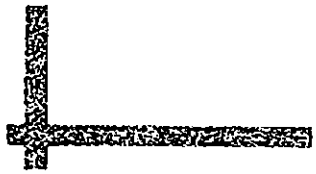
There are a number of factors that can contribute to the development and severity of overuse conditions. These factors are ergonomic, environmental, administrative and personal.

Ergonomic factors. These refer to those elements of the workstation, tools, equipment, machines or the task itself that can influence the occurrence of overuse conditions. Some of the more important workstation factors include the height, area, angle and adjustability of work surfaces, and the shape and contour of supports such as chairs and footrests.

Problems also arise from static (holding) work caused by work surfaces that are too high or workstations that are poorly designed with respect to the body dimensions of the worker. Long periods with one or both shoulders raised, the neck or wrists bent, or the elbows held up or out are very stressful and can exhaust muscles.

Work should be arranged so that it can be performed sitting or standing comfortably. Ideally, the worker should be able to adopt several different forward-facing postures with head and trunk upright or with the head inclined slightly forward. The weight of the body should be well distributed and work should not be performed above heart level without support.

Although some manufacturers have made great strides in the area of ergonomics, many still make tools, equipment and machines that require workers to adopt poor postures, or force their hands and arms into extreme angles. "Fit the task to the man" and "Bend the tool, not the hand" are classic adages that often fail to get the point across. Conventional hand tools such as screwdrivers and pliers are fundamentally unsuited for the function of the forearm because they force the worker to operate with elbow up and out, and with the wrist bent at an unnatural angle.



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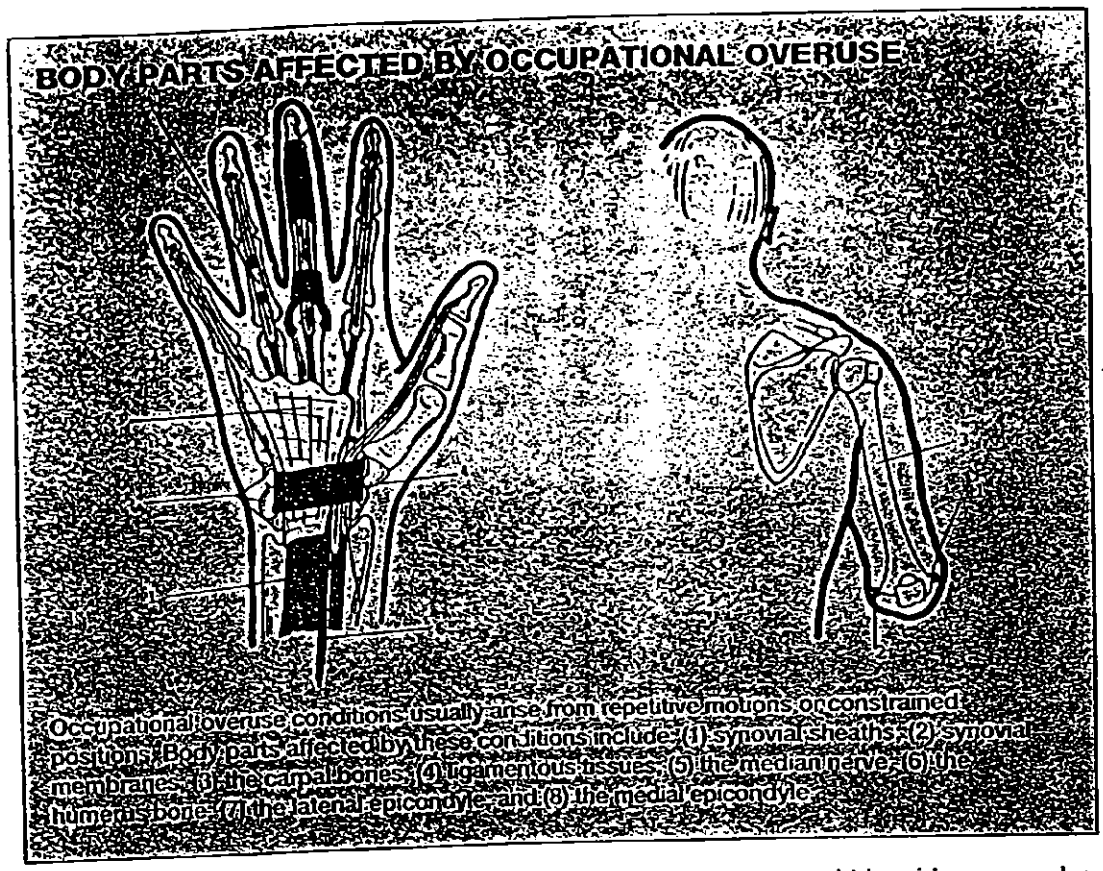


Poor placement of switches and controls, and illegible, inaccessible or poorly lit instrument displays force console workers to maintain postures that can lead to overuse conditions, particularly in the neck and shoulder.

Poor placement of switches and controls, and illegible, inaccessible or poorly lit instrument displays force console workers to maintain postures that can lead to overuse conditions, particularly in the neck and shoulder. The classic typewriting and word processing positions force the hands into extremes of movement with no support for wrists and forearm. Consequently, in addition to neck and shoulder problems, VDT operators experience tenosynovitis and elbow problems.

Work tasks are largely governed by the design of the workstation and equipment. Nevertheless, when designing a task, consideration must be given to avoiding (wherever feasible) actions that induce overuse conditions. Of particular importance are the frequency and total number of repetitive movements and the force, speed, and direction of movements. The work does not necessarily have to be heavy to cause an overuse condition. There is enough strain in the static position of an unsupported hand, even without the stress added by typewriting or other repetitive tasks.

Tasks should be designed to favour maintenance of good posture and limb position and to avoid, or at least minimize, repetitive motion. Joints should operate within mid-range angles. Bending, deviation, full extension and full flexion of the wrist, with constant supination or pronation, should be avoided (*see figure on next page*).

Dynamic (moving) work is preferable to static work. Continued pressure on soft tissues by tools or handles should be minimized, particularly if there are repeated impacts or vibration. Avoid the need for excessive force when using squeeze grips, as is the case with a caulking gun. Replace pinch grips (fingers only) with power grips (hand). Where muscular force must be exerted, it should be done by the largest appropriate muscle groups. If a force has to be exerted repeatedly, either of the arms or legs should perform the action.

The use of muscular effort should be reduced if needed to overcome momentum. Momentum, however, should be used to assist the worker when possible in concert with continuous ballistic or curved motions. These are preferable to motions that follow straight lines and result in sudden and sharp changes in direction.

In assembly work, or other types of very repetitive work, the hands should start simulta-

neously at an appropriate height and perform work in opposite and symmetrical directions. The hands should finish each assembly task or sub-task together at the same time. Try to limit motions to the lowest order for assembly work. That is, try to design the work so that only the fingers, with good support, need to repeat the movements over and over. Only involve the higher orders when absolutely necessary — i.e. first the wrist, then the forearm, then upper arm and then body.

Environmental factors. Overuse conditions occur earlier and become more severe in the presence of cold and vibration, particularly when coupled with the use of hand tools. Hand tools that vibrate in the 100-150 hertz (Hz) range can easily influence the onset and severity of overuse conditions. These vibration problems are also associated with white finger disease or Raynaud's phenomenon.

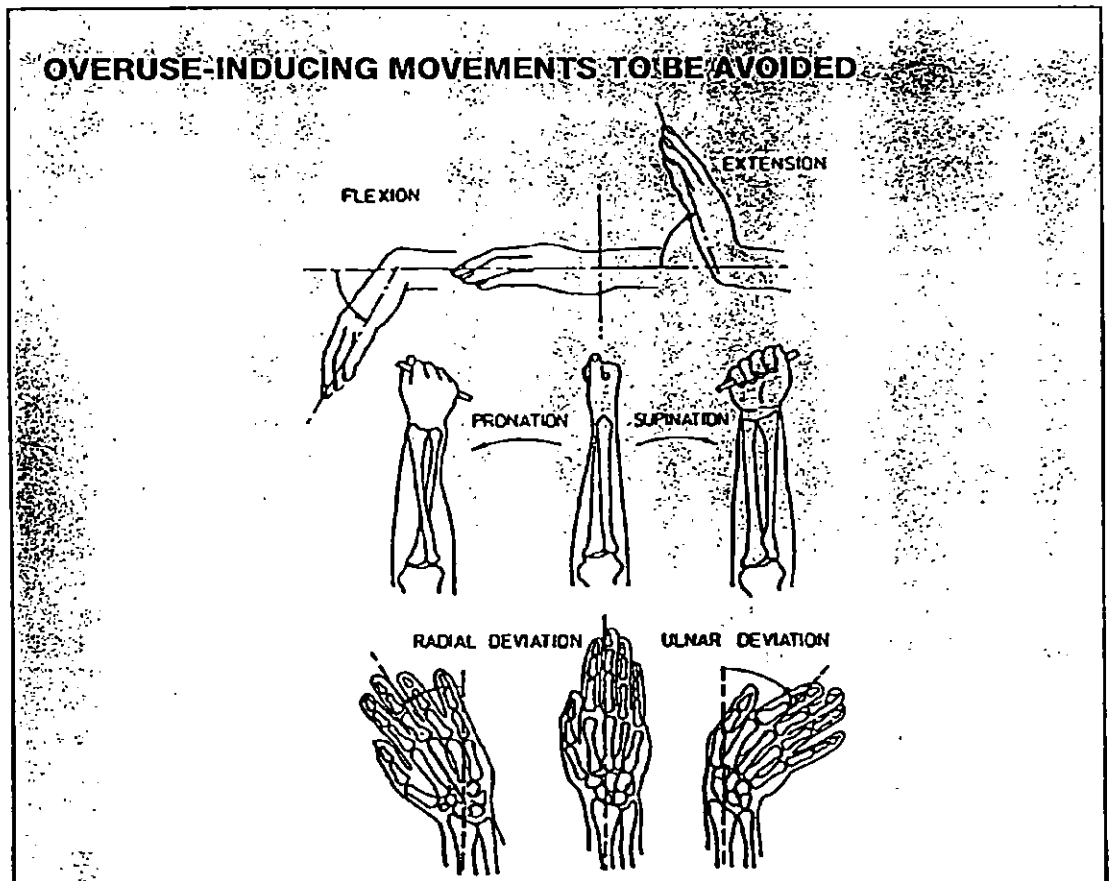
Administrative factors. Production rates in industry have increased markedly because of improvements in technology. These improvements, however, have not always been considerate of the human element. Machines could only go so fast prior to the introduction of the microchip and associated electronics. Today, speeds of production are greater than ever and workers are called upon to do more repetitive work and at faster rates. The accent on performance and productivity can only go so far before people begin to break.

Excessive work rates, whether imposed by supervisors or the magnetism of financial bonus and incentive systems, may force workers to perform beyond their physical tolerance. Long work periods without breaks lead to overuse conditions and tend to reflect poor workplace management.

Individuals also come under psychological and emotional stresses that exacerbate tension and muscle loading. These stressors can stem from poor workplace relations or social unrest within organizations.

Because these factors are difficult to pinpoint, all employees should be trained to iden-

Excessive work rates, whether imposed by supervisors or the magnetism of financial bonus and incentive systems, may force workers to perform beyond their physical tolerance. Long periods without breaks lead to overuse and tend to reflect poor workplace management.



By avoiding extremes of movement, like the ones shown above, the risk of overuse can be reduced or even eliminated.

tify signs and symptoms of overuse disorders. The Department of Industrial Relations in New South Wales, Australia, has defined five grades of discomfort that reflect the severity of overuse symptoms and the probability of the sufferer returning to work *(see table below)*.

Personal factors. Factors such as age and sex seem relatively unimportant when compared with the ergonomic and administrative factors. These factors do, nonetheless, merit discussion. Overuse conditions are more prevalent among female process workers, particularly if they are migratory and unskilled. However, this is thought to occur largely because women hold proportionately more overuse-producing jobs. Of greater importance is the stress associated with these jobs, and the tendency of workers to ignore early warning signs for fear that bringing attention to symptoms could lose them their jobs.

There has also been some suggestion that the occurrence of overuse is greater in middle-aged women and in those individuals with poor nutritional status, but the evidence is limited. Personal recreation or leisure activities ranging from racquet sports to gardening may also aggravate occupational overuse conditions if they involve repetitive movements that are similar to those performed on the job.

Early reporting of overuse is absolutely critical if recovery is to be successful. More detailed health surveillance information may be obtained from properly trained health professionals who can recognize the different overuse conditions.

Identifying problem the first step

The first step toward elimination of overuse in any workplace is accurately determining the extent to which it is present. This can be achieved by discussions with workers, supervisors, health professionals, health and safety committee members and personnel managers. Other clues as to the extent of occupational overuse in a workplace can be found on injury claims records and in absenteeism statistics.

Once it has been determined that overuse is present, the next step is to identify the types of overuse that are occurring. If a worker is suffering from overuse, the severity of the condition should be noted immediately, using a method such as the grading scale below.

GRADING OF OCCUPATIONAL OVERUSE INJURIES

Grade 1: Pain is present only when performing the aggravating duties; the activities of daily living are not interfered with.

Grade 2: Pain remains after the completion of aggravating duties but subsides by evening; daily living activities are minimally interfered with.

Grade 3: Pain continues throughout the evening, is not present on waking, but recurs shortly after resuming aggravating duties; activities of daily living are interfered with to some extent.

Grade 4: Pain is present on waking each working day, and usually at night, but subsides during weekends or when on leave from work; daily living activities are affected significantly.

Grade 5: Pain is continuous; daily living activities are restricted substantially.

- Sufferers with injuries of Grades 1 or 2 can usually be maintained at work with appropriate modification of duties. But workplace assessments should be done by an ergonomist and any recommended modifications to equipment or tasks carried out by the worker should be implemented promptly.
- Grade 3 severity requires absence from employment except in most favourable circumstances. The length of absence will depend on recovery and the extent of job modification. Usually many weeks away from work are necessary.
- Workers with Grade 4 injuries can seldom return to the job without many months of recovery.
- Sufferers of Grade 5 injuries rarely return to the workforce at all.

* Source: Department of Industrial Relations, New South Wales, Australia

Early reporting of overuse is absolutely critical if recovery is to be successful. More detailed health surveillance information may be obtained from properly trained health professionals who can recognize the different overuse conditions. An early reporting system should be established, health and safety assessments and inspections should be conducted regularly, and rehabilitation services, physiotherapy and occupational therapy should be provided.

Before any action can be taken to eliminate the overuse conditions, the exact causes of these conditions must be identified. This often involves a detailed job analysis or modified methods-time-measurement (MTM) analysis of tasks and sub-tasks by a trained observer. Ultimately, administrative reforms and/or engineering controls should be introduced.

Administratively, it may be prudent to reduce the pace of the work, increase rest pauses, improve training or introduce job rotation to shift the load of an overuse-inducing task. If implemented properly, these changes can have a positive influence on job satisfaction and worker morale without any significant decrease in production levels.

Simple procedural changes can also have profound effects and with little capital outlay. Changes in the methods of material handling, for example, can eliminate some of the undesirable actions that induce overuse problems. Daily exercise programs have also proven highly successful as a means of cutting the number of people suffering from overuse. Exercises have been developed for the head, neck, shoulders, hands, wrists, feet, ankles, and even eyes (for VDT operators).

Engineering controls such as partial or full automation, redesign of workstations, and the use of powered lifts may be complex and expensive, but they can be very beneficial.

But what about the injured worker — the individual with greater than Grade I injury? First and foremost, he or she must stop performing the actions that are causing the overuse condition.

Successful treatment of occupational overuse has traditionally taken the form of various types of splints and braces used in combination with other physical treatments and therapy. However, muscle wasting due to prolonged immobilization caused by splints can be a problem. All splints should be specifically suited to the type of injury and applied by a medical practitioner who is a specialist in treating overuse. (The use of homemade braces and splints by workers — a common sight in some workplaces — is a tell-tale sign of serious overuse problems.)

The need for cortisone injections or other analgesic drugs is often suggestive of advanced problems from which recovery is difficult. So too is the need for surgery. While many surgical procedures have met with success, some, such as the release of pressure on the median nerve for carpal tunnel syndrome, result in only limited recovery.

While many surgical procedures have met with success, some, such as the release of pressure on the median nerve for carpal tunnel syndrome, result in only limited recovery.

Education is vital

Education is a vital part of any program designed to prevent occupational overuse. Education should be directed at outlining the responsibilities of labour and management for the control and eventual elimination of overuse. Programs can be conducted in-house by knowledgeable instructors or advantage can be taken of courses offered by health and safety centres or associations.

Occupational overuse is too serious and too insidious an injury to be ignored or dismissed by employers any longer. A healthy workforce means more productivity, lower absenteeism and lower compensation costs. It also means less wear and tear on your company's most important and irreplaceable resource — people.

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The Effects of Repeated Mechanical Trauma in the Meat Industry

Madelon Lubin Finkel, PhD

Meat handlers are more prone to traumatic hand lesions and wound infections than most other occupational groups. This paper deals with the carpal tunnel syndrome (CTS), which is thought to be a major occupationally related condition affecting thousands of workers engaged in repetitive hand motion tasks. The literature reveals a high prevalence of CTS among meat handlers. Additional epidemiological research is needed. Further, it is important to educate workers about the signs, symptoms, and causes of CTS.

Key words: carpal tunnel syndrome, occupationally related disorders, meat handlers

INTRODUCTION

Meat and poultry handlers are at high risk of developing traumatic hand lesions and wound infections, more so than most other occupational groups [SACCH, 1978]. Dermatologic lesions, cuts, abrasions, and various mechanical injuries are frequent, unwanted by-products of the tools of their trade—knives, cleavers, shears, scissors, drills, and the like. Also, sharp bits of broken chicken and animal bones easily puncture the skin, inciting inflammation. Warts are rather common among meat handlers as well as rashes of varying kinds [Litt, 1969; Cohen, 1974; Taylor, 1980; Mergler et al, 1982]. The object of this paper is to discuss another condition that has an unusually high prevalence in this occupational group, the "carpal tunnel syndrome" (CTS).

WHAT IS CARPAL TUNNEL SYNDROME?

Carpal Tunnel Syndrome encompasses all anatomic alterations that produce compression of the median nerve within the carpal tunnel. Any process that reduces the cross-sectional area of the carpal canal or swells its contents will compress the median nerve. The signs and symptoms consist of sensory and motor changes in the median distribution of the hand including the lateral half of the palm, lateral half of the ring finger, volar aspect of the entire middle finger, index finger, and thumb [Phalen. 1968. 1970. 1972]. Sir James Paget [1854] first described the syndrome in a

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patient with a fracture of the wrist. The condition did not become known as carpal tunnel syndrome until 1947 [Brian et al, 1947].

CLINICAL MANIFESTATIONS

The major signs of CTS are (1) tingling and numbness in the long finger or in part of the median nerve distribution, (2) pain, often radiating to the elbow and shoulder, (3) decreased sensibility, and (4) sometimes a burning sensation. Compression may be episodic with corresponding fluctuations in symptomatology. The symptoms are usually most severe in the early morning and are often relieved by hanging, shaking, massaging, or exercising the hand.

The diagnostic criteria are (1) hypoesthesia restricted to the median distribution, (2) a positive Tinel sign with light tapping over the median nerve at the wrist, (3) a positive wrist-flexion test, and (4) an increase in the nerve conduction time in motor and in sensory pathways [Phalen, 1981]. Atrophy of the median-innervated muscles of the thenar eminence is confirmatory [Sandzen, 1981].

Ancillary laboratory studies include routine X-ray examinations of the carpus, studies of nerve conduction time, and electromyography. Expert neurologic examination will differentiate carpal tunnel syndrome from other conditions [Sandzen, 1981].

The diagnosis can usually be made on clinical grounds alone. In fact, carpal tunnel syndrome may be present without electromyolographic abnormalities. Measurement of motor and sensory condition is not useful in patients with only subjective findings and with referred pain from the wrist to the elbow and shoulder [Phalen, 1970].

TREATMENT OF CARPAL TUNNEL SYNDROME

Symptoms may resolve with a change in sleeping habits, avoidance of unusual strain on the hand or with antirheumatic medication. In mild cases, conservative treatment is strongly recommended, ie, wrist splinting, nonsteroidal anti-inflammatory drugs, steroids, and steroid injections into the flexion tenosynovium of the wrist. Sometimes it is necessary to change to a less strenuous occupation. In severe cases, surgery is the best option.

Surgical intervention is simple and the results are excellent. Still, sectioning of the transverse carpal ligament is not minor surgery [Phalen, 1981], and mild cases should be treated conservatively.

POPULATIONS AT RISK

Certain groups have higher susceptibility: women at or near menopause; young women who are pregnant, breast feeding or taking oral contraceptives; individuals with systemic disorders (for example acromegaly and diabetes); endocrine abnormalities; renal dialysis, and individuals performing repetitive manual tasks [Sandzen, 1981]. It has been suggested that carpal stenosis is genetically determined rather than acquired [Dekel et al, 1980].

Carpal tunnel syndrome appears to be especially prevalent among females in low-skilled, low-paid assembly jobs, particularly jobs that emphasize piecework.

Repeated wrist bending and the rapid pace on the assembly line are strongly predisposing. Perhaps gender is less important than work pattern and hand stress.

Armstrong and Chaffin [1979] found that forceful exertions and pinch hand positions were associated with CTS. Phalen [1966] found that occupations requiring active finger flexion with the wrist flexed are predisposed to the syndrome. Smith et al [1977] suggested that forceful exertions of the second and third digits (particularly with flexed wrist) were important factors. Birkbeck and Beer [1975] found that 79% of patients with CTS were employed in jobs requiring light, highly repetitive movements of the wrist and fingers. Reinstein [1981] found that CTS occurred significantly more frequently in the dominant hand of both right- and left-handed persons. Lublin [1983] compared 30 patients with carpal tunnel syndrome with 90 matched controls and found that vibratory hand tools were strongly associated with the disorder.

According to the Wall Street Journal, eight unions representing employees in the auto, garment, meat processing, furniture, food retailing, and other industries are trying to seek workmen's compensation benefits for carpal tunnel syndrome sufferers [Lublin, 1983].

While unions are pressing management to change the workplace or provide more efficient tools, management is generally reluctant to focus on job redesign. However, given the mounting costs of surgical care, absenteeism, and employee turnover as a result of CTS, manufacturers for the electronics, food processing, meat packing, and automotive industries are starting to test tools that keep workers' wrists "straighter."

PREVALENCE OF CTS AMONG MEAT HANDLERS

Reliable prevalence data are not available. Most union locals do not know how many of their members suffer from CTS or how much has been paid for surgery.

The United Food and Commercial Workers International Union has analyzed Bureau of Labor Statistics injury and illness records from all of the United Food and Commercial Workers (UFCW) meat packing companies. This search showed that tendonitis and related injuries were the third leading injury among meat packers. The UFCW has reported that CTS is more prevalent among those who bone, gut, trim, and wrap meat and poultry; among those who shuck oysters and filet fish; among those on sewing and trimming operations in boot and shoe plants and in fur plants; among cash register operators; and among machine operators and packers [Quattrucchi, 1982].

The prevalence of carpal tunnel syndrome among the members of a food workers union was determined by reviewing all surgical claims from 1979 through 1982. The study indicated that seven members were treated surgically for carpal tunnel syndrome. The prevalence rate for this time period was 2.4 per 1,000. All those with CTS were female, and four of the seven were in their mid-to-late fifties (postmenopause) [Quattrucchi, 1982]. These individuals had their condition treated surgically. The "walking wounded" who might be candidates for surgery are thought to be considerable in number.

Armstrong [1984] reviewed accident and personnel records of a turkey processing plant to determine the number and the type of repetitive trauma complaints. Thigh skinning and boning operations were found to have the highest rates of CTS. Arm-

strong estimated that the average worker at this plant would develop a cumulative trauma disorder after only 38 weeks on the job.

WHAT CAN BE DONE TO REDUCE THE INCIDENCE OF CARPEL TUNNEL SYNDROME

In most cases, simple changes in tool and workplace redesign could do much to prevent CTS. Speed and efficiency on the production line often are management's overriding concerns. In the meat and poultry industry, knife redesign has evidently reduced the incidence of cumulative trauma disorders. Pilot studies need to be conducted to test this hypothesis, since management is reluctant to spend money for new equipment without evidence of cost benefit.

The UFCW has produced a slide/tape show for its local unions as an educational tool [UFCW, 1982]. The material discusses a number of hand and wrist diseases that have increased in prevalence over the past decade. The Food and Beverage Trades Department, AFL-CIO, has issued guidelines to prevent CTS. They recommend (1) maintaining sharp knives and scissors; (2) lowering or raising the height of work tables and providing platforms for workers to stand on; (3) rotating jobs; (4) redesigning tools to eliminate bent hand and wrist positions; (5) increasing the training period in order to strengthen the wrist and to insure that workers are using the correct grip on knives and tools; and (6) using a grasp or closed fist movement instead of a pinching movement.

A better reporting system is needed.

ACKNOWLEDGMENTS

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Ergonomie des abattoirs de volaille : le défi ultime?

Glenn Harrington

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Le problème est évident :

- Dans une émission de la série américaine "20/20" télévisée à l'automne 1989, on a présenté le désossement des cuisses de poulet comme étant <<le travail le plus dangereux en Amérique>>.

- Le bureau des statistiques du département du travail des États-Unis a déclaré que l'industrie de l'emballage des viandes avait la plus haute incidence de blessures au pays. Selon leurs statistiques, cette incidence est trois fois plus élevée pour l'emballage des viandes (y compris la volaille) que pour les autres industries manufacturières.

- Le conseil national de la sécurité des États-Unis estime que les usines de transformation et d'emballage des viandes dépensent près de 140 millions de dollars par année pour des accidents du travail entraînant une période d'invalidité.

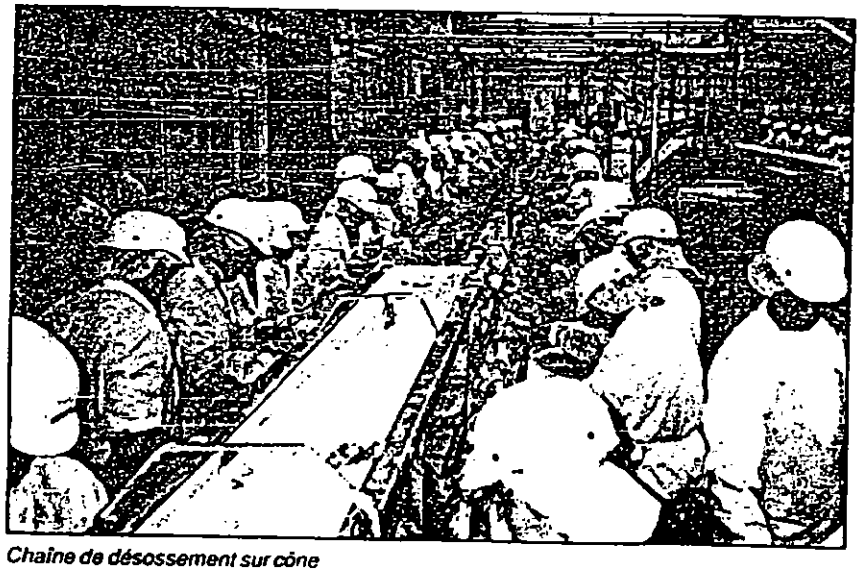
- Ce printemps, l'OSHA (Occupational Health and Safety Administration) a présenté à l'industrie de la transformation des viandes un programme intégral visant les risques ergonomiques du milieu de travail. L'OSHA a pour but d'établir un programme efficace d'identification, de prévention et de réduction des risques qui entraînent une incidence élevée de blessures et de maladies professionnelles.

Lésions attribuables au travail répétitif (LATR) dans les abattoirs de volaille

Généralités

Le désossement est une tâche où de nombreux travailleurs effectuent des mouvements très coordonnés (le nombre exact varie selon la vitesse de la chaîne de montage et le procédé de désossement). Dans une chaîne de désossement, les volailles arrivent devant les travailleurs pendues dans des entraves ou placées sur un cône de hauteur fixe. À mesure qu'elles passent mécaniquement d'un travailleur à l'autre, ceux-ci effectuent une série de coupes et de parures pour enlever systématiquement la viande. On obtient ainsi des poitrines et des cuisses ainsi que des filets, en plus des ailes, des pattes et de la peau qui restent.

L'un des rôles essentiels de l'ergonomiste est d'identifier les facteurs de risque que comporte une tâche. Les facteurs de risque sont des conditions ou des éléments d'une tâche, d'un milieu de travail ou d'un équipement susceptibles de causer des lésions ou de l'inconfort pour le travailleur. Bien que les facteurs de lésions attribuables au travail répétitif soient nombreux, les plus courants dans les abattoirs de volaille sont la répétition, la force, la posture, les gants et la température.



Chaîne de désossement sur cône

Facteurs de risque

Répétition

À cause de la petite taille des volailles et de la courte durée de chaque coupe, la vitesse des chaînes de montage est ordinairement élevée partout dans l'industrie. Pour produire des grandes quantités de viande désossée, on passe souvent de 19 à 21 volailles à la minute. Les coupes effectuées par un seul travailleur prennent environ trois secondes. Lorsque les coupes sont plus difficiles ou prennent plus de temps, deux ou trois travailleurs sont affectés à la tâche, ce qui augmente le temps nécessaire pour effectuer la coupe. Quelle que soit la division du travail, un coupeur doit dans la plupart des cas effectuer entre 8 000 et 20 000 mouvements répétitifs par quart de travail.

Force

On se préoccupe aussi de la nécessité d'exercer une force excessive. Il est essentiel que les couteaux et les ciseaux qui servent au désossement soient toujours très tranchants pour éviter la nécessité d'exercer trop de force. Il faudrait aiguiser les couteaux et ciseaux tout au long de la journée de travail. L'importance d'un programme d'entretien des couteaux et ciseaux bien organisé est critique; il devrait comprendre une formation théorique et pratique sur l'emploi approprié des aciers.

Deux autres facteurs influant sur la quantité de force nécessaire sont les poignées de couteaux glissantes et le port de gants. Le désossement est ainsi conçu que le travailleur doit continuellement toucher les volailles de la main qui porte le couteau et de l'autre main. La friction entre le gant et le manche du couteau d'une main et entre le gant et la volaille de l'autre est réduite du fait que la viande, la peau et le gras sont extrêmement glissants. Cette réduction de la friction fait qu'une plus grande force est nécessaire pour bien maintenir l'objet.

Posture

La posture du travailleur est elle aussi cause de préoccupation, surtout dans le cas des mains et des membres supérieurs. La conception du couteau et du poste de travail sont des facteurs importants à considérer lorsqu'il est question de posture.

Plusieurs coupes exigent souvent que le travailleur adopte une posture anormale ou inconfortable des membres supérieurs. Les poignets sont particulièrement vulnérables à une déviation de leur posture neutre. Dans certains postes de travail, il serait plus approprié d'avoir des couteaux présentant divers angles entre le manche et la lame; de là le concept d'un couteau particulier pour chaque tâche. Ce concept risque de provoquer une certaine résistance de la part des gérants et des acheteurs. Malheureusement, ce genre de couteau n'est pas très répandu et on ne fait pas assez de recherche et de vérification des prototypes. Il y a donc lieu de procéder à une analyse plus approfondie.

Un autre aspect insatisfaisant de la conception des couteaux et ciseaux est l'absence d'un éventail suffisant de formats des poignées. Bien qu'on ait souvent reconnu la nécessité d'avoir des outils munis de poignées de tailles variées, ce n'est que récemment que les fabricants ont commencé à offrir des couteaux dotés de cette caractéristique. Malheureusement, les ciseaux inadaptés aux mains sont encore très répandus dans l'industrie.

En matière de posture au travail, mentionnons aussi l'emploi des marchepieds. Comme c'est le cas dans plusieurs industries, toutes les tâches s'effectuent debout. Il existe une documentation abondante sur les effets nuisibles de la station prolongée (par ex. travail musculaire statique entraînant des douleurs aux jambes et au bas du dos ainsi qu'une circulation inadéquate), mais le cas des abattoirs de volaille est aggravé par la basse température (huit à 10 degrés Celsius) et les planchers mouillés. L'emploi de marchepieds avec grillage antidérapant s'est avéré très utile pour plusieurs raisons. Premièrement, on peut ainsi réduire l'incommodité des postes de travail de hauteur fixe pour les travailleurs plus courts et améliorer la posture de travail de leurs membres supérieurs. Deuxièmement, on crée ainsi un espace entre le plancher en béton mouillé et glissant et les pieds du travailleur qui se tient sur une surface non glissante et quelque peu élastique.

Gants

Des normes d'hygiène rigoureusement appliquées par Agriculture Canada exigent que la température des volailles soit maintenue à environ quatre degrés Celsius. Pour se tenir au chaud malgré le contact avec ces volailles froides, les travailleurs doivent porter plusieurs épaisseurs de gants. La main non dominante (celle qui ne porte pas le couteau) doit pour sa part être recouverte d'un gant en toile métallique pour éviter les coupures.

Il arrive souvent que les travailleurs portent des gants mal ajustés. Tout en admettant que le port de gants entraîne généralement une réduction de force, il faut retenir que les gants doivent être bien ajustés lorsqu'il est nécessaire d'en porter. Les gants mal ajustés, qu'ils soient trop lâches ou trop serrés, contribuent à l'incidence de LATR. Les gants trop lâches se ramassent dans la paume et entravent la sensibilité tactile, ce qui pousse le travailleur à empoigner le couteau plus fermement. Un gant trop serré limite le mouvement des muscles et entrave la circulation sanguine ainsi que la conduction nerveuse. En l'absence de gants, le refroidissement des mains entraînera une réduction de la circulation sanguine.

Il est évident que les abattoirs de volaille présentent un défi pour l'ergonomiste. Par sa nature, cette industrie exige l'exécution de mouvements très répétitifs en contact avec un produit froid et glissant, dans un environnement froid et à l'aide d'outils qui ne sont pas conçus pour chaque tâche particulière. Jusqu'à présent, les stratégies d'intervention ergonomique visant les facteurs de risque reliés aux LATR ont connu divers degrés de succès. Le travail se poursuit en ce qui a trait à l'élaboration de prototypes de couteaux et de gants pouvant favoriser une meilleure posture, réduire la quantité de force nécessaire et conserver la chaleur. On continue les essais d'outils mécaniques destinés à remplacer les couteaux manuels et à réduire la répétition tout en maintenant une rentabilité acceptable. Il est vrai que les changements ne se sont pas produits assez rapidement, mais les caractéristiques qui font des abattoirs de volaille une industrie unique en son genre sont précisément celles qui rendent les changements ergonomiques conventionnels difficiles à effectuer. Ces problèmes ne sont pas près d'être résolus, mais avec le travail qui se poursuit et l'adoption de diverses solutions ergonomiques à court et à long terme, l'industrie des abattoirs de volaille s'engage certainement dans la bonne direction.

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Investigation of optimal table height and surface angle in meatcutting

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Butchers have a high frequency of occupational disorders or pain localised to their hands, shoulders, low back and neck, compared with other occupational groups. It is likely that the disorders are caused by high loadings of these parts of the body during work. The high loadings have been found to be caused by high resistance when cutting, inappropriate working postures and by manual handling of material.

To improve the butchers' working conditions by providing means for appropriate working postures, cutting tables with adjustable height and surface angle were constructed and tested. Evaluations were made during work in the laboratory and in the industry. The aim of these tests was to find the optimal height of the table for each butcher and to find out if a tilted surface would improve the working postures and be accepted by the butchers. The evaluations were made by biomechanical calculations from photos, ergonomic analysis of videotapes taken during the tests and by using ranking scales.

The results show that (1) one optimal height of the table was not to be found, meaning a height resulting in a posture that causes no load on both back and shoulders at the same time; (2) a table height of 17 to 22 cm below elbow height resulted in low loadings on both the low back and the shoulders and was ranked as the most comfortable height; (3) tilting of the surface 5° to 10° was accepted by the butchers and ergonomically favourable; (4) the possibility of altering the table height during the workday was perceived as unloading since the load could be shifted between different parts of the body.

Keywords: Working postures, butchers, musculoskeletal system

Introduction

Butchers' working conditions have been of great interest lately in Scandinavia. Butchering is hard and strenuous work performed in cold rooms; it is risky and demands great skill. The workload is illustrated by the fact that many butchers develop disorders or pain in their muscles and joints at an early age, that all butchers are men, and that few remain butchers after 40 to 50 years of age.

Butchers who are cutting meat have a high frequency of occupational disorders compared with other occupational groups (Ronquist and Hansson, 1979; Jonsson and Ouchterlony-Jonsson, 1980; Viikari-Juntura, 1983). The disorders are mainly localised to their low back, shoulders and neck. These body parts are also subjected to high loadings during work which are mainly caused by factors such as inappropriate working postures, heavy materials handling and high knife forces due to the cutting resistance of the meat (Magnusson *et al*, 1981, 1987).

Cutting meat is done either with the meat hanging on hooks or lying on a table. A great deal of the cutting and trimming is actually done at tables, particularly when cutting pork.

At many places several butchers of various heights are working at a large common table, meaning that the table is either too high or too low for each one working there. The shorter butchers often adjust the table height by standing on a platform. However, the use of it obviously increases the risk of stumbling and slipping accidents. Even at workplaces where the butchers have a table of their own, it is often difficult to adjust the table to a proper height because the adjustment is tedious and usually requires help and tools from the maintenance department. Thus, the height of the tables will be a compromise to suit some of the butchers but will be too high or too low for others.

Working at a table that is too low requires a forward bent posture, meaning increased load on the back; when the arms

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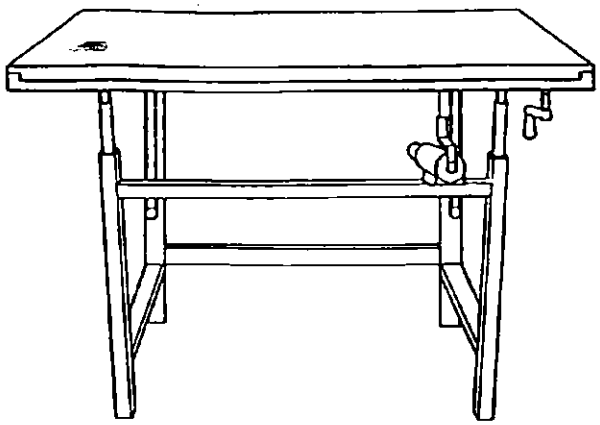

Fig. 1 A table was constructed that could be adjusted in height between 75 cm and 100 cm above the floor. The angle of the table surface could be varied from −10° to +10°. The adjustments are made by two handles which act on hydraulic pistons attached to the legs of the table

are kept in front of the body the load increases even more (Nachemson, 1966; Andersson *et al*, 1977; Schultz *et al*, 1982). When the work is performed at a table that is too high, a compensatory raising of the shoulders and an abduction of the arms are demanded. Such arm positions very quickly lead to fatigue in the shoulder muscles even when the load is only the weight of the arm (Hagberg, 1981). The reason why fatigue develops rapidly when the arms are abducted over 30° is that larger torque is required and that the shortening of the active muscles decreases their capacity to develop force (Chaffin, 1973). Butchers often work with their neck bent forward. This may cause large load on the neck (Hagberg, 1981). To reduce the forward bending of the neck we have suggested that the surface of the tables should be tilted (Magnusson *et al*, 1981). The use of tilted tables has been adapted in butchering before, but never thoroughly evaluated (Snijders, 1977; Ramel, 1981). By the shorter sight distance the head could be kept in a more upright and comfortable position. A tilted surface also allows variation of the working height by movement of the workpiece closer to, or further away from, the body. The ergonomic effect of a tilted surface has been studied by Grandjean (1979). He found that for certain types of office work, an angle of the surface of 60° to 70° reduced the load on the neck and the back. Such a large tilt is only possible for a few working tasks in which the table must not also function as storage area.

The aim of this study was (1) to investigate the relation between body load and table heights in order to find an optimal height for each butcher, and (2) to investigate the usefulness of a tilted table surface and if possible give recommendation about the angle.

Material and method

A cutting table was constructed which permitted testing both in the laboratory and at workplaces. The table height and the surface angle could be adjusted easily by means of handles (Fig. 1). Five experienced butchers participated in the laboratory tests, which were performed at four different table heights. For the first test each butcher was asked to choose a height that he considered to be the most comfortable. The choice was made separately while he was cutting up one half of a pig. For the second and the third test, the table was raised and lowered 5 cm respectively. The last test was performed at the best height in the previous tests, but with the surface tilted 8°. Each table height was measured as well as some body measures of the butchers. Here the table height is expressed as the distance between the table surface (at the close edge) and the elbow of the butchers. The elbow height was defined as the distance between the floor and the olecranon when the elbow was flexed 90°.

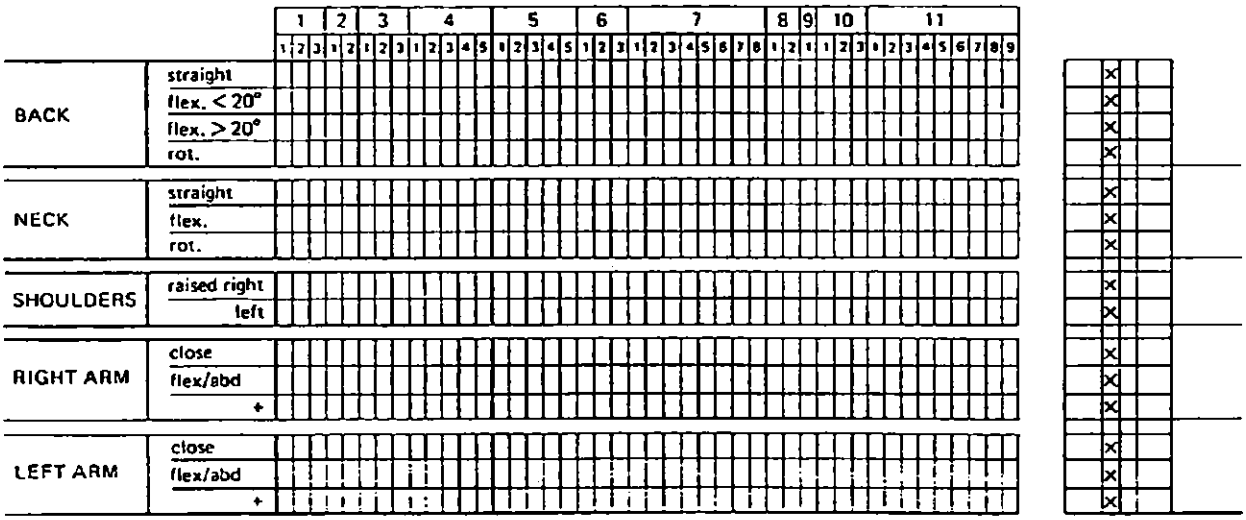

Fig. 2 The scheme used for the videotape analyses. The numbers 1 to 11 represent the different tasks when cutting up a half-pig. The figures below these denote work moments selected for evaluation. The number differs for the different tasks as they vary in time duration and complexity. At each stop of the tape, observations were made of the positions of the back, the neck, the shoulders and the arms according to the classes given

At each height the butchers cut four halves of a pig which took about 25 min. The work was photographed and video-filmed. When the work in each test was finished, the butcher was asked about his experience of the work load. Two subjective ranking scales described by Corlett and Bishop (1976) were used for this evaluation. The first one was a seven-point scale for ranking the overall comfort-discomfort experienced during the work; the other was a body map with ten demarcated areas, which were ranked in order from the most to the least loaded during the work just performed.

The videotapes were analysed using a special classification procedure worked out for these tests. The tape was stopped at each of 45 events which had been selected to be representative of the work performed considering both load and time. At each event the positions of the back, the neck, the shoulders and the arms were noticed, classified and marked in a table (Fig. 2). By summing the number of markings for each class and dividing by the total number of events, a time distribution of load on the body parts during work could be calculated. (By multiplying each marking by a scale factor roughly indicating the magnitude of the load and summing, a simple biomechanical evaluation of the work load on different body parts is obtained. This procedure was not used in the present study.)

The laboratory tests took a relatively short time to perform and we could see that the butchers judged the self chosen height as the most comfortable one, probably because it was the height that they were used to. Therefore another series of three tests was performed, in different plants and at ordinary production speed, testing each height during a whole workday. Different table heights related to the elbow height were tested with the table surface horizontal and tilted. In addition, the butchers varied the height regularly during one workday. Five experienced butchers participated at each workplace. The evaluations were made by using the two subjective methods described before and by interviews.

Table 1: Results of load evaluation using the seven point comfort-discomfort scale for each test person (Tp). X denotes the self-chosen height, and D denotes distance between elbow and table. For the tilted table, the previous most comfortable height was chosen individually for each test-person.

Tp	D	X	+ 5 cm	− 5 cm	8°
1	22	2	5	6	1
2	27	3	2	5	6
3	18	1	5	7	7
4	22	1	3	7	2
5	27	1	3	5	3
Rank		2	3	4	1
		2	1	3	4
		1	2	3·5	3·5
		1	3	4	2
		1	2·5	4	2·5
Σ		7	11·5	18·5	13
		1	2	4	3

Results

On the comfort-discomfort scale, three of the five butchers judged the self-chosen height as the most comfortable. This height varied between 18 and 27 cm below elbow height. One butcher judged the tilted table at 22 cm below elbow height as the most comfortable and one butcher found that the higher table, meaning 22 cm below elbow height, was the best. The lowest table was considered to be the most uncomfortable by four of the five butchers (Table 1).

On the body map the test persons mentioned a different number of loaded body parts for the different table heights (Table 2). The number mentioned indicated the load a table height was causing for each butcher. The total number over

Table 2: Number of loaded body parts on the body map for each test person (Tp). X denotes the self-chosen height, and D denotes distance between elbow and table. For the tilted table, the previous most comfortable height was chosen individually for each test person (see Table 1)

Tp	D	X	+ 5 cm	− 5 cm	8°
1	22	3	2	1	2
2	27	5	4	6	4
3	18	3	6	4	6
4	22	2	3	3	2
5	27	6	6	5	2
Rank		4	2·5	1	2·5
		3	1·5	4	1·5
		1	3·5	2	3·5
		1·5	3·5	3·5	1·5
		3·5	3·5	2	1
Σ		13	14·5	12·5	10
		3	4	2	1

Table 3: Order of selection of body areas for the fourth test person. X denotes the self-chosen table height which was 22 cm below elbow height. The results show that the load moves from the shoulders to the back when the table height is lowered

Body area	X	+ 5	− 5	8°	
Neck			3		
Shoulder dx		1			
Shoulder sin		2			
Elbow dx					
Elbow sin					
Hand dx	1	3	2	1	
Hand sin					
Thor back	2				
Lumb back			1	2	
Legs					
	2	3	3	2	Tp 4

Table 4: Inverse rank numbers of load level in different body parts experienced by each butcher during work at the four table settings. Inverse rank means that 0 denotes no load, 1 denotes lowest load, 2 denotes second lowest load, etc

Table setting	Tp	Neck	Domin shoulder	Non domin shoulder	Thoracic spine	Lumbar spine	Domin elbow	Non domin elbow	Domin hand	Non domin hand	Leg	Sum
x												
	1	0	0	0	0	3	0	0	2	0	1	6
	2	1	5	0	0	4	2	0	0	3	0	15
	3	0	3	0	0	0	0	0	2	0	1	6
	4	0	0	0	1	0	0	0	2	0	0	3
	5	0	5	0	0	6	4	0	3	2	1	21
Sum		1	13	0	1	13	6	0	9	5	3	51
+ 5 cm												
	1	0	0	1	0	2	0	0	0	0	0	3
	2	1	4	0	0	0	3	0	2	0	0	10
	3	0	6	5	0	0	4	2	3	1	0	21
	4	0	3	2	0	0	0	0	1	0	0	6
	5	5	0	0	3	6	0	4	0	2	1	21
Sum		6	13	8	3	8	7	6	6	3	1	61
− 5 cm												
	1	0	0	0	0	1	0	0	0	0	0	1
	2	3	6	0	2	4	5	0	1	0	0	21
	3	0	3	0	4	0	0	0	2	0	1	10
	4	1	0	0	0	3	0	0	2	0	0	6
	5	3	0	2	4	5	0	1	0	0	0	15
Sum		7	9	2	10	13	5	1	5	0	1	53
8° tilt												
	1	0	2	0	0	1	0	0	0	0	0	3
	2	1	4	0	0	0	3	0	2	0	0	10
	3	0	4·5	4·5	0	6	2	0	3	0	1	21
	4	0	0	0	0	1	0	0	2	0	0	3
	5	1	0	0	0	2	0	0	0	0	0	3
Sum		2	10·5	4·5	0	10	5	0	7	0	1	40

all butchers was lowest for each butcher. The total number over all butchers was lowest for the tilted table. By studying in which order the loaded areas were mentioned, it became obvious that the load moved from one body part to another when the table height was changed (Table 3). By ranking the loaded body parts according to the order in which they were mentioned, but inversely, a scale was obtained where a high figure indicates a high load and zero indicates no load. The sum of the inverse ranks calculated over all butchers was used to indicate the overall load. The smallest sum – meaning the lowest load – was obtained for the tilted table and thereafter followed the self-chosen height. The largest sum was obtained for work at the highest table (Table 4).

From the videotapes, two analyses at each table height were made for each of the two butchers in order to get greater confidence in identifying the events to observe, and classifying the body posture. There was a good agreement between the two analyses and the mean values were used in calculations of load distribution. The results are given in Table 5. It is seen that both butchers bent the back most when working at the lowest table height and least when working at the highest table and at the tilted one. Their backs were twisted least when working at the tilted table. Their necks were bent most of the time independently of the table setting. The shoulders were least loaded when working at the lowest table for both the butchers. None of the table adjustments yielded mimimal load on both shoulders and back at the same time. The highest table gave lowest load on the back for one butcher and the tilted one did so for the other. The lowest table height gave the least load on the shoulders for both butchers. Relatively low load on both shoulders and back was obtained when the table height was in the range 18 to 22 cm below elbow height.

The results from the first of the in-plant tests showed that a table height of 17 cm below elbow height was the best height, that a tilt of 5° was felt to be comfortable, and that varying the height about 4 cm was considered to be a good way to unload different body areas temporarily (Tables 6 and 7).

At the second workplace, four of the five butchers estimated that a table height between 17 and 20 cm below elbow height was the most comfortable. Only one butcher liked to have a tilted surface but only 2–3°. In the last series, four of the five butchers estimated the best height to be between 18 and 24 cm below elbow height (Table 8).

Table 5: Distribution of body postures in percent of the working time as evaluated from video recordings of two test-persons engaged in cutting up one half of a pig each. The percentage values are averages of two successive evaluations

	Self-chosen height		+ 5 cm		− 5 cm		8°	
Back	Tp 1	Tp 2	Tp 1	Tp 2	Tp 1	Tp 2	Tp 1	Tp 2
straight	27·5	22·5	24	30·6	15	7	33·3	20·5
little bent	36·5	49	49·5	49	33·5	51·6	51·7	56·8
much bent	36	28·5	28·5	20·4	51·5	41·4	15	22·7
rotated	28·5	11·5	18·5	12·5	19·8	11·5	10·3	7
Neck								
straight	0	4·5	2	7	0	2	2	0
bent	100	95·5	98	93	100	98	98	100
rotated	14	21·5	11	9	14	18	17	13·5
Shoulder								
raised right	32	24	28	24	21	14·5	35	22·5
raised left	22	22·5	16	17	16	19·5	17·4	17

Table 6: Results of load evaluation during one day of production work using the comfort-discomfort scale (first test series)

Table height	22 cm below elbow height	17 cm below elbow height	22 cm below elbow height + 5° tilt	17 cm below elbow height + 5° tilt	Varied heights
Tp 1	6	1–2	5	3	1–2
Tp 2	6	4	6	4	3
Tp 3	3	4	2–3	3	3
Tp 4	6	0	7	1	5
Tp 5	5	3	7	5	4
Sum	26	13	28	16	17

Table 7: Number of loaded parts on the body map during production work (first test series)

Table height	22 cm below elbow height	17 cm below elbow height	22 cm below elbow height + 5° tilt	17 cm below elbow height + 5° tilt	Varied heights
Tp 1	3	0	3	3	4
Tp 2	6	1	1	1	1
Tp 3	3	1	3	1	1
Tp 4	6	1	6	3	0
Tp 5	3	0	6	3	6
Sum	21	3	19	11	12

Table 8: The best table height during production work according to comfort-discomfort scale ranking for ten butchers in the second and third test series. The table height is given as the distance D between elbow height and table height. The average is 18·3 cm and the range is 16–24 cm

Tp	D (cm)	Tp	D (cm)
1	17	6	20–24
2	24	7	20
3	17–20	8	18·5
4	20	9	24
5	20	10	16

To sum up, for four of the five butchers in the laboratory tests the best height was between 18 and 22 cm below elbow height and for 12 of the 15 test persons in the production tests the best height was between 17 and 20 cm below elbow height.

The results show that there is no height giving minimal load on both the back and the shoulders at the same time. On the other hand, there is an interval of 5 cm – between 17 and 22 cm below elbow height – in which the loads on both shoulders and back are low.

Discussion

A good working posture causes minimal load on the body and at the same time allows good accessibility, good sight and exertion of enough force for the work being performed. Conditions for the least load on the body due to posture are that the working height permits the trunk to be kept straight, the shoulders and arms in positions where they are not statically loaded, and the neck as little bent as possible. The working height should also be felt to be comfortable, which is not necessarily synonymous with these conditions because of the influence of habit.

The working height for standing working postures must be adjustable both to the individual and to the working task. The main condition to achieve this is to have separate tables for each individual. Recommendations about the table

heights for standing work have been given by Grandjean (1979). He used the elbow height as reference level and recommended three different height ranges depending on whether the working task is demanding precision or if it is 'light' or 'heavy'. For 'light' work, the working height should be 10–15 cm below elbow height, and for 'heavy' work the height should be 15–40 cm below elbow height. The butchers' working tasks at the table are both light and heavy and the materials they handle vary in form and size.

One would think that the worker would know best which working height is the best for his work. In our tests we let the butchers choose one table height. Subjective ratings show that three of the five butchers considered the self-chosen height as the most comfortable one compared with 5 cm lower and 5 cm higher table height. This height varied for these three butchers within 18 and 27 cm below elbow height. A probable reason for this large variation could be that the self-chosen height turned out to be the height that the butcher was used to, and therefore was felt most comfortable. The other evaluation methods used showed, however, that the best height for four of the five butchers was between 18 and 22 cm below elbow height. The results from the test series at the workplaces show that 12 of 15 butchers found their best working height between 17 and 20 cm below elbow height.

Several butchers were sceptical of the tilted surface, which became obvious on the comfort-discomfort scale; only six of 20 thought that the tilted surface was the best. The body map evaluation, on the other hand, showed that the number of loaded body areas was least with the tilted surface, when summed over all the five butchers in the laboratory tests.

The analysis of the videotapes showed clearly that one fixed optimal working height in butchering was not to be found because different heights load different parts of the body. Thus, the height at which the back is most unloaded gives more load on the shoulders, and vice versa. Because there is no general agreement on how to value loads on different body parts against each other, the working height must be decided upon depending on whether the concern is to unload the back or the shoulders. However, in the range 17–22 cm below elbow height, the loads on the back and the shoulders were quite low; so this can be recommended as a good compromise (see Fig. 4).

Thus, for cutting meat an individual table height is chosen within the range 17–22 cm below elbow height, the lower limit when the concern is to minimise the load on the shoulders, the upper limit when it is to minimise the load on the back. A good practice would be to alter the height within this interval during the workday to alternately unload the shoulders and the back. The full effect of this is probably obtained only if the variation is done automatically and not by the butcher himself.

As habit has an influence on the feeling of comfort, the working height that the butcher is used to is felt to be more comfortable than one that he is not used to. It is therefore important that the time for testing out the right table height is long enough to minimise the influence of habit. It is also important to make clear how a too high and too low table height affect the body load so that the user of the table pays attention to this while testing out his optimal table height.

(a)

(b)

Fig. 3(a) When the table was too high the butcher had to raise his shoulders and abduct his arms. This posture leads to increased strain and fatigue in the shoulder muscles

(b) When the table is too low the posture will be bent forward which increases the load on the low back

Fig. 4(a) A proper table height – in this case 22 cm below elbow height – gives low load on both the back and the shoulders

(b) When the surface was tilted the neck was often straightened

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Nguyen

An ergonomic study of work methods and physical disorders among professional butchers

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Butchers considered that the back and the upper extremities were subjected to high loads from their work. Of the 92% with reported physical disorders, 80% had pains or complaints from more than one body area. Most frequent were disorders of the back and shoulders. 50% of the butchers had been on sick leave due to their disorders. By ergonomic analysis of the work, several work tasks which caused high loads on those body parts in which disorders had occurred were identified.

The high loads were found to have the following main causes, which occurred together in many work situations:

(1) Exertion of high forces when cutting the meat.

(2) Frequent and heavy manual materials handling.

(3) Inappropriate working postures.

It appeared from the study that the workload on the butchers was unnecessarily high and that it could be the main reason for the high frequency of disorders amongst them. The strain on them was to a large extent caused by bad working postures, which could be improved by introducing improved equipment. The equipment should be such that the working-height may be adjusted both to the individual and for the task performed.

Keywords: Butchers, workload, working postures

Introduction

Previous studies have indicated that butchers suffer from pain in the neck-shoulder area, arms, hands and the low back (Romquist and Hansson, 1979; Jonsson and Ouchterlony-Jonsson, 1980; Viikari-Juntura, 1983). These problems seem to have increased in Sweden since the introduction of a new law about temperature of the meat and in the room where the meat is being cut. Butchers consider their work to be heavier after these changes, and they and their union representatives have increasingly emphasised the need for improved working conditions. The aim of this study was to survey working conditions and overload problems amongst professional butchers in some companies in western Sweden in order to identify work tasks which were in particular need of ergonomic improvements.

Materials and methods

To survey the frequency of physical troubles, a questionnaire was designed and sent to all butchers in four small companies in Gothenburg and two larger companies elsewhere in western Sweden. The questions in the medical part of the questionnaire were focused on localisation of the disorders. These questions were taken from an early version of a questionnaire prepared by the Nordic Council of Ministers (Jonsson, 1984). Only disorders prevalent during the last three months were asked for, as were the consequences of the disorders such as consultation with a doctor, sick leave, decreased capacity for work and experiences of fatigue during or after work. In addition, the butchers were asked for those parts of the body in which they experienced the highest loads and which types of work

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they considered to cause these loads. The butchers were instructed to judge the loads irrespective of whether they experienced any pain or not. To give a general picture of the butchers' working conditions, the questionnaire also included questions about psychological strains, injury risks and physical loads due to other factors such as noise, lighting, temperature, etc.

The butchers' workplaces were visited on several occasions in order to investigate the working tasks and to make an ergonomic review of these tasks. In judging the load on the body during work, biomechanical factors were taken into consideration; the weight of the handled material, the distance between the body and the burden, and a rough estimate of the resistance and force required when cutting meat. Also the degree of flexibility of the working posture and the degree of monotony in repetitive movements were considered. The butchers' work was described and documented in a protocol and by photography.

A possible connection between workload and bodily disorders was investigated. The distributions of disorders and discomfort were compared with the subjectively experienced loading on different parts of the body, and with the type of work – i e, dynamic or static work, repetitive movements and transportation of material – both as specified by the butchers and according to the observations made during the workplace studies. In this way it was possible to arrange the work tasks according to the workload and frequency of disorders. High workload on a body part that had a high frequency of disorder was considered sufficient evidence to call for ergonomic improvements of the work situations in which high loads occurred.

Results of the questionnaire

The questionnaire was distributed to all butchers at the companies, and 73 butchers (88%) answered the questions. The results showed that the number of young butchers was high and very few were near the age of retirement; there was only one butcher over 60 years old and 50% were less than 30 years old (Fig. 1). The frequency of disorders was high among both older and younger butchers.

Pain from any part of the body was experienced by 92% (Fig. 2). Most common was pain from the hands and wrists (about 60%) and from the shoulders and low back (55%). Pain from the elbows occurred in 40%. Almost 80% had pain from more than one area of the body, and the most frequent combination was pain from the neck and one or more joints of the arm. About 50% of those with disorders had consulted a doctor, and about the same number had been on sick leave at least once. Fourteen percent had been forced to decrease their rate of work due to their problems. More than half of the butchers claimed that they felt fatigue during or after work (Fig. 3).

According to the butchers' opinions, the shoulders, hands, elbows and low back were the areas of the body which had the largest load. Almost 80% considered the shoulders and hands to be heavily loaded and more than 60% thought that the low back was heavily loaded during work (Fig. 4).

The room where the work was being done was usually very noisy. Noise and the low temperature were judged as factors of high work stress. The possibility of slipping or stumbling and, of course, also the risk of injuring oneself

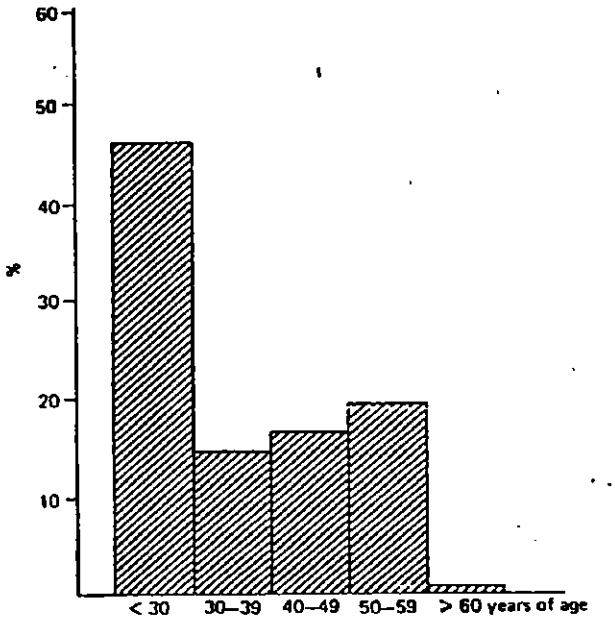


Fig. 1 Age distribution of 73 butchers in western Sweden 1981

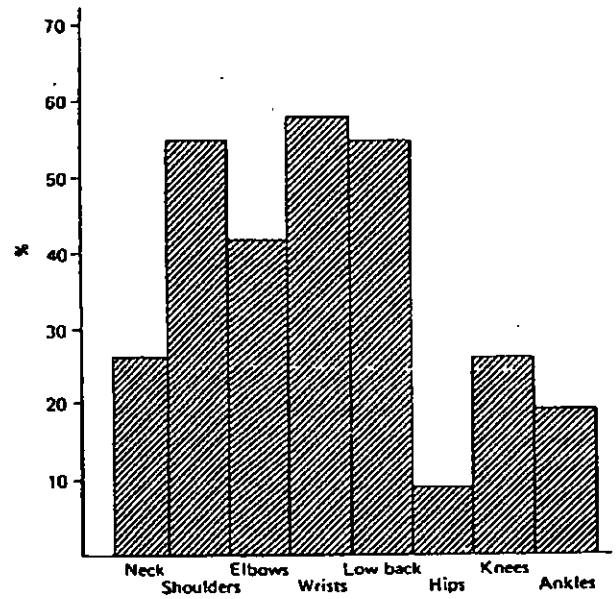


Fig. 2 Distribution of bodily disorders among 73 butchers in western Sweden 1981

with the knife were factors which were experienced as troublesome (Fig. 5). Also the high rate of work and the monotony were factors particularly mentioned.

Working routines in cutting beef and pork

The carcass of an ox is normally divided into four parts while that of a pig is divided into two parts before it arrives at the butcher to be cut into pieces. The procedure of cutting these parts into smaller details involves different tasks and the

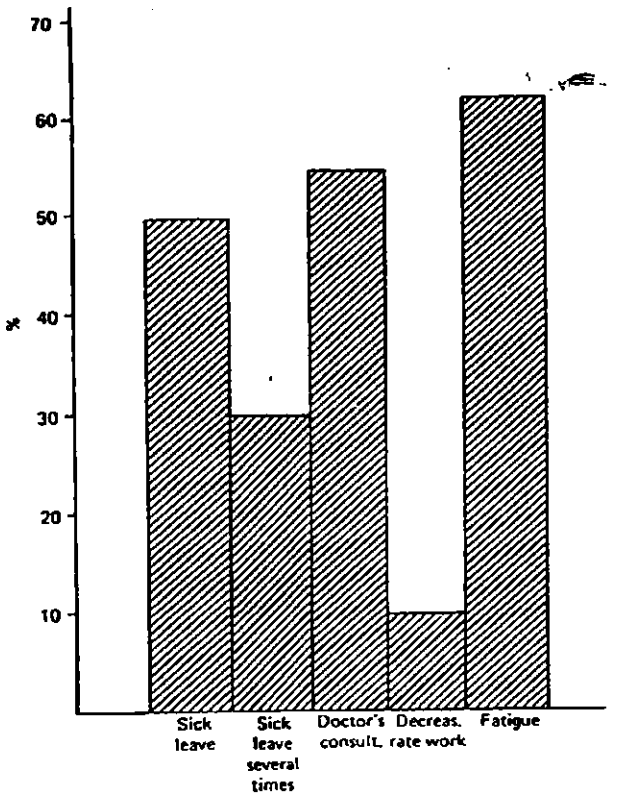


Fig. 3 Distribution of the consequences of disorders among 73 butchers

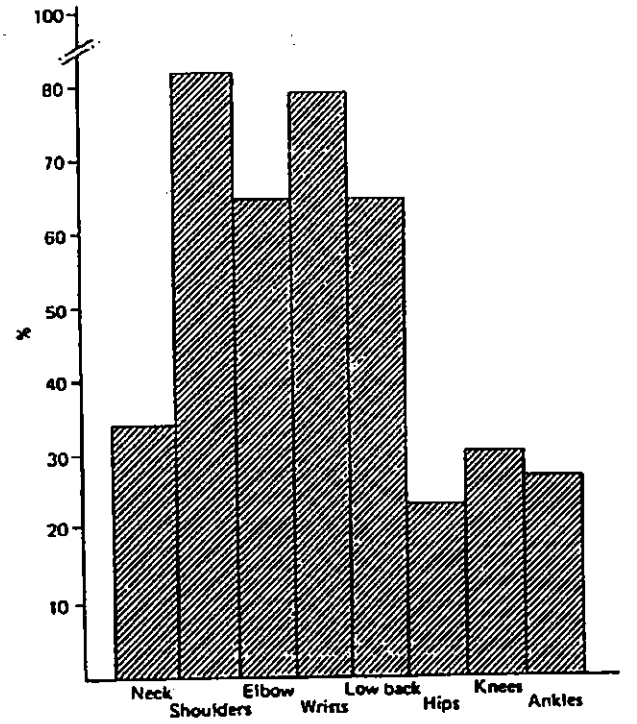


Fig. 4 Distribution of the body load as experienced by 73 butchers

manner differs between beef and pork cutting. Beef parts are usually being cut hanging on a hook which implies that the meat is divided into relatively big pieces weighing 10–30 kg (Fig. 6). The meat is then further cut up at a table. The cutting of pork is done entirely at a table.

In several companies the butcher's tasks also include sawing, transporting, sorting, packeting and weighing. Since the meat is cold and hard after having been kept in cold-store, the cutting resistance is large.

The large pieces being cut contribute to high resistance by the increase of frictional force as the knife cuts deep in the meat. The resistance therefore causes large forces in the shoulder and arm muscles and in the joints. When cutting hanging meat, the cutting heights range from above the shoulders to the level of and even below the knees (Fig. 7). When the arm is kept above shoulder level some shoulder muscles must work statically to keep the arm in this position at the same time as they (together with other muscles) work dynamically in the cutting movements. The cuts imply large abduction and extension movements, sometimes in positions where the muscles have less capacity to produce force. The muscles of the arm and hands are loaded by repetitive work and with a high static component, as complete relaxation of the muscles only occurs between the arrival of different carcass parts.

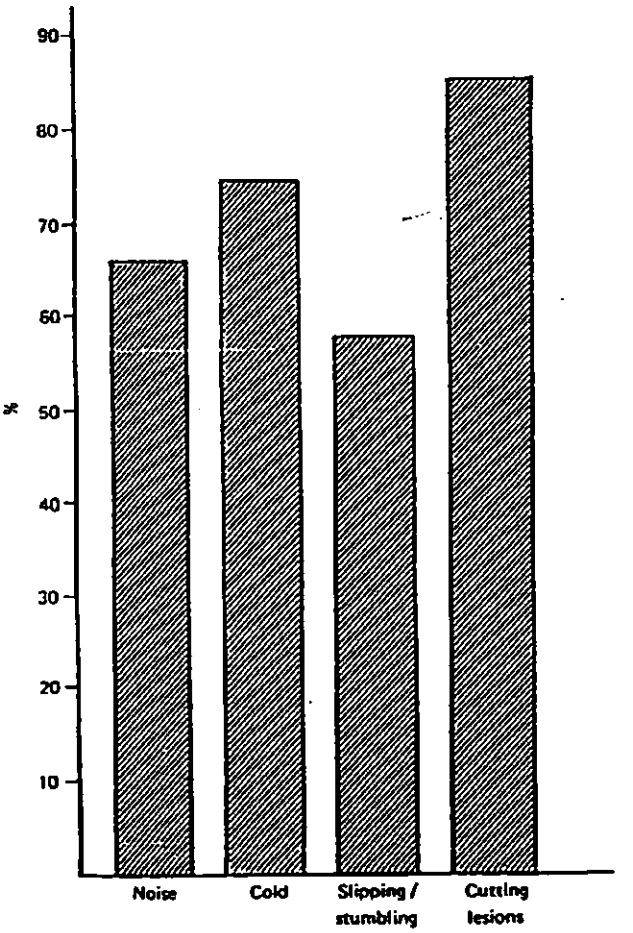


Fig. 5 Distribution of physical and technical load and strains experienced by 73 butchers

(a)

(b)

Fig. 6 Big pieces are being cut hanging from a hook

(a)

(b)

Fig. 7 The cutting heights vary from above the shoulders to the level of the knees, leading to high loading of the shoulder muscles and of the low back

Unhooking large pieces off the conveyor is strenuous because of the high level of the hook (Fig. 8). To carry out this task the arm must be stretched to its maximum, the neck bent backwards and the butcher has to stretch on his toes to reach the hook. From this unstable and strenuous posture the meat is lifted off the hook and caught and carried to a table. These pieces weigh as much as 70 kg.

Cutting at a table consists of highly repetitive movements of the arm (Fig. 9). Powerful abductions and flexions of the arm from the shoulder-joint are often performed with the arm lifted 70–90°. The elbow is kept in a flexed position and is statically loaded as the movements are very small. The hand is mainly loaded by static muscle work, holding the knife and working with a stiff wrist. The pieces handled on the table are smaller, especially when cutting pork, but are more numerous; the work speed is high and the movements are therefore repeated at a high frequency.

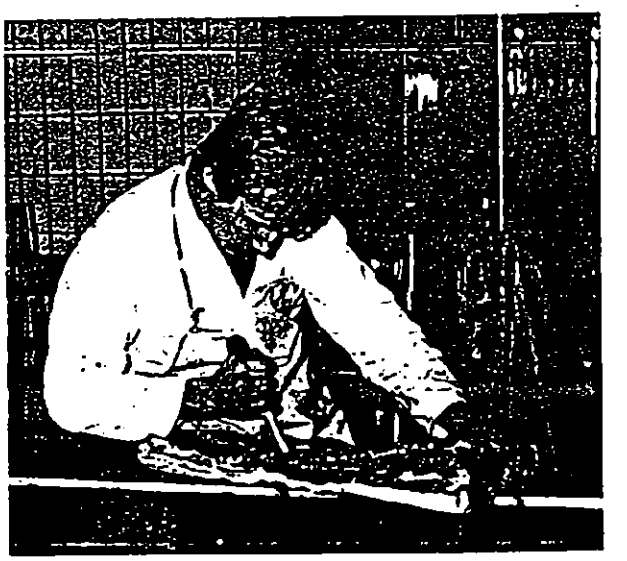
When sorting the meat, one hand and forearm is loaded by frequently repeated movements since the task is often accomplished by throwing the different pieces into several boxes placed in front of and beside the butcher (Fig. 10). Normally the throwing is done with the same hand.

The tables at which butchers work can usually be adjusted in height, but this adjustment is seldom utilised since the adjustment is tedious and often requires help and tools from the maintenance department. Sometimes several butchers of various heights are working at a large, common table, so that the table is either too high or too low for each one working there. The shorter butchers often adjust the table height by standing on a platform. The height of the platform is fixed at about 10 cm. The use of it obviously increases the risk for stumbling or slipping accidents.

Sawing at a bandsaw is a task which implies unnecessarily high loads on the low back. The construction of the saw inhibits the butcher from getting closer to the work area

Fig. 8 Unhooking of a large piece implies stretching of the arm, extension of the neck and a heavy burden to carry

(a)



(b)

Fig. 9 Cutting at a table. The cutting is associated with high dynamic loading of the shoulder muscles and repetitive and static loading of the muscles of the arm and hand

Fig. 10 Repetitive work when throwing the pieces into boxes. This task is probably one cause of the occurrence of epichondylites among butchers

(Fig. 11). Thus, when sawing he starts from a position of slight forward flexion and bends further forward, once for each cut. Also the risk of injuring himself on the saw leads to high psychological strain on the butcher.

Moving belts and conveyors are used for transportation. Only in large companies are they driven by motors and used for all transportation. Therefore most handling of materials is manual, causing high loads on shoulders and backs. Boxes weighing about 40 kg and meat parts weighing 20–30 kg, even as much as 70 kg, are lifted and carried frequently (Fig. 12). Containers on wheels are used for bulk transportation of meat. The containers weigh up to and above 100 kg when filled and require high forces to manoeuvre, especially on narrow bends. Another strenuous task is to push carcasses which are hanging on hooks on conveyors, especially as the floor is often very slippery.

Discussion

Butchers have, without doubt, a hard job. Both the frequency of disorders and the butchers' experience of high loads signify this. Also the fact that only men are butchers and that they seldom remain butchers until their pensionable age supports this statement. Disorders appear in all parts of the body, but the frequency of discomfort and pain was highest in the arms, shoulders and the low back. The troubles had led to sick leave for more than half of the butchers and many of them had been forced to reduce their rate of work during some period of time. There were no

Fig. 11 Sawing at a bandsaw requires frequent forward bending, starting from slight forward flexion of the trunk

signs that the few older butchers had more troubles than the younger ones; this may be a reflection of the 'healthy worker effect', however.

The body-areas in which the butchers experienced a high load during work corresponded with the areas of pain, although the frequency of experience of load was larger. This can indicate a risk that more butchers will develop disorders from the parts that are loaded during work, since those who do not experience pain might not have worked long enough.

By analysis of the working tasks we could identify several that caused high loads on the body parts in which pain or trouble had developed. High stresses were found to have the following main causes which occurred together in most work situations:

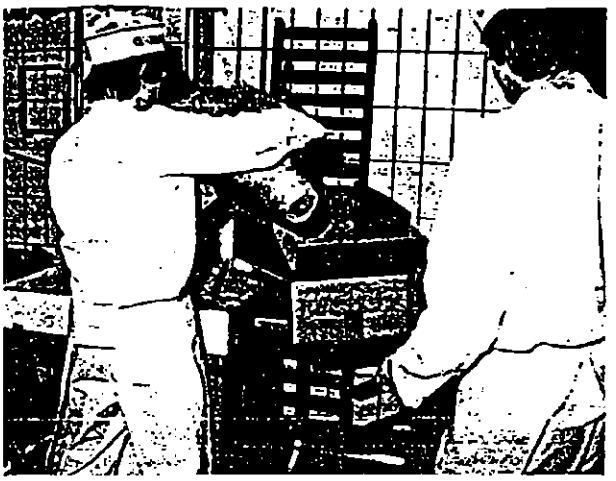
(1) Exertion of high forces when cutting the meat.

(2) Frequent – and often heavy – manual materials handling

(3) Bad working postures.

The resistance when cutting is due to the toughness of the meat which is influenced by several factors related to storage conditions – e g, temperature, age, dryness – and to the history of the animals – e g, care, feed stuff and exercise. The large size of the pieces that are being cut also leads to high knife forces which are particularly strenuous when the cutting is done in positions in which exertion of maximum force is reduced. The arm is often lifted out from the body for extended periods of time, which leads to a static load on the muscles.

At the same time these muscles are working dynamically together with others in the cutting movements. The dynamic work is, however, often so frequent that it is comparable with static work because the pauses between the contractions are too short for the muscles to relax and recover. The consequence is that the muscles may not relax



(a)

(b)

Fig. 12 Lifting and carrying meat and boxes is frequent. Manual lifting of 75 kg occurs and one man may lift and carry 4000–6000 kg a day

at all for long periods of time. When the arm is lifted above heart level, the circulatory conditions are negatively influenced, which also decreases the time before fatigue occurs. Thus, the position of the arm and the resistance of the meat are two factors that cause the high loading on the shoulder. Also, the numerous throwing of pieces when sorting is highly repetitive work causing high loads on one arm. The throwing is carried out by a rapid, powerful extension of the hand and might contribute to the high frequency (40%) of disorders of the elbow.

The transportation of meat in the working room is to a great extent a manual task. Lifting and carrying boxes and cases weighing up to 40 kg and above are common tasks. At several workplaces each man lifted and carried more than 4000 kg every day. When cutting beef and pork at a table, throwing is a common way of distribution of meat and cleaned bones into boxes and containers. When cutting beef from a hanging carcass, the meat is carried to a table for further division. The carrying is particularly stressful due to the large weight of the pieces.

In many companies which we visited the use of buffers and the flow of material between workstations were not very well planned, leading to time losses and unnecessary work. There is no doubt that an increased use of mechanised equipment to transport the meat both to and from the butchers' workplace should reduce the work load to a large extent and increase the efficiency.

The high loads on the low back are caused mainly by the working postures. Sixty five percent of the butchers considered the low back as highly loaded and 55% had low-back pain. When cutting hanging meat the cutting and the catching of the meat being cut off often took place at a low working height. This resulted in a more or less forwardly bent posture of the back and caused high loads on the spine. Lifting in a posture of combined forward flexion and rotation was common.

Unfavourable working postures occurred during work at a table when the height was not properly adjusted. Only at one workplace did the butchers have a table of their own which could also be easily and rapidly adjusted in height. At all other workplaces, several butchers of various heights worked at tables that were shared or at a table otherwise fixed in height. Those for whom the table was too low had to work in a forwardly bent position which increased the load on the back, and those for whom the table was too high had to work with elevated shoulders and arms which caused sustained static loading, especially on the shoulder muscles.

It appears from our study that the workload on the butchers is unnecessarily high and that it can be the main reason for the large frequency of disorders among them. By reducing the workload, the incidence of overload troubles would decrease and the possibility for the butchers to carry out their work until their pensionable age would probably increase.

A desirable way of reducing the workload in a work-intensive job like meat cutting is to introduce a machine to do the heavy part of the job. Although cutting robots have been designed and tested in production, they are not yet able to handle meat of varying size and shape; thus other means must be attempted.

An increase in temperature has been suggested. It has been found that a small increase in temperature is not sufficient, however. In hot boning – i e, cutting the meat immediately after the slaughtering and before it has been refrigerated – the resistance of the meat is favourably reduced (Romquist and Hansson, 1979), but the method demands a particularly high hygienic standard and that the slaughtering and the cutting are organised together. Most meat cutting companies in Sweden have no slaughtering and many of them are quite small and not likely to accept measures that lead to heavy investments.

Fortunately, the strain on the butchers is, to a large extent, caused by bad working postures which can be improved in fairly simple ways, including introducing improved equipment at the workplaces. The equipment should be designed so that the butchers could work standing upright with their hands reaching from waist level to breast level.

Conclusions

By adjusting the working height to the individual and to the task performed, the loads on both the back and the arms could be kept at much lower levels. Tables should be

one for each butcher, easily adjustable in height and also tiltable. By tilting the table surface the neck can be kept in a more upright position, meaning decrease of load. When cutting hanging meat, the cutting level should be adjustable so that the work could be performed with an upright trunk and with the arms not lifted too much. An increased use of mechanised transportation of meat to and from the butcher's workplace should further reduce the work load and increase the productivity. In a future paper we plan to report on how this can be accomplished and on the reduced workload on the butchers.

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Résumé

Conseils de sécurité à l'intention des personnes travaillant dans les secteurs de la boucherie et de la charcuterie. Ils concernent notamment: les couteaux, les machines, la manutention, l'entretien, l'organisation du travail et de la prévention.

En France

COMPARAISON DES RISQUES

ACTIVITES INDUSTRIELLES	INDICE DE FREQUENCE DES ACCIDENTS AVEC ARRÊT (1)	EXEMPLES DE COMMERCES ET SERVICES ALIMENTAIRES
		271 Abattoirs
		185 Commerce de gros des viandes
Bâtiment menuiserie métallerie bâtiment	184	
Bâtiment et gros oeuvre	166	
Chaudronnerie lourde et construction navale	164	
Travaux publics, génie civil	159	
		146 Entrepôts frigorifiques
		130 Transports frigorifiques
		127 Charcuterie - conserverie
Bâtiment second oeuvre	125	
Transport et manutention de marchandises	120	
Fonderie de métaux, bâtiment platerie	117	
		115 Conserverie de poissons
Découpage, Emboutissage, Estampage, Forge	108	
		102 Volailles, Gibiers (abattage & commerce de gros)
Pierres & terres à feu (verres, briques, tuiles ...)	101	
Industrie du bois	98	
Mécanique moyenne	93	
		91 Cantines - Traiteurs
Transport de personnes et marchandises	87	
		86 Plats cuisinés
		79 Epicerie
Ateliers mécanique moyenne	78	
		77 Hyper et supermarchés
Caoutchouc - papier - carton	74	
		73 Industrie lait, fromages
		67 Boyauderie - salaisonnerie
		65 Restaurants
Automobile	61	
Fabrications mécaniques diverses	55	
Textile	54	
Sidérurgie	48	
Industries chimie - Pétrochimie	46	
		42 Commerce de gros
Transports terre - air - mer	40	
Aéronautique, cuirs, peaux	38	
Livre	36	
		31 Santé - Hôtellerie
Vêtement	29	
		8 Bureaux - Activités administratives
	0	0

(1) L'indice de fréquence des accidents avec arrêt correspond au nombre annuel d'accidents avec arrêt pour 1000 salariés. Exemple : 98 salariés sur 1000 ou 9,8 % de salariés ont été victimes d'un accident avec arrêt dans le secteur Commerce de détail des viandes au cours de l'année 1984.

POURQUOI CE MEMENTO ?

Comme vous pouvez le constater sur l'échelle ci-contre, le nombre des accidents du travail dans votre profession est anormalement élevé, comparativement à certaines activités industrielles. Il est à noter que la fréquence des accidents est de deux à trois fois plus élevée dans la tranche des 16-24 ans.

La CNAMTS a donc conçu ce mémento pour aider la boucherie de détail à résoudre elle-même les problèmes d'hygiène et de sécurité qui se posent actuellement. De très bons niveaux de qualité et de service lui seront indispensables pour être présente sur le marché communautaire, en 1992. Il faut, dès maintenant, prendre conscience de l'importance des accidents du travail et de leurs conséquences sur le plan humain et sur la qualité sanitaire des viandes. De plus, un suivi strict des règles d'hygiène est nécessaire pour assurer cette qualité.

La CNAMTS pense que rendre un bon service à une profession, ce n'est pas se substituer à l'un ou l'autre de ses rouages, c'est lui apporter les outils et méthodes nécessaires pour qu'elle assure elle-même la sécurité du travail, sans avoir besoin de l'aide directe de spécialistes extérieurs.

La présente démarche sera en outre complétée par des conseils aux concepteurs, constructeurs et installateurs de magasins, ainsi qu'aux responsables de la formation professionnelle, pour permettre toutes les améliorations souhaitables, en accord avec la profession de la boucherie et de la boucherie-charcuterie.

Les conseils indiqués dans ce mémento vont vous aider, dès maintenant, à réduire le nombre des accidents du travail et les coûts qui en résultent.

DES ACCIDENTS TROP NOMBREUX

En 1984, on dénombrait, en effet, dans le commerce de détail de la viande, 95 accidents du travail pour 1 000 salariés, dont 6 avec incapacité partielle permanente (IPP).

Actuellement, le niveau de risque diminue progressivement pour toutes les professions mais beaucoup moins vite dans la boucherie que dans les activités industrielles notamment.

Dans les boucheries de détail, le niveau de risque actuel est sensiblement le même que dans les années 1970, après avoir atteint un maximum de 103 accidents pour 1000 salariés en 1981.

On observe notamment que, depuis 1985, l'indice de fréquence des accidents dans la boucherie est supérieur à celui des industries du bois, de l'automobile et de la sidérurgie, par exemple.

LES ACCIDENTS DU TRAVAIL

Eléments matériels à l'origine des accidents
(Matériel ou tâche directement liés à l'accident)

- **Le couteau** ..... **45 %**
- Les manipulations de quartiers de viandes ou d'objets divers (y compris les chutes d'objets) ..... 21 %
- Les chutes de plain-pied et notamment les glissades sur le sol ..... 11 %
- Machines coupantes, dont notamment: tranche-jambon, scies (circulaires et à ruban), dénerveuses, hachoirs ..... 9 %
- Chutes avec dénivellation, en particulier les escaliers, puis les escabeaux et les supports de fortune ..... 4 %
- Eau chaude, brûleurs à gaz, produits chauds ..... 2 %
- Installations ou appareils de manutention: Roll-conteneurs, chariots, rails, crochets, dents de loup ..... 1 %
- Autres types d'accidents ..... 7 %

Siège des lésions
(Partie du corps touchée lors de l'accident)

- **Mains** ..... **64 %**
- Bras ..... 11 %
- Jambes ..... 8 %
- Tronc ..... 7 %
- Pieds ..... 4 %
- Autres ..... 6 %

Nature des lésions

- **Plaies, coupures** ..... **63 %**
- Contusions ..... 7 %
- Piqûres ..... 6 %
- Entorses ..... 5 %
- Lumbagos ..... 4 %
- Fractures, fêlures ..... 3 %
- Brûlures ..... 2 %
- Autres ..... 10 %

L'ESPRIT QUALITE - SECURITE

C'est par des actions élémentaires et quotidiennes que vous développerez l'esprit de qualité et de sécurité dans votre commerce.

En définissant des procédures simples, vous conserverez la qualité de vos viandes. Ces procédures intégreront naturellement les exigences d'hygiène, de sécurité et amélioront les conditions de travail.

C'est en donnant vous-même l'exemple du respect scrupuleux de ces procédures que vous obtiendrez les meilleurs résultats. Ainsi votre employé ne portera son tablier que si vous portez le vôtre.

La qualité des produits ainsi que les services rendus à la clientèle renforceront votre image de marque. Faites savoir à votre clientèle que vous, et vos employés, respectez les règles d'hygiène et de sécurité qui assurent la qualité. Le port du tablier en permanence et même à l'étal en est une preuve.

Pour atteindre ces objectifs, il n'est pas nécessaire d'effectuer des modifications importantes de vos installations.

LES ORIGINES DES ACCIDENTS DU TRAVAIL

Les origines matérielles des accidents les plus courants dans votre profession sont répertoriées dans le tableau ci-contre.

On observe l'importance des [illegible], notamment à la main.
Les accidents liés à l'utilisation du [illegible] représentent 45% de la totalité des accidents du travail.
Les machines coupantes interviennent dans 9% des cas.
Sur ces 9%, citons le [illegible] qui représente les deux tiers des causes d'accidents, puis le hachoir, les scies, la dénerveuse et le cutter de table pour le tiers restant.

Mais il existe d'autres causes de coupures (cerclage d'emballages, tôle mal ébavurée, débris coupants, etc.). La totalité des blessures par coupure atteint 63 %.

Ce constat est important au regard de l'hygiène des matériels et des viandes car il pose le problème de la contamination et de la transmission de maladies par le sang.
Les porteurs sains, c'est-à-dire les personnes non-malades mais qui peuvent transmettre certaines maladies, ignorent les risques qu'ils font prendre aux autres. Chacun doit donc soigner immédiatement les coupures comme il est indiqué page 49, ou mieux, [illegible] pour les éviter.

LES COUTEAUX

Le choix

Le [illegible] est l'instrument privilégié qui vous permet d'[illegible]. Il faut donc le choisir avec soin en fonction de la tâche précise à effectuer.

Lors de l'achat, assurez-vous que la qualité de la lame correspond aux normes françaises NF A 35-595 ou A 35-596.

De nombreux accidents sont liés à la forme des manches. En effet, ceux-ci sont glissants, provoquent des cals et des compressions du réseau veineux de la main entraînant une fatigue précoce.

De plus, la plupart des manches ne sont pas conformes aux impératifs de la réglementation européenne concernant l'hygiène. Les couteaux doivent être fabriqués avec des matériaux autorisés au contact alimentaire et doivent être faciles à nettoyer et à désinfecter. De ce fait, les rivets apparents sont [illegible].

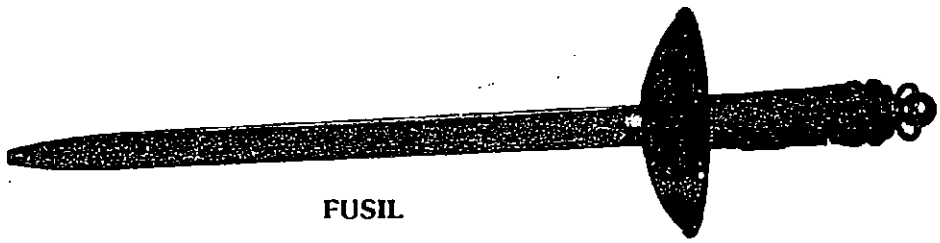
Il est rappelé que l'usage des manches en bois est interdit par les réglementations communautaire et française.

Deux fabricants ont eu l'initiative de faire évoluer les couteaux de façon à améliorer les conditions de travail et la rapidité des tâches. Les nouveaux modèles ont été conçus en collaboration avec des spécialistes de la prévention des accidents du travail, et intègrent les principes de [illegible] ainsi que les exigences internationales d'hygiène.

Ces deux fournisseurs sont:

• Pour les couteaux de découpe notamment:
Charles Ménière S.A. - 67, rue Joseph Claussat - B.P.86 - 63307 Thiers Cedex - Tél. (16) 73 80 41 98

• Pour les couteaux de désossage et de dénervage:
Pernot & Cie - Lanques-sur-Rognon - 52800 Nogent - Tél. (16) 25 31 93 02



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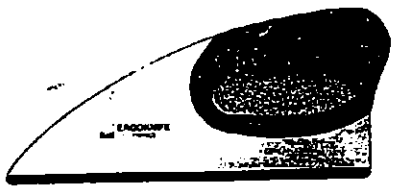
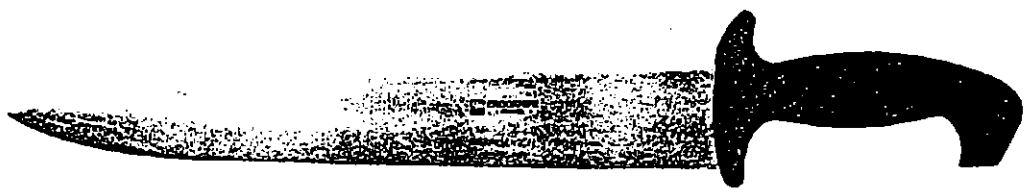


DÉNERVAGE

DÉSOSSAGE

BOUCHERIE DÉCOUPE



SAIGNÉE

CARRELAGES POUVANT ETRE RETENUS (GRES CERANE)

Selon les disponibilités actuelles du marché européen

Marque	Type caractéristiques	Coefficient d'adhérence INRS (4)	Locaux
Hôganas (Suède) **Partek Höganas Céramiques France** 99, rue Henri Gauthier 93000 Bobigny Tél: (1) 48 46 67 67	Type: 500 GK (1) Dim: 150 X150 ép; 20 mm Couleur beige	0,9	A D C F R
	Type: 560 FK (1) Dim: 150 X 150 ép. 16 mm Couleur: beige	0,45	A D C F R
Decize (France) 128, avenue Emile Zola 75015 Paris - Tél: (1) 45 77 32 31	Type: Carborandum (2) Dim: 100 X 100 ép. 12 mm Couleur: blanc	0,47	D (3) C F R
Ostara (RFA) **Agent Général France : Ets. Delattre** 38, rue des Etats Généraux 78000 Versailles Tél: (1) 39 53 63 45	Type: SIC rugueux (2) Dim: 150 X 150 ép. 12 mm Couleurs: porphyré, gris 23 ou blanc 01 Dim: 100 X 200 ép. 14 mm Couleur: blanc 01	0,45	D C F R
Agrob (RFA) **Agrob France S.A.R.L.** Z. I. Gena-Revoisson rue des Frères Lumière 69740 Genas Tél: (16) 78 90 67 44	Type: Mocarbo rèche (2) Dim: 150 X 150 ép. 12 à 13 mm Couleurs: gris porphyré 45 série 1 ou blanc série 2 (Réf: 53 11 30 et 53 11 40)	0,35	D C F R
Villeroy et Boch (RFA) 77320 La Ferté Gaucher Tél. : (1) 64 20 20 00	Type: Granifloor-Corindon Dim: 150 x 150 ép. 12 mm Couleurs: blanc, gris clair	0,35	D C F R

RESINES POUVANT ETRE RETENUES

Selon les disponibilités actuelles du marché européen

Monile France S.A.R.L. 67/69, route de Paris 95310 St-Ouen l'Aumone Tél. (1) 30 37 00 24	Type: Monoquartz Résine acrylique et granulat de quartz ép. 10 à 12 mm Couleurs : Chamois, brun rouge, gris platinium, vert amande	0,38	A D C F R
Goldschmidt (RFA) **Goldschmidt France S.A.** 3, avenue des Chaumes 78180 Montigny-le-Bretonneux Tél. (1) 30 43 44 44	Type: Prodoral EW 99 Résine époxydique et granulat de quartz ép. 3 à 4 mm Couleurs: gris, brun rouge, vert, jaune sable	0,31	C F R

Locaux : utilisations types, à titre indicatif.

A : abattoirs, hall de saignée, chaînes d'habillage, locaux à forte sollicitation mécanique.

D : ateliers de découpe et similaires, charcuteries, salaisonneries, boyauderies, triperies.

C : cuisines (locaux de préparation, cuisson, lavage) et laboratoires similaires (traiteurs, pâtisseries, boucheries).

F : chambres de ressuage, chambres froides.

R : réserves, locaux d'entreposage.

(1) Grains de carbure noyés dans la masse.

(2) Grains de carbure sur 3 à 4 mm d'épaisseur.

(3) Sauf roulage intense chariots à roues métalliques.

(4) Le sol est d'autant moins glissant que le coefficient d'adhérence "INRS" est élevé. Les résultats expérimentaux (observations sur le terrain en milieu de travail) montrent que 0,30 est un minimum exigible.

LES GLISSADES ET LES CHUTES DE PLAIN-PIED

Les [illegible] et les chutes de plain-pied représentent 11% des accidents du travail de la profession.
Les [illegible] les plus fréquentes tiennent à la nature, au nettoyage et à l'[illegible] des , ainsi qu'au port de [illegible] inadaptées.

Le sol-support

Il est généralement constitué d'une dalle qui doit avoir les qualités de résistance, d'indéformabilité et d'isolement aux remontées d'humidité.
La chappe de ciment qui recouvre cette dalle aura les pentes nécessaires pour l'écoulement facile de l'eau de lavage (1 à 2%).
Le plan d'exécution doit préciser les points d'écoulement et les canalisations d'évacuation.
D'une façon générale, il faut éviter les percements du sol pour le passage des canalisations d'alimentation. Si cela n'est pas possible, des fourreaux en matériau inoxydable seront nécessaires et déborderont du sol d'au moins 15 cm.

Le revêtement de sol

Il est indispensable de faire respecter par le poseur les conditions précisées dans le DTU 52-1 d'octobre 1985.
Les joints en mortier époxydique constituent un élément essentiel de l'étanchéité.
Les grilles et les rigoles d'écoulement doivent être disposées au même niveau que le carrelage.
Il existe des siphons adaptés et compatibles avec les dimensions de carrelage qui évitent les découpes.

L'ensemble de ces travaux sera réalisé par des professionnels avertis.

Le revêtement de sol doit être: antidérapant, facile à nettoyer et à désinfecter, résistant aux chocs, imperméable et imputrescible, exempt de porosité, non inflammable.
Choisissez, de préférence, le grès cérame antiglissant ou les résines à charges de quartz présentés dans le tableau ci-contre. Ces revêtements ont été examinés et testés au CNERPAC (1) pour l'hygiène et à l'INRS (2) pour l'adhérence.

D'une manière générale, les résines époxydiques ont une moins bonne résistance aux chocs thermiques et au roulement intensif de chariots que les carrelages en grès cérame d'épaisseur suffisante. En l'absence de telles contraintes, les résines époxydiques sont plus économiques.
L'épaisseur minimale exigée pour les carrelages est de 12 mm. Les faïences et grès émaillés sont à proscrire.
Les raccordements plinthe-sol sont à gorge arrondie et étanches.
Prévoir une interdiction de circulation pendant les huit jours qui succèdent à la pose.

(1) CNERPAC - Service du ministère de l'Agriculture chargé de recherches en matière d'hygiène alimentaire - Voir adresse page 60.
(2) INRS - Organisme dépendant de la Sécurité sociale chargé de recherches en matière de sécurité du travail - Voir adresse page 60.

LES METHODES SPECIFIQUES DE NETTOYAGE DES MATERIELS ET DES SURFACES AU CONTACT DES ALIMENTS

Matériels et installations	Mode d'entretien	Périodicité
Billots en bois debout en attente de remplacement par une matière autorisée	• 1 - Brossage à sec éliminant les particules de viande, de gras et d'os. • 2 - Brossage énergique à l'eau très chaude additionnée de détergent autorisé. • Eponger le liquide avec un torchon propre qu'il faudra essorer dans de l'eau claire de rinçage autant de fois que nécessaire. • Gratter la surface (grattoir à lame métallique). • Enfin, passer sur toute la surface du billot un linge propre légèrement mouillé dans de l'eau javellisée (dose normale). • Laisser sécher à l'air.	Une fois par jour (de préférence en fin de journée), un grattage à sec du billot en cours de journée est fortement conseillé.
Tables de découpe : • en bois couché, en attente de remplacement par une matière autorisée telle que le bois densifié, par exemple • ou planche à découper en matière plastique	• Voir 1 ci-dessus. • Voir 2 ci dessus. • Rinçage au jet d'eau chaude. • Arrosage avec un produit désinfectant (eau de javel dose normale par exemple) et laisser sécher cinq minutes puis second rinçage au jet d'eau chaude. • Eliminer l'eau de rinçage avec une raclette en matière plastique propre.	Une fois par jour (idem ci-dessus)
Les crochets, tiges et allonges	La malpropreté des appareils d'accrochage occasionne des détériorations de la viande au niveau des points d'accrochage. Il faut faire bouillir les crochets pendant 20 minutes dans de l'eau additionnée de détergent, rincer, puis tremper pendant 15 minutes dans un bain désinfectant.	Hebdomadaire
Petits matériels	Un équipement spécifique en matériels de nettoyage doit être prévu du genre : brosses de différents modèles, goupillons de différents diamètres pour avoir un accès plus commode à l'intérieur des matériels.	Quotidien
Machines	• Dans tous les cas : débrancher l'appareil. • Démonter les pièces amovibles en utilisant des gants adaptés. • Rincer les pièces à l'eau chaude. • Nettoyer et désinfecter celles-ci ainsi que la partie non démontable. • Laisser les pièces sécher à l'air pendant la nuit puis remonter l'appareil et le recouvrir d'un linge propre. NB : S'il faut protéger certaines pièces de l'oxydation, les sécher à l'aide d'un torchon de papier à jeter et les recouvrir d'une fine pellicule d'huile comestible (à éliminer par eau chaude avant remontage et utilisation car l'huile est alors recouverte de poussières). • L'emploi du jet est interdit pour toutes les machines électriques.	Après chaque usage
Sols	• Racler les débris. • Arroser abondamment avec de l'eau additionnée de détergent. • Effectuer un brossage énergique ou une action hydraulique sous pression. • Rincer abondamment à l'eau chaude et désinfecter. NB : Veiller à l'entretien des grilles et caniveaux d'évacuation des eaux usées ainsi qu'aux paniers retenant les déchets dans les siphons: désinfection quotidienne avec produit désinfectant en dose forte.	Quotidien
Chambres froides (froid positif)	• Vider la chambre de réfrigération et arrêter le groupe frigorifique. • Brosser les équipements (clayettes, crochets), les murs et le sol. NB : Procéder à cet entretien avec rapidité de façon à ne pas laisser monter sensiblement la température. • Opérer à porte ouverte (pour que la vapeur puisse être évacuée). • Rincer à l'eau froide.	Hebdomadaire
Le matériel de nettoyage	• Le matériel de nettoyage lui-même (brosses, goupillons, raclettes, tampons, balais brosses, etc.) doit être nettoyé et désinfecté car il est un lieu privilégié de développement des micro-organismes et des mauvaises odeurs. • C'est pour cela qu'il convient, après chaque séance de nettoyage de procéder à l'élimination des déchets accrochés sur les brosses, au rinçage des matériels puis à leur désinfection (trempage dans un bain désinfectant pendant 10 minutes). Laisser sécher les brosses en les posant sur les poils, suspendre les balais, balais brosses...	Après chaque nettoyage

REMARQUE : Il est nécessaire de prévoir un placard pour le stockage des produits d'entretien, de nettoyage et de désinfection.

LE NETTOYAGE DES SOLS

Un bon nettoyage permet de limiter les risques de glissade, de contamination des matériels et de la viande.
Avant toute opération de nettoyage, veillez à ce que la viande soit à l'abri de toute éclaboussure.

Le [illegible] et l'épandage de tout [illegible] et minéraux) sont [illegible] par la réglementation.
L'épandage de certains produits "absorbants - antidérapants" est cependant encore toléré à condition que ceux-ci aient reçu un agrément du CNERPAC (1). Ce sont essentiellement des produits de nature minérale, à constituant unique, et sous forme cristalline:
- Argiles du type sépiolite, attapulgite...
- Roches volcaniques expansées.

Le sel de cuisine en cristaux est déconseillé car il provoque une détérioration des équipements, des machines et également des chaussures.

Les composés chlorés (essentiellement l'eau de Javel) sont les plus utilisés pour la désinfection. L'[illegible] est sensible à la lumière, la chaleur, au contact avec les métaux. Il faut utiliser et [illegible] ces produits [illegible]. Le personnel qui procède au nettoyage doit être formé à cet effet et être muni de gants adaptés.

Etiquetter correctement les bouteilles contenant des produits dangereux. Des étiquettes autocollantes peuvent être obtenues à la Fédération nationale des entreprises de nettoyage (2).

[illegible] de [illegible] pour stocker ces produits, ni de [illegible] pour leur dosage.

Dose	Exemples de surfaces à désinfecter avec de l'eau de Javel (3)	Dose d'eau de Javel 3,6% de Cl actif ou 12° Chl (4) à ajouter à :	
		1 litre d'eau	1 seau d'eau (8 à 10 l)
Faible	**BATTERIE, RECIPIENTS**	Utiliser un doseur: 0,25 cl	Utiliser un doseur: 2,5 cl
Normale	**SURFACES LISSES** sols, carrelages, revêtements, mobilier, matériel, (appareils électromécaniques de préparation)	Utiliser un doseur: 1,25 cl	Utiliser un récipient gradué: mesurer 10 cl (équivalent d'un verre)
Forte	**SURFACES RUGUEUSES OU TRES POLLUEES** local des réserves, rayonnages, murs, surfaces de travail en bois, poubelles, vide-ordures, hottes d'aspiration, matériel, machines hachoirs	Utiliser un récipient gradué: 10 cl	Utiliser un récipient réservé à cet effet: 100 cl
Très forte	**INSTALLATIONS SANITAIRES** (W.C., canalisations)	Utiliser un récipient gradué: 20 cl	Utiliser un récipient réservé à cet effet: 200 cl

(1) CNERPAC, Service du ministère de l'Agriculture - 5, rue Mazet - 75006 Paris - Tél. (1) 43 25 97 46
(2) Fédération nationale des entreprises de nettoyage - 3 et 5, rue de Metz - 75010 Paris - Tél. (1) 42 46 82 12
(3) Chambre Syndicale de l'eau de Javel et des produits connexes - 10, avenue de Messine 75008 Paris Tél. (1) 45 62 29 60
(4) Chl = degré chlorométrique

LES INSTALLATIONS D'HYGIENE ET LE MATERIEL SANITAIRE

Les installations générales d'hygiène comprennent divers postes d'eau permettant le [illegible] et la [illegible] utilisé par le personnel:

- Des lavabos stérilisateurs pour le nettoyage, la désinfection des couteaux et du matériel de travail.

Ces [illegible], construits en acier inoxydable, sont à [illegible] et sont équipés d'un mélangeur eau chaude/eau froide ainsi que d'un distributeur de savon. S'il existe un bac stérilisateur pour couteaux, il est alimenté en eau dont la température est égale ou supérieure à 82°C.

De manière générale, il faut aménager au moins un lavabo par local (1).

- Une plonge pour le lavage manuel du petit matériel se trouve dans une zone à l'écart des denrées alimentaires.

Elle est équipée d'une douchette ou d'un pistolet laveur monté sur flexible avec eau chaude et eau froide.

LES LOCAUX SANITAIRES DESTINES AU PERSONNEL

Les sanitaires

Les sanitaires homme et femme sont distincts et ne communiquent jamais directement avec les locaux de travail ou de stockage.

Il est rappelé, pour les cabinets d'aisances avec chasse d'eau, que:

- Les cabinets "à la turque" sont interdits (transport de microbes par les semelles des chaussures).
- Les portes s'ouvrent vers l'extérieur et sont à décondamnation extérieure (secours d'une personne en difficulté).
- Un ou plusieurs lavabos sont placés immédiatement à la sortie de ces cabinets (1).

Ces lavabos sont à commande non manuelle. Il existe différents types de commande: par détection magnétique ou optique, commande au pied (au moins à 15 cm du sol) ou au genou.

Un distributeur de savon à action antiseptique, une brosse à ongles souple et un essuie-mains à usage unique sont prévus.

Si des essuie-mains en papier jetable sont installés, prévoir une poubelle à proximité. Veiller à l'approvisionnement et au bon fonctionnement de ces équipements.

Les vestiaires

Les vestiaires ne communiquent pas directement avec les locaux de travail.

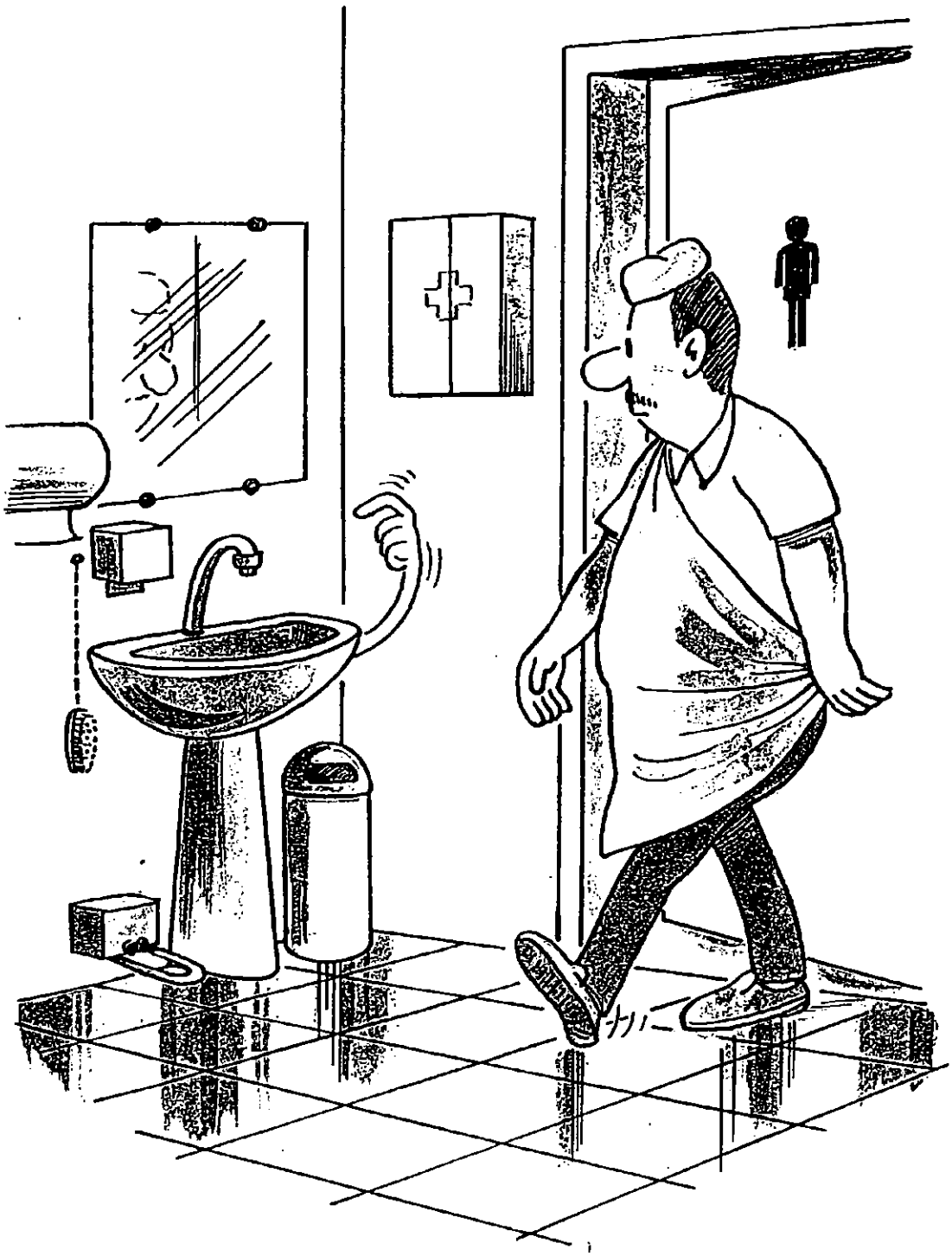
Chaque personne dispose d'une armoire à deux compartiments, l'un pour les vêtements personnels, l'autre pour les vêtements de travail.

Les vestiaires homme et femme sont séparés et situés, de préférence, près de l'entrée du personnel.

Les douches

Elles ne sont pas obligatoires mais conseillées pour un effectif supérieur à huit personnes. les cabines individuelles seront distinctes pour hommes et femmes et aménagées dans des locaux chauffés et ventilés.

(1) Exemple d'un matériel agréé CNERPAC: PROCI - Z.I. - 89110 Aillant-sur-Tholon - Tél. 86 91 51 29



L'HYGIENE DU PERSONNEL

Le personnel est tenu à la plus . . . . . Il porte des . . . . . et une . . . . . . Cette coiffe enveloppe la totalité de la chevelure et son port est obligatoire.

Les vêtements et les chaussures de travail sont lavés et désinfectés quotidiennement. Ils ne comportent pas de revers (manches et bas de pantalon). En effet, les revers sont des nids à poussière et à microbes. Préférez les manches courtes.

Ne pas oublier de . . . . . à la prise et à la fin du travail. En effet, les chaussures de ville sont porteuses des microbes de la voie publique.

Le . . . . . et sa manipulation sont . . . . . à toute personne portant un . . . . . , sauf s'il s'agit d'un pansement étanche et si la blessure n'est pas purulente. Il faut donc prévoir des doigtiers étanches en cas de blessure aux doigts. La désinfection et la protection systématiques des plaies et égratignures sont effectuées immédiatement.

Les mains sont lavées et désinfectées à chaque reprise ou changement de travail.

Les . . . . sont courts et . . . . . .

Il est formellement . . . . . sur le lieu du travail.


AVEZ-VOUS TROUVÉ LES ERREURS D'HYGIÈNE ET DE SÉCURITÉ ?

Scand J Work Environ Health 10 (1984) 203—205

Prevalence of epicondylitis and tenosynovitis among meatcutters

by Pekka Roto, MD, Pertti Kivi, MD[1]

ROTO P, KIVI P. Prevalence of epicondylitis and tenosynovitis among meatcutters. *Scand J Work Environ Health* 10 (1984) 203—205. The prevalence of epicondylitis and tenosynovitis was assessed among 90 meatcutters and 77 referents (construction foremen). All the participants filled out a self-administered questionnaire about subjective symptoms of the upper extremities. The questionnaire was part of the Nordic standardized questionnaire for rheumatic symptoms. The subjects were examined by the authors, who did not have prior knowledge of the subjects' occupations. The prevalence of epicondylitis and tenosynovitis among the meatcutters was 8.9 and 4.5 %, respectively. One referent had epicondylitis, and none suffered from tenosynovitis. The results indicate that the meatcutters had a higher risk for epicondylitis in comparison with the referents. The risk increased with age and number of exposure years.

Key terms: slaughterhouse workers, meat-processing workers.

The character of meatcutting has not changed as much as that of other types of work as the result of automatization. The major such modification to occur in this occupation has been the shifting of the physical load from general physical strain to local muscle work. The lifting and moving of slaughtered animals have been mechanized, but the cutting and separation procedures have remained physical work that loads the upper extremities and shoulders.

In Finland the daily amount of meat handled by one cutter has doubled during the last 10 years because of the demand for efficiency and because of the payroll system used by the meat industry in this country. The increasing local physical work load on the upper extremities of meatcutters, together with our observation that meatcutters often complain of upper-extremity and shoulder symptoms, was the impetus for the present study. In addition there were no other studies available concerning the prevalence of epicondylitis and tenosynovitis among meatcutters. Even the occurrence of these diseases in a normal population is poorly known (6). The relatively short duration of symptoms and the lack of epidemiologic diagnostic criteria have limited the possibilities for research on these diseases (12).

The purpose of the present study was to determine the prevalence of epicondylitis and tenosynovitis among meatcutters and to evaluate a possible association between meatcutting and epicondylitis and tenosynovitis.

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Subjects and methods

The study population of 90 meatcutters, all men, was selected from 250 workers examined in a project aimed at revealing the prevalence of epicondylitis and tenosynovitis among workers of meat-processing enterprises in and around the city of Tampere. Two of the companies had more than 200 workers, two about 100 workers, and the rest employed less than 50. There were two slaughterhouses, and the rest were firms producing different types of processed meats, eg, frankfurters, bologna, and other types of sausages. All the meatcutters employed by the companies took part in the study. They had all worked more than one year in the food industry, and none of them currently had tasks other than meatcutting in their daily work.

The reference group was formed of 77 foremen from the construction industry. The foremen were selected as the referents because they had not been exposed to repetitive movements of the upper extremities in their work.

We chose the following commonly used signs for the determination of epicondylitis (12): local tenderness, pain during resisted extension/flexion of the wrist and fingers, and decreased hand grip power in comparison to that of the opposite hand. The diagnosis of tenosynovitis required the following symptoms: local pain during movement, swelling, and weakness of finger movements.

All the participants filled out a self-administered questionnaire about subjective symptoms of the upper extremities and located the painful areas on a picture representing the upper part of the body. The questionnaire was a part of the Nordic standardized questionnaire for rheumatic symptoms (1). The subjects came to the physical examination with the ques-

tionnaire already filled out. They were then checked by one of us, neither of whom had any prior knowledge of the subjects' occupation because, at the time of the examination, the subjects were part of the larger group of 250 meat-processing workers. Every other worker was assigned to one of the authors in turn. All of the workers in whom objective symptoms were found were referred for serologic laboratory tests for rheumatic arthritis (the latex test and sedimentation rate). The physical examination was performed about 1—2 h after the beginning of the workday.

Seventy-two of the 77 referents participated in the physical examination. The health records of the five nonparticipating referents were checked. They did not participate in the examination because they were traveling on business. There was no indication that they would have had either epicondylitis or tenosynovitis.

The Mantel-Haenszel chi square (7) for several 2-x-2 frequency tables, stratified by confounder (in this study: age), and the associated risk ratio estimate (7) were calculated. Test-based confidence limits for the risk ratio were obtained through the application of the method introduced by Miettinen (8).

Results

Objective symptoms. Eight meatcutters (8.9 %) met the criteria for epicondylitis, and four (4.5 %) were diagnosed as having tenosynovitis (table 1). There was one case of epicondylitis and no cases of tenosynovitis among the referents. The cases of epicondylitis occurred in the older age groups, whereas the few cases of tenosynovitis occurred in younger workers. The one referent with epicondylitis was 58 years old. Three of the meatcutters were referred directly from the examination to therapy and sick leave.

The risk estimate for epicondylitis among the meatcutters was 6.4 ($\chi^2_1 = 3.81$, $p = 0.05$; 95 % confidence interval 0.99—40.9).

Table 1. Occurrence of epicondylitis among 90 Finnish meatcutters and 77 referents

Age group (years)	Number of subjects	Occurrence of epicondylitis	
		N	%
Meatcutters (mean age 39.2; SD 11.4)			
≤ 30	24	—	—
31—40	31	2	6
41—50	19	2	11
51—65	16	4	25
Total	90	8	9
Referents (mean age 38.4; SD 9.2)			
< 30	12	—	—
31—40	34	—	—
41—50	18	—	—
51—65	8	1	—
Total	72	1	—

In addition to the diagnosed cases, seven meatcutters (7.8 %) showed some objective signs in the upper extremities, eg, local tenderness in the region of the epicondyli, in the physical examination.

All the meatcutters with epicondylitis had worked more than 15 years in their current occupation. The average length of the meatcutters' work life was 10 years.

Subjective symptoms. During the week before the subjects completed the questionnaire, 29 % of the meatcutters and 7 % of the referents had felt pain in the region of the epicondyli, whereas 43 and 16 % of the meatcutters and referents, respectively, had felt pain in the same location during the last 12 months before the study. Thirty percent of the meatcutters and 10 % of the referents had felt discomfort or pain in their wrists or hands during the week before the study. During the year preceding the study 54 % of the meatcutters and 17 % of the referents had felt pain in their wrists or hands.

All the reported symptoms were associated with increasing age, as well as with the dominant hand of the meatcutter. The results of the latex tests were negative. The sedimentation rates were within the normal range (< 10 mm/h).

Discussion

There is still controversy about the etiology and diagnostic criteria of epicondylitis and tenosynovitis (5, 9, 10). Many authors agree that the external cause of epicondylitis is overexertion of the finger and wrist extensors (6). Grip and playing technique have been suspected to play some role as causative agents in the occurrence of tennis elbow (9, 10). It is possible that the etiology of the meatcutters' epicondylitis is associated with local muscle-tendon load. A meatcutter must, eg, overstrain the extensors and flexors of the wrist and fingers of his work hand, especially when he is cutting frozen meat. The individual work methods of meatcutters have to be taken into account also as a possible individual risk factor of epicondylitis.

Epicondylitis does not seem to be connected with repetitive or monotonous work movements so clearly as tenosynovitis, but the risk of epicondylitis is more associated with ageing than the risk of tenosynovitis (4, 5). Meatcutters do not use the small muscles of the hand and forearm in a repetitive monotonous way; instead they use the whole powerful musculature of the upper arm and shoulders in their work.

We chose relatively strict diagnostic criteria for our study in order to avoid false positive cases. Both authors detected almost the same number of cases (three and five). Therefore we believe that there was no significant observational bias.

In the normal male population of Finnish industry between the ages of 40 and 64 years the prevalence of pain and discomfort symptoms in the upper extremi-

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ties is about 9 %, and for the region of the hands and wrists the corresponding figure is 11 % (11). For the same age group of the referents of the present investigation the corresponding prevalence was 10 % in both cases. Although one must be cautious in comparing questionnaire data from different studies, the magnitude of discomfort symptoms seems to be clearly higher among meatcutters than among workers who are not exposed to repetitive movements of the upper extremities.

The use of self-administered questionnaires may cause some overreporting of subjective symptoms. However the fact that there were separate clinical symptoms in the clinical examination for almost 8 % of the meatcutters who did not meet the criteria for epicondylitis favors the hypothesis that the meatcutters actually had more subjective symptoms of the upper extremities than the reference group.

In a recent report about the musculoskeletal complaints of meatcutters Hagberg et al (2) were able to show that local muscle strain increases the serum level of creatine kinase, a finding which indicates local overloading of muscles among meatcutters. Their observation about the localization and susceptibility factors of musculoskeletal complaints parallels our observations.

In another recent study about musculoskeletal disorders and complaints among workers in slaughterhouses, Wiikari-Juntura was not able to show epicondylitis among butchers and meat industry workers (13). The mean age of her study population was clearly lower than ours.

We are fully aware of the difficulties of interpreting cross-sectional data in favor of the hypothesis that meatcutting increases the risk of epicondylitis. However our observation that meatcutters with epicondylitis had been exposed, on the average, five years longer than the other meatcutters leads us to the conclusion that epicondylitis is probably associated with meatcutting. The overreporting of local musculoskeletal symptoms among meatcutters also supports the view that meatcutting causes local muscle-tendon load, which may cause epicondylitis in older meatcutters.

There seems to be a strong tendency towards early pensioning or change of work after the age about 50 years among slaughterhouse workers (3). If the same type of early retirement also occurs among meatcutters, our figures are probably underestimations. During the last seven years the Finnish unemployment rate has been 9—10 %. Therefore the opportunities for changing jobs have diminished dramatically since the early 70s. We think that this phenomenon has stabilized the study population, and selection due to discomfort symptoms is not a factor to be considered. More precise inferences on the association between meatcutting and epicondylitis would be possible in the context of an incidence type of study.

Our figures for tenosynovitis were low. Therefore it is not possible to make inferences about any association between meatcutting and tenosynovitis. The cases were more prevalent among the younger workers, and it is already generally known that tenosynovitis occurs more often in younger people (12).

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Neck and upper limb disorders among slaughterhouse workers

An epidemiologic and clinical study

by Eira Viikari-Juntura, MD[1]

VIIKARI-JUNTURA E. Neck and upper limb disorders among slaughterhouse workers: An epidemiologic and clinical study. *Scand j work environ health* 9 (1983) 283–290. The aim of the study was twofold, (i) to detect neck and upper limb disorders in slaughterhouse workers and (ii) to develop methods for the epidemiologic screening of these disorders. A total of 117 slaughterhouse workers underwent a physical examination of the neck and upper extremities and were interviewed for their subjective symptoms. In addition to a prestructured screening diagnosis, a clinical diagnosis was made. The prevalence of tension neck syndrome was 6.2 %, and that of tenosynovitis and peritendinitis of the wrist and forearm 4.4 %. The screening diagnoses were not always the same as the clinical diagnoses obtained in more-detailed examinations. However, the nine disorders in the screening method fairly well represented the disorders detected in the clinical examination.

Key terms: carpal ganglion, cervicobrachial disorder, occupation, peritendinitis, rheumatic diseases, screening method, tenosynovitis, tension neck.

The Finnish Occupational Disease Register has reported high incidences of occupational musculoskeletal disorders (including tenosynovitis and peritendinitis of the wrist and forearm region and humeral epicondylitis) among slaughterhouse workers (17). However no epidemiologic studies with clinical examinations have been done for the detection of neck and upper limb disorders in slaughterhouse workers. The subjective musculoskeletal symptoms of these workers have been screened in questionnaire studies (5, 9).

Suggested causative factors of the disorders include repetitive work in meat cutting, fast work paces, and high resistance, especially of beef (9). In some slaughterhouses the temperature of the meat to be cut is low, and low temperatures increase both the resistance of the meat and the stress of the work.

The diagnosis of musculoskeletal disorders is often difficult and confusing, both at clinics and in epidemiologic settings. Generally accepted and used diagnostic criteria exist for a few disorders only, whereas the criteria for such common disorders as tension neck syndrome, cervical syndrome, humeral epicondylitis, and tenosynovitis and peritendinitis of the wrist and forearm vary widely (18). Diagnostic criteria for these disorders would be of value in the comparison of research results.

Subjects and methods

The slaughterhouse under study in the present investigation employed a total of 119 butchers, meatcutters, and meat by-product workers. Two were on sick leave because of illnesses not related to the study. Of the 117 workers examined, four were excluded from closer analysis, three because of a recent injury and one because of recent surgery for a habitual humeral dislocation. No one reported active rheumatoid arthritis. Eighty-two of

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the remaining 113 workers were men and 31 women; there were 52 cutters, 38 butchers, and 23 meat by-product workers. Twelve cutters and eleven butchers were trainees who did the same work as their more experienced workmates.

The temperature of the meat to be cut varied between 0 and 7°C, and the temperature of the workplace was 10°C.

The slaughterhouse had been operating only seven years. At the beginning many young trainees were hired, and therefore the workers were very young. Their mean age was 31.8 (SD 9.3) years, 30.1 years for the men and 36.1 years for the women. The mean length of employment was 5.5 (SD 5.4) years. The work pace was reported to have been reduced by approximately 25 % for the two weeks preceding the examinations because of salary disputes; the reduced work pace was used throughout the study.

The screening method used in this study (18) was also used in two earlier epidemiologic screenings (6, 8). According to the method a physiotherapist gives each subject a preplanned physical examination and interviews the subject, and the screening diagnosis is made by a predetermined set of criteria. The disorders and the criteria for the disorders, as well as the tests used and the symptoms recorded, are presented in table 1.

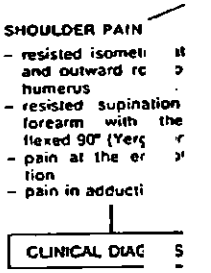
In the present study the subjects were asked, at the end of the interview, to make a drawing of the pain experienced during the last 24 h. The screening diagnosis was approved if it did not conflict with the pain drawing.

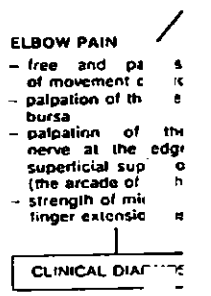
All the workers were examined by the author. A neurological examination of the upper arms was added to the standard set of tests. The neurological examination tested for brachioradial and triceps deep tendon reflexes; shoulder elevation; and deltoid, biceps, triceps, lumbrical and interosseus functions (strength, with special reference to the difference between the sides). Sensitivity to light touch and pain in the upper arms was tested, as was sensitivity to vibration at the ulnar styloid processes and the lateral malleoli. Roos' elevated arm stress test for thoracic outlet syndrome (14) was also included in the standard set of tests. The subjective component of performing and judging each test was reduced by the procedure of first examining the subjects and then interviewing them.

The examination procedure was continued so that a clinical diagnosis could be obtained if the diagnosis based on the screening method conflicted with the pain drawing, if there was marked pain and no screening diagnosis was made, and if there was localized paresthesia, numbness, or a disturbed sensitivity to light touch or pain. At this stage other forms of the mentioned pain syndromes and differential diagnostics were also taken into consideration, as were some other common painful conditions and the most common distal

Table 1. Criteria for screening diagnoses of neck and upper limb disorders (18).

Disorder	Criteria
Tension neck syndrome	Feeling of fatigue or stiffness in the neck, neck pain or headache radiating from the neck; at least two tender spots or palpable hardenings; muscle pain or tightness upon neck movement
Cervical syndrome	Pain radiating from the neck to the upper extremity, limited neck movement, radiating pain provoked by test movements
Thoracic outlet syndrome	Pain radiating to an upper extremity, positive Morley's sign, positive Adson's test, or drooping shoulder
Supraspinous tendinitis	Pain in the shoulder region, local tenderness, pain during abduction, or painful arch; limited active abduction
Bicipital tendinitis	Pain in the shoulder region, local tenderness
Frozen shoulder syndrome	Progressive pain and shoulder stiffness during the last three to four months, active and passive outward rotation limited
Acromioclavicular syndrome	Pain in the shoulder region, local tenderness during palpation or percusion of the joint
Epicondylitis syndrome	Local pain during rest and/or movement, local tenderness at the lateral/medial epicondyle, pain during resisted extension/flexion of the wrist and fingers
Tenosynovitis and peritendinitis of the wrist and forearm	Local ache, pain during movement, tenderness along the course of the tendon or muscle-tendon junction, swelling, weakness in gripping





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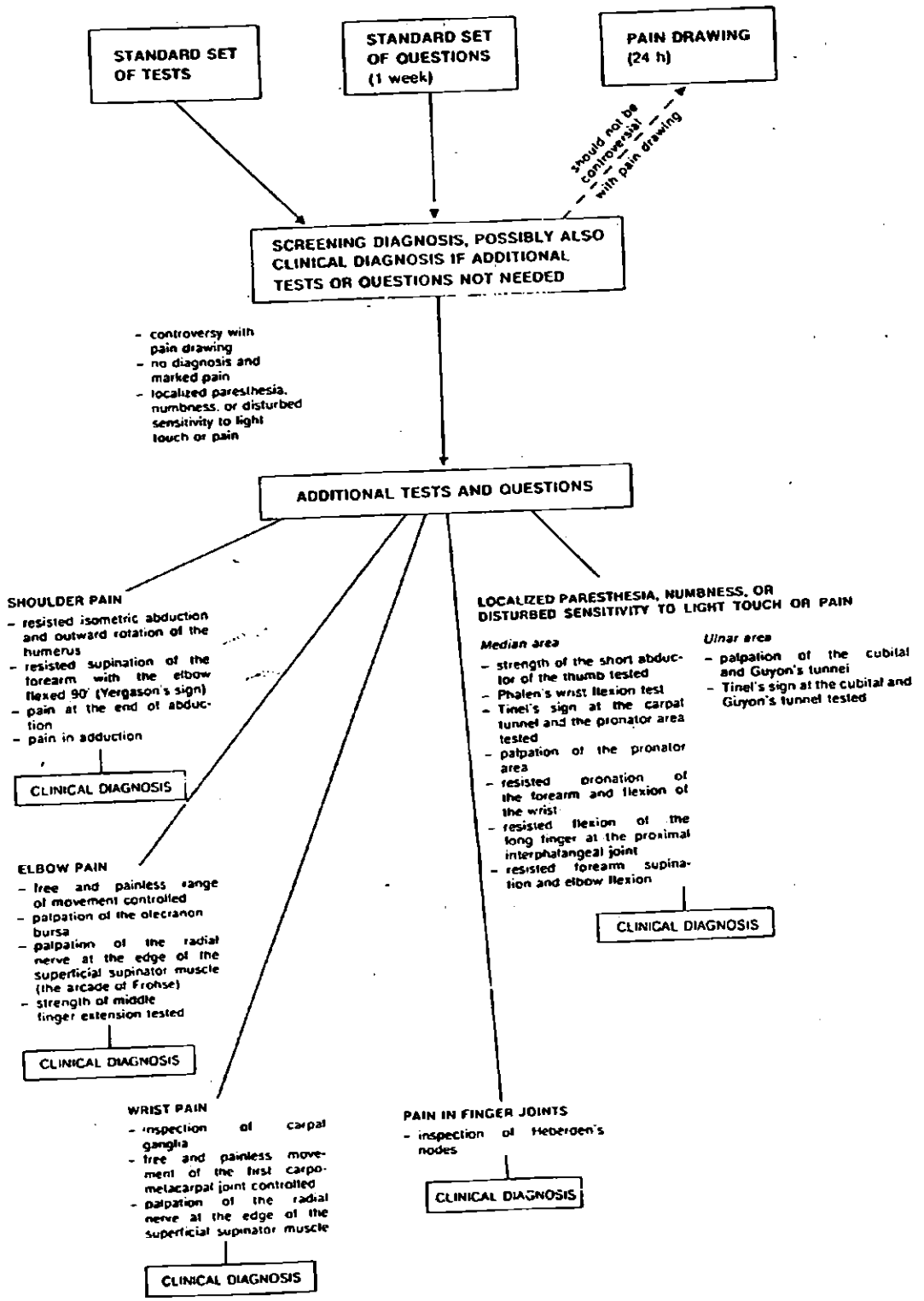

Fig 1. Schematic representation of the screening and clinical diagnoses.

nerve entrapments of the upper arm. The procedure followed in making the diagnosis is shown in fig 1, and the criteria for clinical diagnoses are presented in table 2.

So that the repeatability of the tests of the screening method could be checked, 33 persons were examined by a specially trained physiotherapist.

Table 2. Criteria for clinical diagnoses of neck and upper limb disorders.

Disorder	Criteria
A. Disorders contained in the screening method presented in table 1	
Tension neck syndrome	Same as the criteria for the screening diagnosis (table 1); muscle pain or tightness upon neck movement not necessary (cases that also meet criteria for the clinical diagnosis of cervical syndrome classified as cervical syndrome)
Cervical syndrome	Pain radiating from the neck to the upper extremity or pain in the neck and numbness in the hand, limited neck movement, pain in the neck during neck movement (peripheral entrapment neuropathy of the upper arm excluded)
Thoracic outlet syndrome	Pain radiating to an upper extremity, positive elevated arm stress test (distal nerve entrapments excluded)
Supraspinous tendinitis (18)	Same as the criteria for the screening diagnosis (table 1), but limited active abduction not necessary, pain in resisted isometric abduction possible
Bicipital tendinitis (18)	Same as the screening diagnosis (table 1), possibly also pain in the shoulder at resisted supination with the elbow flexed 90° (the frozen shoulder syndrome excluded)
Frozen shoulder syndrome	Same as the screening diagnosis (table 1)
Acromioclavicular syndrome (18)	Same as the screening diagnosis (table 1), also pain in the shoulder region and pain at the end of abduction or in adduction, all other shoulder diagnoses excluded
Epicondylitis syndrome	Same as the screening diagnosis (table 1)
Tenosynovitis and peritendinitis of the wrist and forearm	Local ache or pain during movement, tenderness along the course of the tendon or muscle-tendon junction, all other diagnoses excluded
B. Other disorders	
Infraspinous tendinitis (3)	Pain in the shoulder region, local tenderness, pain in resisted isometric outward rotation of the humerus, painful arch possible
Olecranon bursitis	Palpable painful olecranon bursa
Carpal ganglion	Dorsal or volar ganglion detected
Painful first carpometacarpal joint	Painful joint at palpation, pain in the joint when moved
Osteoarthritis of finger joints	Heberden's nodes noticed
Carpal tunnel syndrome (10, 12)	Pain or paresthesia in the median distribution of the hand, positive Tinel's sign at the carpal tunnel or positive Phalen's wrist flexion test; diminished sensitivity to touch or pain in three and a half fingers on the radial side of the hand and diminished strength of the short abductor of the thumb possible (median nerve entrapment at the pronator level and cervical syndrome excluded, and the rest of the neurological examination normal)
Pronator syndrome (1, 11, 16)	Pain in the proximal volar aspect of the forearm or paresthesia or numbness on the volar side of the forearm; paresthesia in three and a half fingers on the radial side of the hand possible; symptoms increased by resistance to pronation of the forearm and flexion of the wrist, forearm supination and elbow flexion or flexion of the middle finger at the proximal interphalangeal joint; diminished sensation in three and a half fingers on the radial side of the hand, the thenar eminence, and weakness of the short abductor of the thumb possible (carpal tunnel syndrome, cervical syndrome, and flexor tenosynovitis and peritendinitis of the wrist and forearm excluded)
Posterious interosseus nerve entrapment (Frohse's syndrome) (4, 15, 19)	Pain in the elbow during rest, radiating pain downward or upward and tenderness at the edge of the superficial portion of the supinator muscle (the arcade of Frohse); the extension force of the middle finger possibly diminished (epicondylitis syndrome, tenosynovitis and peritendinitis of the wrist and forearm excluded, and the rest of the neurological examination normal)
Ulnar nerve entrapment at the elbow (1)	Pain, paresthesia or numbness in the fourth and fifth fingers, tenderness to palpation at the cubital tunnel, Tinel's sign at the cubital tunnel possibly present; diminished sensation in the fourth and fifth fingers and weakness of the interossei and the third and fourth lumbricales possible (ulnar nerve entrapment at the Guyon's tunnel, cervical syndrome, and thoracic outlet syndrome excluded)
Ulnar nerve entrapment at Guyon's tunnel (1)	Pain, paresthesia, numbness and/or weakness of the fifth finger, tenderness to palpation at the Guyon's tunnel possible, Tinel's sign at the Guyon's tunnel possible; diminished sensation in the fourth and fifth fingers or weak abduction of the fifth finger (ulnar nerve entrapment at the cubital tunnel, cervical syndrome, and thoracic outlet syndrome excluded)

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Peritendinitis of the wrist extensors and flexors	

Results

Screening and clinical diagnoses

The results are presented as screening diagnoses and clinical diagnoses in table 3. According to the set of criteria seven workers (five men and two women) had tension neck syndrome. The syndrome was evenly distributed among the different occupations and occurred in subjects of different ages.

Six men were clinically diagnosed as having cervical syndrome. They represented different occupations. Four were over 40 years of age.

Five cases of peritendinitis were found in the forearm region of four workers (table 4). These cases did not meet the criteria of the screening method. Four were on the extensor side, one was on the flexor side, and one worker had peritendinitis on both the flexor and the extensor side of her forearm. Three of the workers were men.

In addition to the disorders contained in the screening method used, five cases of painful carpal ganglia were found. Four were on the volar side and one on the dorsal side of the wrist. All volar ganglions were found in cutters, and they were in the dominant hand. Three of these cutters were men, and one was a woman. Three cases were residual after earlier surgery. Two workers with a volar ganglion had nocturnal paresthesiae of the median area of the same hand, and one of them also had a positive Tinel's sign and Phalen's wrist flexion test that suggested carpal tunnel syndrome. Other disorders occurred only seldom.

As the tests of the screening method revealed few positive signs, no statistical analysis was necessary for the findings of the two examiners. There was a trend for the palpation tests of the neck and shoulder region administered by the physiotherapist to reveal more positive results than the palpation tests administered by the author.

Table 3. Distribution of the screening diagnoses and clinical diagnoses among 113 slaughterhouse workers.

	Screening diagnosis	Clinical diagnosis
Tension neck syndrome	7	6
Cervical syndrome	1	6
Thoracic outlet syndrome	–	1
Supraspinous tendinitis	–	3
Bicipital tendinitis	1	1
Frozen shoulder syndrome	–	–
Acromioclavicular syndrome	–	–
Epicondylitis syndrome	–	–
Tenosynovitis and peritendinitis of the wrist and forearm	–	5
Infraspinous tendinitis	–	–
Olécranon bursitis	–	–
Carpal ganglion	–	5
Painful first carpometacarpal joint	–	–
Osteoarthritis of finger joints	–	–
Carpal tunnel syndrome	–	1
Pronator syndrome	–	1
Posterior interosseus nerve entrapment	–	–
Ulnar nerve entrapment at the elbow	–	–
Ulnar nerve entrapment at Guyon's tunnel	–	–

Table 4. Cases of forearm and wrist tenosynovitis and peritendinitis.

Diagnosis	Sex	Age (years)	Occupation	Duration of employment (years)	Other factors	Other disorders (screening or clinical diagnosis)
Peritendinitis of the long abductor of the thumb	Male	22	Cutter (trainee)	2	Returned from sick leave 1 d before the examination	None
Peritendinitis of the wrist extensors	Male	21	Butcher (trainee)	3.5	Returned from military service six weeks before the examination	Bicipital tendinitis
Peritendinitis of the wrist extensors	Male	18	Butcher (trainee)	0.1	–	None
Peritendinitis of the wrist extensors and flexors	Female	32	Meat by-product worker	4.5	Returned from maternity leave two weeks before the examination	None

Symptoms reported by the subject

In addition to their present symptoms the workers were also asked about pain or trouble in the neck and shoulders, the back, and the arms and hands during the past 12 months. Table 5 shows that neck and shoulder trouble was more common among women than men and, in both sexes, more common than back trouble. There were no appreciable differences between the sexes concerning arm and hand trouble. Neck and shoulder trouble, back trouble, and arm and hand trouble were found about as often in all the age groups.

The workers were also asked if a doctor had diagnosed tenosynovitis or peritendinitis of the wrist or forearm or humeral epicondylitis during the past 12 months. There were 15 (13.3 %) subjects who had had 18 (15.9 %) cases of tenosynovitis or peritendinitis and four (3.5 %) who had had epicondylitis. One worker had had both lateral epicondylitis and flexor tenosynovitis at the same time. Three workers had had tenosynovitis twice during the past year. Two workers who had experienced peritendinitis earlier also had peritendinitis at the time of the examination. All 15 workers who had previously had tenosynovitis or peritendinitis were men, cutters or butchers by occupation, and 12 of them were under 30 years of age. The workers with epicondylitis were 30 years or older.

Discussion

Results

As shown in table 6, the prevalences of both tension neck syndrome and tenosynovitis and peritendinitis of the wrist and forearm were very low when compared with the corresponding values of three groups of predominantly female subjects examined by the same method. However, the five cases (4.4 %) of current peritendinitis agreed with the reported 18 clinical cases (15.9 %) of tenosynovitis or peritendinitis that had occurred during the past 12 months.

Table 5. Occurrence (%) of pain or trouble (reported symptoms) in the neck and shoulders, the back, and the arms and hands in two groups of slaughterhouse workers during the past 12 months.

Body region where pain or trouble was experienced	Slaughterhouse workers of present study			Swedish slaughterhouse workers in report of Jonsson et al (5)[a] (N = 53)
	Men (N = 82)	Women (N = 31)	Total (N = 113)	
Neck and the shoulders	45.7	58.1	49.1	45
Back	39.5	45.2	41.7	42
Arms and hands	59.3	61.3	59.8	36

[a] All the subjects were men.

Table 6. Occurrence (%) of neck and upper limb disorders in slaughterhouse workers and three other worker groups.

Disorder of neck or upper limb	Occupational groups[a]			
	Slaughterhouse workers (N = 113)	Scissor makers (N = 93)	Shop assistants (N = 143)	Factory workers (N = 152)
Tension neck syndrome	6.2	61.3	27.8	37.5
Tenosynovitis and peritendinitis of the wrist and forearm	4.4	18.3	13.5	55.9
Other disorders	1.8[b]	4.3	0.6	19.0

[a] Slaughterhouse workers from the present study, scissor makers from the investigation of Kuorinka & Koskinen (6) and shop assistants and factory workers from the study of Luopajärvi et al (8).
[b] One cervical syndrome and one bicipital tendinitis.

The fact that cases of tenosynovitis or peritendinitis were encountered during the past 12 months only among cutters and butchers and predominantly among young workers supported the concept that overexertion and lack of experience are its important causative factors (7). Furthermore, a recently terminated absence was the triggering factor in most current cases of peritendinitis.

The low prevalence of tension neck syndrome and peritendinitis of the forearm can most likely be attributed to two factors. (i) high selection and (ii) reduced work pace. The seven years that the slaughterhouse had been operating provided a suitable time for selection. Young, unfit workers had left the workplace, and the remaining workers became skillful in their work. The reduced work pace evidently had a direct effect on such signs as tenderness and swelling of the muscles and tendons, which were the objective criteria for tenosynovitis and peritendinitis.

The higher prevalence of neck and shoulder trouble in women (table 5) has been noticed also in other studies of working populations (5). The trend was the same in the "normal population" according to the preliminary reports of a recent Finnish study called "Mini-Finland." However the relatively high prevalence of neck and shoulder trouble also in men, which was higher than the prevalence of back trouble, is noteworthy. The situation was the reverse in the "normal Mini-Finland" population, for which back trouble was far more common in men than neck and shoulder trouble. Comparison of the frequencies of neck and shoulder trouble, back trouble, and arm and hand trouble among the men of this study with those among a group of Swedish slaughterhouse workers in similar occupations (table 5) showed that the frequencies for neck and shoulder trouble and for back trouble were approximately the same, whereas trouble in the arms and hands was more common among the Finnish slaughterhouse workers.

The occurrences of painful carpal ganglia, most of which were on the volar side of the wrist, should be noted. The carpal ganglion in itself does not often cause problems. All five ganglia found were painful, probably because of the work demands on the wrist.

The method

The *validity* of the screening method used for this study is unknown, nor can it be directly tested by this study, as the clinical and screening diagnoses were based partly on the same tests.

However the thorough physical examinations did not reveal many cases of disorders not contained in the epidemiologic screening method. The cases of carpal ganglia were an exception. Much has been written lately about entrapment neuropathies and their relation to work (2). Two workers in this study group had symptoms that suggested carpal tunnel syndrome, and one worker had symptoms of a more proximal median nerve entrapment. No other symptoms or signs indicating entrapment neuropathy were encountered.

There were five cases of cervical syndrome, one case of thoracic outlet syndrome, three cases of supraspinous tendinitis, and five cases of peritendinitis of the wrist that could be diagnosed clinically (table 3). But these cases did not meet the set of criteria in the corresponding screening diagnoses of the method. Thus the criteria are "soft" for some disorders (eg. tension neck syndrome and bicipital tendinitis) and "hard" for most other disorders (eg. cervical syndrome, supraspinous tendinitis, tenosynovitis, and peritendinitis of the wrist and forearm). Cases diagnosed according to the "hard" criteria are very likely to be remarkably painful conditions not often encountered at workplaces. For epidemiologic purposes it would be more appropriate to use "softer" criteria so that disorders are detected in their early stages.

Testing the *repeatability* of the tests of the physical examination by having two persons examine the same individual contains many sources of error. As most of the test results rely on the subject's announcement of pain, paresthesiae, disturbed sensitivity, etc. it is probable that the subject learns the results of the test, the objectivity of the examination thereby being reduced.

Opinions differ about the *value of physical examinations in epidemiologic studies*. Comparisons between different groups of workers can be made on the level of subjective symptoms, objective

signs, or complexes of symptoms and signs. The "diagnoses" of the screening method used in the present study are an example of the last-mentioned type.

Some evidence has been found which indicates the predictive value of certain symptoms and signs. Riihimäki et al (13) found that current neck pain better predicted the experiencing of neck pain after five years had passed than did findings of degeneration in cervical radiographs. Tenderness upon palpation of the brachial plexus was predictive of neck pain five years later at a statistically significant level. Nothing is known about the predictive value of the symptom complexes of the screening method used in the present study, as no follow-up studies using this method have been published.

The screening method used in this study is time-consuming and hard for both the subject and the examiner, especially when examinations are performed individually for each worker. Both this study and another unpublished study by the author rarely found objective signs without subjective symptoms. Consequently it could be thought that only persons with subjective symptoms should be chosen for physical examination.

In middle-age and older study groups degenerative changes cause symptoms and signs that cannot be singled out in a physical examination. Thus the method would probably be more valuable when relatively young populations are screened.

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Workplace Factors Contributing to the Musculoskeletal Disorders of Meat Process Workers

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ABSTRACT

The purpose of this research was to assess workplace factors identified as contributing to cumulative trauma disorders among workers in the meat processing industry. This large industry has undergone technological change, but manual operations, including knife use, are still prevalent, and task specialization and productivity have increased while the incidence of back and upper limb cumulative trauma injury has increased.

The research involved 400 meat processing workers in retail stores and beef and pork wholesale operations. Various occupational health problems experienced by the various occupational groups were examined and the impact on upper limb disorders of a number of workplace factors, including knife design, environmental conditions and work procedures, was assessed. The causes of occupational health problems appear to differ among sectors of the industry, although the problems are similar. Thus, solutions such as work breaks, equipment modification, worker training, and limiting weight of materials handled manually must be applied according to the requirements of each industry sector. The range of possible causes and solutions indicates that much further research is needed.

INTRODUCTION

The production of meat and its many byproducts represents one of the world's leading economic activities. In Canada, the meat processing industry ranks third largest of all industries and employs a total work force of nearly 31,000 people.

The meat processing industry has experienced a wide range of technological changes in the past fifty years, from sausage making machines to assembly-line cutting and packaging meat. Despite these innovations, manual operations are still prevalent in the industry. One tool which has not undergone much change, yet is frequently in use, is the meatcutter's knife.

The range of technological developments in the meatcutting sector has affected the overall employment picture of meat cutters, and has also resulted in increased task specialization and increased productivity. However, at the same time, increasing numbers of cumulative trauma type injuries related to the back and upper limbs have been observed in the industry.

Occupational diseases such as tendonitis have been reported in a number of occupations which use hand knives (Armstrong et al, 1982; Hall, 1984; Karlqvist, 1984). Recent studies from Sweden and Finland (Magnusson et al, 1985; Flack and Aarino, 1983) reported that butchers are expereriencing a high frequency of occupational disorders. Factors identified as contributing to these disorders include job activites, workstation layout, the psycho-social climate of the workplace, and worker characteristics.

METHODOLOGY

A number of diverse research tools were used to answer the many questions posed by the project. To obtain an overall understanding of industry problems, questionnaire surveys of retail and wholesale workers were carried out. To determine whether cold environmental temperatures were a contributing factor in the incidence of upper limb disorders in wholesale meat cutters, hand skin surface temperatures were monitored.

368 industry specific questionnaires were completed . Responses were divided into successive groups based on industry, occupational group within industry, and reported pain or lack of pain in a specific body part (hand/wrist/finger, elbow, shoulder, back, leg). Subjects reporting fractures, arthritis, or rheumatism were removed from the analysis.

Finger and wrist temperatures of the knife holding hand were measured for an entire work day of 15 beef cutters (eight healthy, seven with sore wrists) and 10 pork cutters (five healthy, five with sore wrists). The same workers whose hand temperatures were monitored were also measured for wrist and hand dimensions and grip strength.

Three subjects were filmed cutting a beef joint with a standard knife.

RESULTS

Retail

Jobs in the retail sector are meatcutters, who divide larger pieces of meat into small pieces for sale: meat wrappers, who wrap and price the pieces: deli workers, who slice, cut and wrap meat and cheese and prepare salad portions: and fish workers, who clean and prepare fish for sale and maintain the fish display counters.

Meatcutters reported back pain (46%), shoulder pain (29%) and hand problems (22%). Meat wrappers experienced back pain (70%), hand disorders (52%), and shoulder discomfort (38%) – the highest incidence of these problems of all retail workers.

Back pain was also reported by deli workers (58%) and fish workers (50%).

Beef

Jobs in the beef sector are skinners, who remove hides from carcasses and make initial cuts: sawyers, who cut further on the initial cuts and place pieces on conveyor belts: boners, who debone pieces: cutters, who cut deboned pieces into smaller cuts and remove fat: and packers, who cover pieces with fibre wax reinforced material. Floaters fill in wherever extra workers are needed.

Skinners reported pain only in hands (50%) and shoulders (33%). Sawyers reported back pain (50%), and packers experienced problems mostly in shoulders (36%). The most hand and shoulder disorders were experienced by boners (72% and 45%) and cutters also had a high incidence of hand problems (67%). Floaters all reported elbow, shoulder, and hand problems, and had the highest incidence of back problems (57%).

Temperature analyses showed that beef workers, especially those with hand disorders, had colder finger temperatures and greater temperature fluctuations throughout the day than the control group.

Pork

The jobs in this sector are sawyers, who divide the carcasses: skinners (trimmers), boners, and cutters, who trim, debone and remove fat from pieces: and packers, who package the pieces. Wizard knife users use rotating power–driven knife blades to trim fat and salvage any remaining meat on the bones. Tasks in the pork industry are generally less well defined than in other sectors.

As in the beef sector, sawyers reported hand (67%) and back (67%) problems. Pork boners, trimmers, and packers experienced problems in the same body parts. The highest incidence of problems was experienced by wizard knife users, who suffered hand (71%), shoulder (71%) and back (70%) problems.

In the pork plant, unlike the beef plant, there were no significant finger temperature differences between subjects and controls.

Analysis of hand dimensions and strength for beef and pork workers and control groups of office workers showed no significant difference in hand dimensions. However, subjects had less strength than controls in their knife–using hands. Some test knives used in the EMG analysis appeared to require more strength for successful use than others.

Hand motion analysis indicated that approximately 70% of the time the knife cutting hand was flexed at the wrist and that the hand deviated to the radial aspect 49% of the observed time.

DISCUSSION

Occupational health problems of workers in the meat processing industry are diverse and occupation specific. Problems may arise from work procedures performed, equipment and tool design, workstation characteristics, and the environment. Since each of these factors differs within the industry sectors discussed, each sector will be addressed individually.

Retail

In retail stores excessive worksurface dimensions (size of display cases), cold drafts, and work procedures, including lifting of heavy boxes and meat trays, were the primary factors associated with back and upper limb disorders in retail workers.

A large number of retail workers (28%) were excluded from the study because of self-reported arthritis or rheumatism. Further study of this problem may be warranted.

Beef and Pork

In the beef industry, hand/wrist disorders were most prevalent amongst beef boners and cutters. Workplace factors associated with these disorders included cold hands, wearing a mix of cotton and rubber gloves on the knife-holding hand, and interaction between the knife and the cut which frequently placed the hand in a deviated position.

Of all three groups examined in this project, the pork industry reported the highest incidence of hand/wrist disorders. A pork plant differs from a beef plant in that the meat is greasier, hence making the entire workplace greasier, and also that the environment is considerably warmer. In the pork industry the majority of workers do not wear gloves. Major workplace factors which need to be addressed are knife handles designed to reduce slippage, possibly introducing gloves for the knife holding hand, and examining the effect of handtool vibration.

CONCLUSION

Despite the similarity in the occupational health problems in the different meat processing sectors, it is evident that the different workplaces must apply different solutions in order to properly solve their problems. This approach will reduce industry costs in addressing the problems and will ensure prompter worker relief.

Both beef and pork workers frequently assumed static work postures for prolonged periods of time, repeatedly stressing the same joints; mini-stretch/massage pauses and job rotation are therefore recommended. Other suggestions include reconsidering the knife design, which requires adapting the knife to the job and the worker, reviewing the use of gloves, modifying equipment, training workers in which hand positions to avoid, rotating workers amongst different jobs so that the joints most used are stressed in different ways, and limiting the weight of boxes handled manually.

This study is the first in North America to examine the musculoskeletal problems of meat processing workers from an ergonomic perspective. In addition, it is obvious that many problems are site specific. Hence, much more in-depth investigation is needed.

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Le but de cette recherche était d'évaluer les conditions de travail identifiées comme étant la cause des traumatismes répétitifs chez les travailleurs de l'industrie de transformation de la viande. Cette industrie importante a subi de nombreux changements technologiques mais les opérations manuelles, y compris l'utilisation de couteaux, sont encore dominantes et la spécialisation des tâches ainsi que la productivité ont entraîné un nombre accru de blessures répétitives accompagnées de traumatismes aux bras et au dos.

Cette recherche a porté sur 400 travailleurs de l'industrie de transformation de la viande, aux niveaux des magasins de détail et du marché de gros pour le porc et le boeuf. Différents problèmes de santé reliés à ces occupations ont examinés, et l'impact d'un certain nombre de conditions de travail, comme la conception des couteaux, l'environnement les techniques de travail, sur les problèmes intervenant au bras, a été évalué. Nous constatons qu'il existe une certai similitude au sein des différents secteurs de l'industrie à ces problèmes, bien que les causes sous-jacentes semblent être différentes. Il faudrait donc mettre en pratique des solutions telles que pauses, modifications du matériel, for tion des travailleurs et établissement d'une limite de poic en ce qui concerne les travaux de manutention, et ceci d'ap les impératifs de chaque secteur. L'étendue des causes et solutions possibles indique que des recherches plus approfo dies sont nécessaires.

Zoonoses

5 - ZOONOSES

Les zoonoses sont des maladies causées par des agents infectieux communs aux animaux et à l'homme. Ce sont surtout les travailleurs agricoles, les vétérinaires, les éleveurs et les vendeurs de bêtes qui sont les plus exposés à des infections provenant des animaux. En alimentation, l'hygiène publique s'occupe de ce que l'animal soit sain bien avant qu'il n'atteigne la chaîne alimentaire. Cependant dans une liste[1] assez élaborée publiée en 1985, certains genres de travail dans l'alimentation dont les abattoirs de bétails, de volailles, les boucheries, les poissonneries et les laiteries pourraient contracter des infections venant des animaux. Nous avons inclus un article publié dans la revue International Journal of Zoonoses pour fins de consultation et de documentation de base. On doit porter une attention spéciale à la salmonellose, aux staphylocoques, aux streptocoques, aux colibacilles, à la listériose, à la grippe, à la psittacose et aux dermatophytoses. Ce sont les zoonoses les plus susceptibles de se retrouver dans le travail alimentaire. Plusieurs de ces agents infectieux sont des causes communes d'infections des plaies chez l'humain.

Surveillance médicale et prévention

La surveillance médicale se basera sur une documentation des cas d'infection avec culture à l'appui et en procédant à des cultures sériées dans le milieu de travail. Parfois, le support des vétérinaires et des microbiologistes pourra s'avérer essentiel.

La présence d'une infirmière est très importante pour assurer un contrôle quotidien adéquat des travailleurs présentant des signes d'infection. Présentement dans les petites entreprises, ce rôle est rempli par le secouriste, mais la qualité du suivi n'est pas garantie vu l'absence de formation adéquate. Les mesures d'hygiène doivent être connues et appliquées avec constance par les travailleurs. L'employeur doit s'assurer que tous ses employés aient un traitement précoce et adéquat des plaies et des dermatoses aux mains et aux bras. Idéalement, les médecins traitants des travailleurs devraient être impliqués dans le processus afin d'assurer la guérison avant le retrour au travail.

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[1]Voir Donham, K.J. "Zoonotic Diseases of Occupational Significance in Agriculture : A Review" *International Journal of Zoonoses*, 12, 1985, 163 - 191

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ZOONOTIC DISEASES OF OCCUPATIONAL SIGNIFICANCE IN AGRICULTURE: A REVIEW

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ABSTRACT

This manuscript presents an overview of occupational zoonotic diseases of agricultural workers (agricultural zoonoses). The primary intended use of this manuscript is to provide an educational frame work for public health officials in countries where there is a concern to establish or modify agricultural zoonoses control programs. The material is presented in two parts: 1) *general concepts,* (including definitions, classifications and ecological concepts), and 2) *a description of selected agricultural zoonotic diseases.*

The general concepts and definitions, presented here in narrative form, are common to all agricultural zoonoses, regardless of geographical location. The specific facts for the individual diseases are presented in a tabular format. The tables present the essential features of 40 of the most important agricultural zoonoses, from a worldwide perspective. An extensive reference list is included so the reader may supplement this manuscript with additional readings.

ZOONOTIC DISEASES: A PROBLEM IN AGRICULTURE

The number of zoonotic diseases is relatively large. Over 150 zoonoses are distinguished worldwide,[1] with at least 40 having significance as occupational diseases in agriculture.[2] The tables of 40 diseases covered in this chapter were generated from a review of all significant publications (as listed in the references) that have considered this topic in recent years.[2-23]

In addition to direct human health problems, agricultural zoonoses are a major economic drain on the animal protein industry. As examples, brucellosis and leptospirosis cost livestock producers millions of dollars annually.[16] This loss occurs despite brucellosis eradication programs which have dramatically reduced incidence of these diseases in many countries in the past 30 years.

These control programs are expensive. For example, the brucellosis eradication program cost the United States Department of Agriculture nearly 54 million dollars in 1978.[16] In

many countries millions of dollars are spent on programs to prevent potentially hazardous red meat, poultry, and dairy products from reaching the public. Additional major expenses include clinical costs associated with treatment and prevention of zoonoses in humans. For example, 15 million dollars are spent annually in the United States for administering rabies post-exposure prophylaxis to approximately 30,000 people.[16] In countreis where rabies and other zoonoses are greater problems, these costs would be significantly higher.

WORLDWIDE PERSPECTIVE OF AGRICULTURAL ZOONOSES

In most developed countries infectious diseases in general have become less significant compared to chronic diseases.[16] However, in *developing countries*, infectious diseases in general are more important than chronic diseases, and zoonoses remain a major cause of acute human illness. In addition to acute health problems, zoonoses can also cause chronic health problems. For example, schistosomiasis and hydatid disease are associated with long term physical debility, and probably long term psychological stress as well.[16]

Although zoonoses are generally recognized as significant world-wide health problems, the actual prevalence and incidence of zoonotic infections is difficult to determine. Many of these diseases remain uncounted.[16] This occurs in part because zoonoses are often not diagnosed or misdiagnosed. Although clinical manifestations may be severe, symptoms are often protean or nonpathognomonic and may mimic severe influenza. Lack of physician awareness and of appropriate diagnostic support further increases the rate of misdiagnosis. Also, in rural areas of many countries where agriculture predominates, medical services are scarce and ill persons may have little chance to see a physician, so no diagnosis is made.[13]

Incorrect counts of zoonotic infections also result from lack of comprehensive reporting systems. Although countries vary in their requirements and in their systems for reporting infectious diseases, most include only those diseases specified by the national health authorities. This may include only a few of the important occupational zoonoses in each respective country. In addition, few countries have reporting systems for occupational diseases.

For the reasons discussed above, only a small percentage of human zoonotic infections are properly diagnosed, treated, and reported. Thus, it is thought that data on the number of zoonotic infections occurring in human beings, worldwide, is a gross underestimate.

Although exact numbers of zoonotic diseases occurring annually is not known, general changes in incidence or trends can be traced.[16] As a country moves from developing to developed status, the trend in disease pattern usually changes from an endemic nature or widespread epidemics to geographically localized and sporadic cases. Also, as countries move towards developed status, the relative importance of zoonoses and other infectious diseases decreases relative to chronic disease. Several factors are responsible for this trend, including improved nutrition, improved public health measures, and better environmental sanitation.

Future trends include a probable continued decrease in the number of human cases of certain zoonoses, such as brucellosis and bovine tuberculosis, in those countries having active control or eradication programs. Vast epidemics are not likely as more countries move toward developed status. However, natural or human-induced events that disturb ecological balances

can have significant effects on disease patterns. For example, the Aswan Dam, built in the early 1930's, allowed year-round irrigation in several provinces of Egypt. The resulting changes in ecology and agriculture caused a 60 percent increase in the incidence of schistosomiasis.[7,16] Another future trend may be the recognition of even more zoonoses as having occupational significance in agriculture. For example, influenza, campylobacteriosis, and leukemia may emerge as important occupational problems in agriculture as more is learned about the animal-human relationships involved.[16]

DEFINITIONS AND CLASSIFICATIONS

Zoonotic diseases may be classified in three ways:[16]

- according to the major reservoir of the infectious agent,
- according to the mode of transmission of the infectious agent among natural host species,
- according to the major human population at risk.

An understanding of these classification systems can increase comprehension of the natural history of these diseases and aid in their diagnosis and control.

Classification based on the major reservoir of the infectious agent categorizes zoonoses by the following definitions:

A *zooanthroponosis* is a zoonotic disease for which humans are the natural hosts of the infectious agent. Other vertebrate animals may acquire the infection by contact with humans. For example, dairy farmers infected with *Mycobacterium tuberculosis* can transmit this infection to their dairy cattle.

An *anthropozoonosis*, in contrast, is a disease for which a vertebrate animal species other than a human is the natural host. Humans are infected by contact with diseased animals. Most zoonoses that are a potentially significant human health hazard belong to this group. For example, brucellosis is primarily a disease of domestic cattle, sheep, goats, and swine. If a person contracts brucellosis, it is almost certain that infection was contracted from one of these animals rather than from contact with another human.

Amphixenosis refers to a disease for which humans and other vertebrate species serve equally well as natural hosts. Infections may be transmitted freely between humans and animals. It is often difficult to determine if human infections are acquired from animals or from other humans. Examples of amphixenoses include strains of *Staphylococcus*, *Streptococcus*, *E. coli* and *Salmonella* that are not host-specific.

Classifications of zoonotic diseases according to the primary mode of transmission are as follows:

Direct-zoonoses require only one vertebrate host to maintain the infectious agent. For example, the rabies virus can be maintained in the wild skunk population by direct transmission from an infected skunk to a susceptible skunk.

Cyclo-zoonoses require two or more vertebrate hosts for maintenance of the infectious agent. For example, the tapeworm *Echinococcus granulosis* is maintained in a cyclical transmission pattern when sheep ingest tapeworm eggs passed in feces of dogs. The eggs encyst in the sheep's viscera. The life cycle is completed when the dog ingests infected tissues of the

sheep and adult tapeworms develop in the dog's intestines.

Meta-zoonoses require both a vertebrate and an invertebrate host for maintenance of the infectious agent. For example, in equine encephalitis, the mosquito is required to transmit the virus from an infected vertebrate to a susceptible vertebrate.

Sapro-zoonoses are diseases caused by an infectious agent that is maintained in a fomite – that is, soil, water or another type of inanimate object. Histoplasmosis, for example, is contracted when persons inhale spores from soil with high concentrations of avian or bat feces, where the fungus grows.

Zoonoses can also be less formally grouped according to the major human populations at risk. Zoonoses typically are most common where contact with animals or their environment is maximized – that is, whenever human activities encroach on disease cycles as they occur in the natural setting. *Agricultural work is a specific type of activity that increases the risk for acquiring a zoonotic disease.*[2,9,10,12,16,22]

Risk for specific diseases vary with the particular type of animal production and geographic location. For example, people who work with cattle are at risk for a number of infections, but risk for specific diseases vary with certain work factors, and ecological factors. For example, people working with *dairy cows* are primarily at risk for milker's nodules brucellosis, Q Fever, and ringworm. On the other hand, people working with *beef cattle* may be more at risk for rabies and leptospirosis. Furthermore, those working with beef cattle in certain areas of Africa are at risk for Rift Valley fever.

Zoonoses are occupational hazards not only for people who raise and care for animals but also for people in agriculturally-related occupations who work with animals or animal products. Those at risk include veterinarians, packing plant workers, poultry processing plant workers, and hair and hide industry workers. These workers may contract diseases such as brucellosis, ornithosis, anthrax, and contagious ecthyma.

ECOLOGICAL FACTORS

An understanding of why zoonotic outbreaks occur is helpful to health officials. This understanding can best be developed by examining the infectious agent as a part of the total environment – that is, by understanding the disease as part of an ecological system, or ecosystem. An ecosystem is the group of all plants and animals, their interactions, and the abiotic environment surrounding the organisms, in any given place at any specified time. With specific reference to zoonotic diseases, we could define an ecosystem in this more limited way: a set of all vertebrate hosts, the invertebrate organisms including infectious agents that affect these hosts, the disease vectors, the abiotic environment that surrounds them all and the interactions among the organisms and with the environment.[16]

In natural, undistrubed ecosystems – those in which all inhabitants have evolved balanced interrelationships with each other and their environment over thousands of years – infectious agents typically maintain a steady, low rate of infection in the host population. Infection and sporadic disease are a natural part of the ecosystem. In this way, infectious agents derive what they need for survival without decimating the host population. For any particular in-

fectious agent, the natural ecosystem is called the agent's nidus, and the agent's natural environment is called its nidality.

Disease outbreaks are a result of a change of the natural balances of ecosystems. Ecosystems naturally change through time as a result of internal processes, such as geological erosion. Today, direct and indirect human intervention produce most large-scale ecosystem changes. Ecosystems also continue to change as a result of exterior pressures, such as variations in climate or geological events. An ecosystems change and the interactions among organisms change, a frequent result is alteration of the number and types of organisms present. When such organisms are infectious agents, their vectors, or hosts, may either decrease or increase. If there is a significant increase, a disease may reach an epidemic level. This alteration is the basic source of zoonotic outbreaks.

Following are three common examples of ecosystem changes and the resulting potential changes in human disease rates.

Introduction of new livestock species into a natural ecosystem can lead to disease outbreaks when these species transmit infectious agents from native vertebrates to humans. For example, agricultural practices involved with raising cattle in South America have led to the potential transmission of rabies from bats to cattle to people. Vampire bats are natural hosts for rabies in certain areas of South America. Introduction of cattle provides a feeding source for these bats and they transmit rabies to cattle when they take a blood meal. The cattle, in turn, are sources of exposure to rabies for people who tend them.

Alteration of the abiotic components of an ecosystem can result in changes in the ecosystem's population structure, and thus in disease outbreaks. For example, as land in Egypt has been irrigated with water made available by the Aswan Dam, the habitat for snails has improved. Snails have increased, providing an intermediary host for the blood fluke *Schistosoma*.[7] The incidence of schistosomiasis in humans has increased dramatically in this area. Similar problems are anticipated in Ghana, Ivory Coast Mali, Nigeria, Sudan, Brazil Philippines, and Thailand.

Changes in the host's body (also an ecosystem) can be considered a change in the infectious agent's environment. Changes in the host's nutrition, climate, physiological state and the like can lead to an increase of infectious agents and subsequent transmission of the agents to other hosts. For example, *Salmonella* commonly is carried in the gut of many animal species Under stress, gut flora and immunoglocial mechanisms may change, and increased numbers of *Salmonella* may be shed. These can then infect other domestic animals or humans.

SUMMARY OF GENERAL CHARACTERISTICS

The following list summarizes the general characteristics of zoonotic diseases. This list capsulizes the importance of zoonoses as occupational health problems in agriculture.[2,13,16,20]

Zoonoses often cause severe economic burdens because of loss of diseased animals. and

because of the cost of preventing and treating infections in animals and humans.

Many zoonotic infections in humans are never diagnosed. Reasons are numerous, such as the protean and nonpathognomonic symptoms, the lack of physician awareness and the lack of adequate diagnostic support. Thus, accurate figures on the rate of zoonotic disease are not available.

Human infections generally occur sporadically rather than in epidemics. This is because humans are accidental, dead-end hosts for infectious agents and do not transmit infections to other people.

The majority of zoonoses are anthropozoonoses, being maintained primarily by vertebrate species other than humans.

There are specific groups of people that have an increased risk of acquiring infection These risk groups include persons with greater than average contact with animals: agricultural workers, abattoir workers, meat processing plant workers, veterinarians, pet owners, and people living in rural areas or engaging in outdoor activities.

Most zoonoses have only one or a few major host species. However, infectious agents do typically have a broad potential host range. For example, the bacterium *Francisella tularensis*, which causes tularemia, has been isolated in over 100 mammalian species and numerous other vertebrates. However, many of these species are infected only by accident and are not significant in perpetuation of the disease cycle.

Animals may be inapparent carriers of infection. They may pose a health hazard for humans and other livestock without offering demonstrable signs.

Human infections typically result in morbidity but rarely in mortality. For example, leptospirosis, brucellosis, histoplasmosis and Q Fever all can cause moderate to severe illness However, when properly treated, they rarely lead to death unless complications develop.

Health officials can increase their ability to deal with zoonotic diseases by consulting local practicing veterinarians and veterinarians working for public health or agricultural sections of the government. Health officials must also develop an awareness of specific environments and agricultural activities typically responsible for contraction of these diseases within their geographic locations. Such an awareness is essential to be able to recognize, evaluate, and control zoonotic diseases in agriculture.

SPECIFIC ZOONOTIC DISEASE TABLES

The following Specific Zoonotic Disease Tables outline the primary aspects of 40 zoonotic diseases that can result in occupational infections of agricultural workers. These charts are meant to be used in combination with the information presented here, with supplementation from the references listed, 1-23, and with consultation with regional experts. Using this combined approach, health officials should be able to help establish control programs for occupational zoonoses in their individual localities.

Table 1. Bacterial Infections

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
Anthrax (Malignant pustule, wool sorter's disease)	*Bacillus anthracis*	(A) *Human*—Localized skin lesions usually on hands or arms —Pulmonary form less common but much more severe with fairly high case fatality rate —gastro-intestinal form is least common (B) *Animal*—usually overwhelming bacteremia and septicemia with rapid death in cattle, sheep and goats —less acute in horse, pigs and dogs	(A) 1. (B) Cattle-sheep-goats-horse-pig-dog	(A)—Soil —Water (stagnant ponds near incubator areas) (B) 1, 3, (C)—Direct contact with infected animals or their carcasses or body parts or animal fertilizers or feeds —Inhalation of spores from hair or hide of infected animals —Consumption of improperly cooked meat of infected animals	(A)—Sheep and goat producers —Cattle producers —Veterinarians and other animal health workers —Hair and hide processors —Abattoir workers (B) Worlwide in endemic foci —May be transported to distant locations with hair and hide from infected animals	—Vaccination of animals in endemic areas —Personal protection when handling potentially infected animals or tissues —Deep burial and covering with lime of infected animal carcasses —Vaccination of humans at high risk.
Brucellosis (undulent fever, Malta fever, Bangs disease)	*Brucella abortus* *B. suis* *B. melatensis* *B. canis*	(A) *Human*—generalized prolonged influenza-like illness, spiking fevers, myalgia, malaise —occasional chronic forms include lesions of heart valves, abcesses of bone, liver, or other body parts (B) *Animal*—Abortions —possible chronic infections of R.E., urogenital, Bone and other tissues	(A) 1. (B)—Cattle-swine —Sheet-goats —Less common are dogs, camels, deer, buffalo, and others	(A)—Cattle, swine, goats, dogs mainly —Other susceptible animals less important (B) 1. (C)—Direct contact with infected animals or their tissues especially placenta and abortion products —Ingestion of milk products from infected animals —Possible air borne transmission	(A)—Sheep, goats, cattle and swine producers primarily —Abattoir workers (B) Worldwide, especially in dairying areas	—Eradication of disease in the primary livestock species (several countries have established such programs) —Personal protection when handling infected animals, especially following abortion —sanitation of the animal environment —pasteurization of milk products

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
Leptospirosis (Well's disease, swine herd's disease, swamp fever, mud fever)	*Leptospira interrogans* -many different serovars involved	(A)–Generalized febrile, influenaz-like illness of variable severity –mild cases malaise, myalgia, symptoms of meningitis, vomiting –severe cases, hepatorenal involvement jaundiced, case-fatality ratio 20%-40% (B)–Abortion –Hepto-renal involvement with jaundice, possible kindey failure	(A) 1. (B)–Cattle, swine, are the the main livestock species infected. –Sheep and goats, less common –Dogs-Rats –Wildlife including squirrels, racoons, mice, shrew, bandicoot fox, jackals, hedgehog and others	(A)–Cattle, swine, rats mainly, but most other susceptible animals also –water, muddy soil (B) 1 and 3 (C)–Direct and indirect contact with urine from infected animals –Contact with abortion products of infected animals –Contact with water contaminated with urine from infected animals	(A)–Persons working with cattle or swine –Persons working in rice paddies contaminated from urine of infected animals –Abattoir workers –Persons swimming in contaminated water –Hunters and trappers (B)–Worldwide, specific serovars vary with locality	–Control infection in livestock with good environmental sanitation, immunization and proper veterinary care –Prevent infected animals from urinating in water where humans have contact –Personal protection of workers when handling infected animals or tissues –Rat control
Tetanus (Lockjaw)	*Clostridium tetani*	(A)–Tonic Clonic Convulsions –Spastic contraction of skeletal muscles –Respiratory failure –death (B)–Hyperirritability of central nervous system –Tonic clonic convulsions –Spastic paralysis –Death	(A) 1. (B)–Sheep and horses mainly –other animals more resistant	(A)–Soil –Large intestine of herbivores and to a lesser extent carnivores (B) 3. (C)–Wound contamination with soil or feces containing spores, anaerobic conditions in wound required for organism to germinate and produce toxin	(A)–Most agricultural workers who are subject to punctures or cuts, especially in areas where herbivore animals are raised (B) Worldwide	–In humans-proper treatement of open wounds to prevent infection –Immunization with tetanus toxoid

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
Tuberculosis	*Mycobacterium tuberculosis* *M. bovis* *M. avium*	(A)–*M. tuberculosis* and *M. bovis*-granulomatous lesions of lungs, intestine, or other tissue-Long standing debilitating lesions, unless treated –*M. avium*-uncommon wound infections and lymphadenitis mainly, pulmonary infections rare (B) Granulomatous lesions of lungs, intestines, bones and other tissues	(A) *M. Tuberculosis*-2 *M. bovis*-1 *M. avium*-1 (B) *M. bovis* cattle mainly, especially dairy cattle –*M. tuberculosis*-humans –*M. avium*-chickens	(A)–*M. bovis*-cattle –*M. tuberculosis*-man cattle –*M. avium*-chickens, soil (B) 1, possibly 3 (C)–Inhalation of infected droplets –Direct contact with infected animals –Consumption of unpasteurized milk –Direct contact with tissues of infected animals	(A)–*M. bovis*-Dairy farmers cattle producers, meat cutters, abattoir workers –*M. avium*-general farm workers especially if chickens have been on the place (B) Worldwide but *M. bovis* nearly eradicated in several western countries	–Eradication programs based on testing herds & removal of infected animals have reduced the disease in many areas –Good sanitation in the animal environment, including ventilation –Personal protection when handling infected animals or tissues –Proper cleansing and treatment of wounds –Pasteurization of milk –BCG immunization of persons in high incidence countries
Tularemia	*Francisella tularensis*	(A) Four forms: –Ulceroglandular-most most common form, localized wound infection with generalized symptoms, cellulitis with regional lymphadenitis –Oculoglandular, serve conjunctivitis with regional lymphadenitis	(A) 1. (B)–Infections found in 125 species of vertebrates, 101 species of invertebrates ticks, mosquitors, deer flies horse flies, fleas –Most important for agricultural exposure	(A)–Sheep –Infected mammals –Ticks and other blood –sucking arthropods –contamined water (B) 1 2, and 3 (C)–Hanlding infected sheep –Bites from blood sucking arthropods	(A)–Sheep ranchers, sheep shearers and sheep handlers –Outdoor occupation or recreation where exposure to blood sucking arthropods is common (B)–North America –Mexico	–Personal protection (gloves and dust mask) when handling potentially infected sheep or wile mammals –Avoid drinking untreated surface water from ponds and streams

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zoonanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
		–Pulmonary-pneumonia with severe generalized symptoms –Typhoidal-gastro-enteritis, fever, toxemia, ulcers in mouth, pharynx and esophagus (B)–Varies according to species, some rodents and lagomorphs are most susceptible, prolonged generalized illness fatal septicemia. Sheep, other rodents and birds have intermediate susceptibility with non fatal generalized illness. Carnivores, have low susceptibility, usually with subclinical infection	are sheep and arthorpods –Other important exposures are Lagomorphs rodents, water in an endemic area	–Handling infected rodents, Lagomorphs (hunters and trappers) –Consumption of water from a stream or pond –Possibly inhalation –cat bites	–European Continent –Turkey –Iran –China –Japan	–Thoroughly cook meat from small wild mammals consumption –Wear gloves when handling or cleaning small wild mammals
Glanders (Farcy, Malleus)	*Pseudomonas mallei*	(A)–Variable-acute, chronic and subclinical infections –Pneumonia, pulmonary abcesses, plural effusions –Fever –Mucopurulant nasal discharge –Oral, mucosal ulcers –Skin lesions (B)–Horses-Chronic, three forms-pulmonary upper respiratary tract, skin	(A)–1. (B)–Horse-Mules -Donkeys	(A) Horse (B) 1. (C) Direct or indirect contact skin, mucous membranes of nose and eye, from lesion discharge of infected animals	(A)–Persons handling horses, mules, or donkeys (B)–Brazil East Africa Asia Eradicated from Europe and North America	–Most important control is eradication of the infection in the equine populatior –Environmental hygiene of horse stables –Detection and proper treatment of human cases

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
		–Mules, donkeys-acute severe systemic illness, pneumonia, diarrhea, death 1-3 weeks				
Melioidosis (Whitmores disease, pseudo-glanders)	*Pseudomonas pseudomallei*	(A)–Pneumonia and gastroenteritis with fever, visceral abcesses –Chronic cases-necrotic and granulomatous lesions of bone and soft tissues (B)–Sheep-Multiple abcess of viscera, joints and lymph nodes, may be respiratory involvement, case fatality ratio around 50% –Swine-severe respiratory illness with generalized symptoms, and arthritis	(A) 1. (B)–Epizootics occur in sheep swine and goats –Less susceptible animals include horse, cow, dogs, cats non-human primate, rats, rabbits	(A)–Most susceptible mammals swine, sweep goats –Surface water and soil especially rice puddies and oil palm plantations (B) 3, possibly 1 and 2 (C)–Direct contact with contaminated water and soil –Skin abrasions assist infection	(A)–Workers in rice fields and oil palm plantation of South East Asia (B)–Tropical and subtopical areas, mainly in Americas, and Southeast Asia	–Use of boots for ricefield and plantation workers –Drainage of low-lying areas
Erysipeloid (pork finger, fish finger, swine erysipelas)	*Erysipelothrix rhusiopathiae*	(A)–Skin lesions mainly with swelling –Possible local spread of lesions from primary site –Possible encocarditis (B)–Acute-septicemia with high fever, skin lesions and moderate death loss –Chronic-polyarthritis, myocarditis	(A) 1. (B)–Swine mainly –Also chickens, turkeys, and sheep –Also found in slime layer on fish	(A)–Animals-Swine, sheep, chickens, turkeys –Environment-soil, slime layer on fish (B) 1, 3 (C)–Direct contact-contamination of a cut or break in skin with soil or infections materials from animal or tissues	(A)–People raising or handling swine, sheep, or poultry –Abattoir workers and meat cutters –Fish processing workers (B) Worldwide	(A)–Control in swine vaccination, adding only erysipelas free-animals to the herd –Humans-proper treatment of cuts and wounds –Environmental sanitation –Abattoir workers, protective gloves,

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
						proper treatment of cuts, environmental sanitation
Pasteurel-losis	*Pasteurella multocida* *P. hemaly-tica* *P. phenmo-tropica* *P. urea*	(A)–*P. multocida* primarily animal bite wound and other wound infection, occasionally respiratory infections –*P. hemolytica*, –*P. pneumotropica* & *P. urea* rarely causes disease in man (B)–*P. multocida*- primarily secondary invader in respiratory disease eg. "shipping fever" in cattle and snuffles in rabbits- causes severe generalized illness with high death loss in chicken "fowl chlorea" –*P. hemolytica*-causes hemorrhagic septicemia in ruminants	(A) 1. (B)–Primarily cattle, chickens, rabbits and rodents –Most domestic and wild animals can be infected however	(A)–*P. multocida* is part of normal flora of most livestock and poultry species and domestic dogs and cats –*P. hemolytica*-pri-marily ruminants –*p. pneumotropica*- rodents –*P. urea*-man (B) 1. (C)–For *P. multocida* bite wound infections most common –Contamination of other wounds also important –Inhalation of infectious droplets from animals –Direct contact with infected animals	(A)–People working with cattle chickens, and other livestock species –People at risk of being bitten by dogs or cats (B) Worldwide	–Proper cleansing and treatment of bite wounds –Good sanitation in the animal environment –Avoidance of infection source for persons who have immune deficiency
Plague (bubonic plague, black death, pneumonic plague)	*Yersinia pestis*	(A)–Sproadic form usually localized wound infection, generalized symptoms, regional lymph nodes swell and became inflamed (bubos), whith severe generalized symptoms	(A) 1. (B)–Over 200 species of of wild rodents, rats primarily but small ground rodents such as chipmunks and ground squirrels –Dogs and cats also,	(A) Wild rodents and their fleas (B) 1 and 2 (C) Bites of fleas from an infected animal –Direct contact and wound infection from handling or being	(A) Persons working in endemic areas where they may contact infected animals of their fleas (B)–Natural foci of plague in wild animals on all continents	–Rodent control in combination with pesticides to kill fleas –Education-avoid handling dead rodents in endemic areas without pro

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
		–pneumonia may occur which is usually very severe and involved in epidemic form (B)–Chronic generalized illness, usually results in death	but less common	bitten by an infected animal	except Australia and New Zeland	tective equipment
Salmonellosis	*Salmonella choleraesuis* *S. typhi* *S. enteriditis* (2000 serotypes of enteriditis)	(A)–Gastroenteritis of variable severeity depending on dose and virulence of specific organism –May produce bacteremia and septicemia (B)–Gastroenteritis –Bacteremia and septeicemia pssible in severe cases	(A) 1, 2, or 3 depending on the specific organism (B)–All livestock and poultry species –Most domestic and wild mammals	(A)–*S. typhi*-man –*S. choleraesuis* and *S. enteritidis*-primarily animal hosts-important in livestock and poultry, but there are many domestic and feral anmial hosts (B) 1 and 3 (C)–Most infections are food borne or milk borne –Direct or indirect contact (via ingestion) with animals and their environment	(A)–Livestock and poultry workers who have direct or indirect contact with animals and their environments –Consumption of animal food products that is improperly prepared or stored (B) Worldwide	–Practice sound hygiene in the animal environment –Practice sound personal hygiene –Avoid overuse of antibiotics in animals to prevent development resistant strains –Hygienic practices in the abattoir –Education on proper preparation and storage of animal food products –Sterilization of animal products that go into animal feeds
Staphyloc-occal infections	*Staphylo coccus* (many) different strains)	(A)–Gastroenteritis-skin infection (B)–Gastroenteritis -mastitis-skin infections	(A) 1, 2 and 3 (depending on the strain) (B)–Dairy animals are particularly important in agriculture	(A)–Dairy animals, in milk or normal flora of respiratory tract and skin –Respiratory tract, skin, G.I. tract of most	(A)–Livestock workers-particularly dairy –Those who drink unpasteurized milk or	–Practice sound animal hygiene and management –Detection and eradication of

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
			-All livestock and mamalian species may be infected	livestock species -Man-respiratory tract, skin, or G.I. tract (B) 1 or 3 (C)-Direct or indirect contact with infected animal or their environment -Constumption of unpasteurized milk -Animal food products	consume improperly prepared or stored animal food products (B) Worldwide-ubiquitous	mastitis in dairy herds -Proper detection and treatment of skin lesions of animal handlers -Pasteurization of milk -Sanitary preparation and storage of animal food products -Prudent use of antibiotics to prevent resistant infection
Strepto-coccal infections	*Streptococcus* (Various species and strains)	(A)-Gastroenteritis -Pharyngitis (B)-Gastroenteritis -Skin infections -Mastitis -Subclinical	(A) 1, 2 or 3 (depending on the strain) (B)-Dairy cattle mainly, but most livestock and other domestic and feral species	(A)-Dairy cattle, especially milk from cow with streptococcal mastitis -Most other species, from skin infections or fecal shedders (B) 1 or 3 (C)-Direct or indirect contact with infected animals and their envigonment -Consumption of unpasteurized milk or improperly prepared or stored animal food products	(A)-Dairy workers -Other livestock workers -Those consuming unpasteurized milk or improperly prepared or stored animal food products (B) Worldwide-ubiquitous	-Practice excellent livestock management including good environmental sanitation -Dectec and specifically treat infected dairy animals with mastitis -Pasteurize milk -Proper preparation and storage of animal food products

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
Colibacillosis	*Escherichia coli*	(A)–Gastroenteritis mainly –Possible wound infections or abcess -cystitis (B)–Gastroenteritis mainly –Possible wound infections or abcess	(A) 1, 2, or 3, depending on specific strain (B) All livestock species, most mammals feral or domestic	(A)–Animals are the reservoir for some strains man for others and both man and animals for other strains (B) 1. (C)–Direct or indirect contact with infected animal and waste –Accidental ingestion of organism via hand to mouth contact or ingestion of contaminated food	(A)–Livestock and poultry farmers –General public food and water (B) Worldwide	–Excellent personal and environmental sanitation
Listeriosis (Leukocytosis Mononucleosis, Listeriasis)	*Listeria monocytogenes*	(A)–Abortion and perinatal disease primarily –Inapparent –Encephalitis or meningioencephalitis (B)–Abortion and perinatal disease –polyarthritis –encephalitis with brain abcesses	(A) 1. (B)–Cattle and sheep mainly –Goats, chickens and turkeys also –Wildbirds	(A)–Infected animals –Environemnt decayed vegetable matter, siluge, soil (B) 1 and 3 (C) Unknown- possible direct contact with mucous membranes ingestion, or skin penetration at abrasion or laceration	(A)–Sporadic-often immunodeficient persons or pregnant women work around animals or decayed vegetable material (B) Worldwide, more common in temperate climates	Avoidance of reservoirs by pregnant women for immunodeficient persons –Practice good environmental hygiene –pasteurize milk
Argentine hemorrhagic fever (Junin disease, mal de rastrojas, O'Higgins	Arenavirus	(A)–Febrile illness with varying severity –Mild cases-malaise, fatigue, dizziness, nausea, vomitting which last up to 6 days –Severe illness, hemorrhage from nose,	(A) 1. (B) Various wild rodents	(A)–Various wild rodents (B)–1, 2 (C)–Direct or indirect contact with infected rodents or their excreta	(A) Primarily farm workers involved in harvest of corn and other grain crops (B) Argentina, specifically areas where corn and other grains are grown	–Wild rodent control by change in habitat through use of herbicides –Vaccines are in developmental stages

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
disease)		gum, G.I. tract with nervous system involvement, case fatality ratio 10% (B)–Asymptomatic				
Bovine papular stomatitis	Pox virus	(A)–Rare in humans –papule or wart-like nodules on hands or arms –Possible inflamation of regional lymph nodes (B)–Proliferative wart-like lesions around mouth and teats –No a common disease of cattle	(B) Cattle	(A)–Cattle (B)–1. (C)–Direct contact with infected cattle, often contracted by examining lesions witout use of protective gloves	(A)–People working with cattle, particularly dairy cattle (B)–North America, Europe, Kenya, Nigeria Australia, possibly other countries	–Isolate infected animals –Use protective gloves when handling or examining infected animal
Contagious ecthyma (orf)	Pox virus	(A)–Skin lesions on hands and arms –Start out as small papules, progress to large vesicles which then ulcerate –Last 4-8 weeks (B)–Vesicular lesions in the mouth and on the lips	(A)–1. (B)–Sheep mainly –Goats also	(A)–Sheep –Goats –The animal environ- (eg.) animal sheds, feed bunks, etc. (B)–1 and 3 (C)–Direct contact with infected animals or their environment, especially handling and examining infected animals	(A)–People raising or handling sheep or goats (B)–Worldwide, where where ever sheep are raised	–Isolation of infected animals –Wearing protective gloves when handling or treating infected animals or working in their environment –Practice excellent sanitation of the animal environment
Foot and mouth disease (Apthous fever,	Picorna-virus, rhinovirus subgroup	(A)–Not highly infections for humans –May cause mild influenze-like illness –Vesicles in mouth	(A)–1. (B)–Cattle mainly –Sheep and goats	(A)–Cattle, their tissues also (B)–1. (C)–Direct contact with infected animal or their	(A)–Dairy and beef cow handlers (B)–Eradicated from most of North America and Western	–Eradication program which consisted of quarantine, identification and destruction and

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
aphtosis)		and on lips and hands (B)–Highly contagious in animals –Vesicles in mouth on lips, treats and udders and between the toes		environment, especially during handling or examination, or milking	and Central Europe, Australia, New Zeland and Mexico –Present in South American, Eastern Europe, Asia, some African countries	sanitary disposal of infected animals and environmental clean up –Personal protective gloves when handling infected animals or tissues
Influenza (Grippe)	Myxovirus	(A)-Variable effects depending on virulence of the specific strain –The swine strain is the primary virus where there is good evidence for direct transmission to man from an animal source (B)–Mild to severe upper respiratory illness with generalized symptoms	(A) 1, 2, or 3 (the various interelationships are not completely understood yet) (B) Swine, horses, poultry, domestic and wild avian species	(A)–Infected animals –The specific roles of swine, horses, and birds as reservoirs of influenza for man are yet to be determined (B) 1, possibly 4 (C) Direct contact, primarily respiratory droplet from infected animals	(A)–Swine handlers primarily –Possibly persons working with poultry or horses (B) Worldwide	Provide excellent sanitation in the animal environment, including ventilation –Vaccinate horses –Swine vaccine has been successful in one European Country
Milker's Nodules (paravaccinia)	Paravaccinia subgroup of pox virus	(A)–Wart-like noudles on the skin of hands and forearms (B)–Nodules on the teats and udders of cows	(A)–1. (B)–Cattle	(A)–Infected cattle (B)–1. (C)–Direct contact with teats and udders of cows with active lesions –Hand milking or washing the udder and teats prior to machine milking are primary exposures	(A)–Dairy cow milkers and handlers (B)–Europe and the United States	–Separation of infected animals –Water protective gloves when milking or treating infected cattle

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Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
New Castle Disease (in poultry synonyms are pseudo fowl pest, pneumoencephalitis)	Paramyxovirus	(A)–Conjunctivitis –Occasionally mild influenza-like illness (B)–Disease varies depending on the specific virus strain –3 main forms: –mild respiratory illness –respiratory form with nervous involvement in chicks –severe highly fatal pneumonencephalitis	(A)–1. (B)–Chickens primarily, turkeys also –May other avian species may be infected but are primarily asymptomatic	(A)–Infected avian species, domestic or wild (B)–1. (C)–Direct or indirect contact with infected birds, their environment, or their tissues –Direct contact with aerosolized vaccines for chickens	(A)–Poultry workers –Those who administer aerosol vaccines to chicken flocks –Poultry processing plant workers (B) Worldwide	Most developed countries have eradicated the severe form and have programs to keep it out of the country –Outbreaks do occur and a test and slaughter program is invoked –Effective vaccines are avialbe, but caution must be used with these because they can infect man. Protective clothing and full face respirators should be used with these –Practice good sanitation and personal hygiene in poultry processing plants
Animal Pox –Cowpox –Goatpox –Camelpox –Buffalo-pox	Pox virus	(A) Vesicular lesions on hands and arms (B) Vesicular lesion in mouth, lips, teats, udders, and other hairless parts of the body	(A)–1. (B)–Most domestic mammals have their specific pox virus –Buffalopox is seen in Indian Buffaloes	(A)–Infected animals (B)–1. (C)–Direct contact with with infected animals, particularly during milking	(A)–Persons handling and especially milking animals (B)–Cowpox-Canada Latin American Africa, Asia, Australia –Goatpox-Africa Middle East, Europe –Camelpox-Northern	–Personal protection and personal hygiene when handling or milking infected animals –Vaccination immunization seems to limit extent of disease

Table 1. Bacterial Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
					Africa, Asia –Buffalopox-India Pakistan, Italy USSR, Egypt	
Rabies	Rhabdovirus	(A)–Progressive encephalitis with personality changes and hyperactivity to external stimuli resulting in spastic contractions of skeletal muscles, usually resulting in dysphagia, respiratory failure and death (B)–Variable encephalitis depending on species, but usually behavior changes, paralysis of muscles of mastication, death	(A)–1. (B)–Many species of domestic and wild mammals	(A) Reservoirs vary depending on geographic location, include species of canidae, mustelidae, viverridae (B)–1. (C)–Direct contact via bite wound or contamination of pre existing wound with saliva –Aerosol transmission is rare	(A)–Animal handlers working with bovine species –Agricultural workers in outdoor areas where disease is endemic in wild animal population (B)–Occurs in most areas of the world except-Australia most islands in the Carribean and Hawaii	–Vaccination or removal of reservoir host. –Vaccination of people at high risk –Post-exposure immunization for exposed –Through washing of bite wounds with soap and water
Rift Valley Fever (Enzootic Hepatitis)	Arbovirus	(A)–Fever, headaches, muscle and joint pain, dizziness, nausea, vomiting, prostration, vision changes –Most people recover completely in a few weeks (B)–Periodic outbreaks in sheep, goats and cattle –Highly fatal in young animals, generalized illness with hepatitis –Causes abortions	(A)–1. (B)–Sheep; goats, cattle –Possibly wild ruminants	(A)–Possibly rodents or wild ruminants involved with mosquito vector (B) 1 and 2 (C)–Direct contact with infected animals or their tissues, with entry through skin and mucous membranes –Aerosol transimssion is possible	(A)–Farmers and animal handlers who contact infected animals –Veterinarians (B)–Southern and Central Africa –Egypt	–Vaccination of animals –Strict use of protective clothing, gloves, and respirator when handling animals or their tissues –Personal hygiene when handling or working in the environment of infected animals

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Vesicular Stomatitis (sore mouth)	Rhabdovirus	(A)–Incidence unknown –Fever, influenza-like symptoms –Possible vesicular lesions in mouth lips and hands (B)–Cattle have vesicles in their mouth and between the digits and on udder and teats	(A)–1. (B)–Cattle mainly –Horses –Possible swine and other wild animals	(A) Cattle (B)–1., possibly 2 (C)–Direct contact with infected animals or their environment, expecially when examining infected animals –Possibly sandflies mosquitoes or other biting arthropods	(A)–Primarily people handling dairy cattle and secondarily beef cattle (B)- North and South America, Asia, Africa	–Isolate infected animals –Use of protective gloves when handling or examining infected animals –Mosquito control
Jungle yellow fever (Black vomit)	Flavivirus	(A)–Variable form inappart to fatal illness –mild cases are influenza-like –serve cases-acute high fever with headache, nausea, vomiting, prostration, fever is diphasic, kidney and liver involvement, hemmorhages, jaundice (B)–Symptoms and signs similer to man –highly fatal in American monkeys –African monkeys usually survive the infection	(A)–1 (A)–Various species of new world and old world monkeys	(A)–Maintenance mechanism involves monkeys as the reservoir and mosquitoes as the vector (B)–2 (C)–Bites from several different species of mosquito vectors	(A)–Farmers –Rubber plantation workers –Hunters –Forest workers –Public road workers (B)–Latin America –Africa	–Vaccination of persons at risk –mosquito control –Insect repellants and mosquito protective clothing

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Q Fever (Query Fever)	*Coxiella burnetti*	(A)–Generalized febrile illness with pneumonitis –possible endocarditis –case fatality rate <10% (B)–Often inapparent –May cause abortion especially in sheep	(A)–1. (B)–Cattle, sheep, goats –Many small wild animals	(A)–Cattle, sheep, goats –Ticks –Several species of small wild mammals (B)–1, 3 (C)–Inhalation of airborne organisms in dust –Direct contact with infected animals, particularly placenta and placental fluids –Consumption of raw milk	(A)–Farmers farm workers in contact with animals, or cleaning up the animal environment or assiting at birthing of claves or lambs –Abattoir workers (B) Worldwide	–Personal protection when handling infected animals (especially during parturition) –Respiratory protection when working in a dusty environment contaminated with the organism –Immunization
Psittacosis (ornithosis, fowl chlamydiosis)	*Chlamydia psittaci*	(A)–Varible depending on strain –Generalized febrile illness with headache, constipation and pneumonitus (B)–General latent or subclinical –Under stress symptoms may be seen including depression, emaciation, respiratory distress	(A)–1. (B)–Turkeys primarily –Ducks, geese, and chicken also –Psittacine birds –Many species of wild birds	(A)–Subclinicaly infected poultry, psittacine birds and many species of wild birds (B)–1. (C)–Direct contact with infected birds, their tissues or fecal material via penetration of skin or mucous membranes, or inhalation	(A)–Persons raising and handling poultry particularly turkeys –Poultry processing plant workers –People handling psittacine birds (B)–Worldwide	–Personal protection when handling infected birds their environment, or their carcases –Eliminate carrier state by feeding birds tetracycline –Screen animals before they enter processing plant –Personal protection for poultry processing
Rocky Mountain Spotted Fever (tick borne	*Rickettsia rickettsi*	(A)–Acute febrile illness with headache, muscle aches, and prostration –A characteristic skin	(A)–1. (B)–Squirrels, several other species of small rodents –Rabbits	(A)–Ticks –Small wild rodents and other mammals (B)–2. (C)–Bite from infected	(A)–Occupational hazard for agricultural workers and others whose work place encroaches on	–Personal protection against ticks, including protective clothing, use of repellants

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typhus fever, new world spotted fever, spotted fever, petchial fever, macular fever)		rash starts on palms of hands and soles of feet a few days after onset of fever, then spreads over entire body –Case fatality ratio is 20% (B)–Usually inapparent	–Dogs	ticks –Contamination of skin wound or mucous membrane by feces or internal contents from a crushed tick	endemic areas in nature –Also a hazard for rural residents in endemic areas (B)–United States Canada, Mexico Brazil, Columbia Panama	(diethyltoluamide) –Inspection of body twice daily for ticks, and removal of attached ticks by careful, gentle traction on the tick, being careful not to rupture the body –If feasible use of ticicides in and around localized work places –Vaccines are available for persons at high risk
Scrub typhus (tsutsuga-mushi disease, mite borne typhus tropical typhus)	*Rickettsia tsutsugamu-shi*	(A)–Acute febrile illness with headache and muscle aches –A skin rash may be seen –complications may involve the pulmonary, cardiac or central nervous symptom –Case fatality ratio ranges from 0-35% depending on virulence of infected strain (B)–Usually inapparent or mild illness in animals	(A)–1. (B)–Small wild rodents and other mammals of various species	(A)–Maintenance mechanism involves a mite-small wild mammal cycle –Mites are vectors and reservoirs (B)–2. (C)–Bites from mites	(A)–Occupational illness for farm workers and others whose work place encroaches on endemic foci in nature (B) Southeastern Asia, islands of the Eastern Pacific, Northern Australia, India, Pakistan	–Area application of miticides in places of agricultural work –Protective clothing impregnated with a miticide (benzylbenzoate) –wear repellants (diethtoluamide)

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Balantidiasis	*Balantidium coli*	(A)–Chronic enteritic with diarrhea –Ulcerative colitis (B)–Usually subclinical –May cause diarrhea and weight loss in stressed animals	(A)–1. (B)–Swine primarily are infected with the strains that may infect humans –Non-human primate –Rats	(A) Swine (B)–1. (C)–fecal-oral route	(A)–Agricultural workers in New Guinea have been the notable population at risk, as the swine are kept in close association with the living quarters –Swine producers and handlers worldwide are at risk especially if environmental and personal sanitation is poor (B)–The infectious organism is worldwide but the agricultural zoonotic problem has been positively recognized only in New Guinea	–Separation of human living quarters and animal housing –practice excellent environmental and personal hygiene
Toxoplasmosis	*Toxoplasma gondii*	(A)–Most infections subclinical –Three forms: –Acquired form is variable febrile disease with general lymphadenopathy specific symptoms depend on primary affected organs –Congenital form is most common, resulting in abortion, still birth, or brain damage –Ocular form is a chorioretinitis	(A)–1. (B)–Extremely wide host range –Carnivores and omnivores primarily –Any mammalian or avian species may be infected –Felines are the only animals in which the organism will sexually reproduce	(A)–Soil contaminated with feces of domestic or wild feline species -feces of feline species –Improperly cooked meat of sheep, swine, cow, poultry and many other species (B)–1 and 3 (C)–Ingestion of oocysts by hand-mouth contact or water and food contamination –Ingestion of improperly cooked meat –Congenital	(A)–Farmers who have a high degree of soil contact, especially in warm moist climates (B) Worldwide more prevalent in warm, moist climates	–Practice excellent personal & environmental hygiene –Avoid contamination with cat feces of soil to be tilled for agriculture –Sanitary disposal of cat feces –Avoid consuption of uncooked meat

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		(B)–Most infections are subclinical –Abortion and central nervous system involvement most common –Symptoms vary with specific organ involvement		–Airborne possible		

Table 1. Parasitic Infections

Echinococcosus (hydatid disease)	*Echinococcus granulosus*	(A)–Chronic-progressive gressive space-occupying lesions of the liver, lung, or other body organ –Symptoms vary depending on type and extent of tissue involvement –Anaphylactic shock may occur if the echinococcus cyst ruptures (B)–Sheep, goats-space occupying lesion of liver, lung, brain, or other tissue. Usually fatal over a long period. –Dog (primary host)-asymptomatic or mild enteritis	(A)–1. (B)–Sheep, goats, and a few wild ruminants are secondary hosts. –Several species of candiae are primary hosts	(A)–Maintenance depends on transmission cycle between sheep and dog (B)–4. (C)–Dog eats infected tissue of sheep-adult tapeworm develops in gut of dog- eggs shed in dog feces- man picks up eggs via fecal-oral route	(A)–Sheep herders, sheep handlers, especially those that keep dogs (B)–Western United States –Latin American –Mediterranean coast countries –Southern Russia –Middle East –Kenya –Australia –New Zealand	–Control depends on breaking the dog-sheep cycle –Eliminate parasite from dogs with parasitacides –Avoid dogs with possible infections –Avoid feeding tissues of infected sheep to dogs by sanitary disposal of dead sheep and offal

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Nematodiasis (Ancylostomiasis, Ascariasis, Visceral larval migrans, cutaneous Larval migrans	–Hookworms –*Ancylostoma ceylanium* –*A. braziliense* –*A. caninum* –*A. duodenale* –*Necator americanus* –Others –Intestinal Roundworms –*Ascaris suum* –*Parascaris equorum* –*Neoascaris vitulorum* –*Toxocara canis* –*T. cati* –*A. Lumbricoides* –Others –Nematodes with a free living soil stage –*Strongyloides stercoralis*	(A)–Hookworms with nonhuman hosts may cause a self-limiting dermatitis as a result of skin penetrationby larval forms –Animal hookworms rarely establish intestinal infection-Human hookworms cause intestinal infections, loss of blood, and general debilitation- –Animal roundworms may cause generalized illness from immature forms migrating through the viscera (larval migrans) This is a self-limiting infection. Complications may result from eye, brain, or heart damage–Only one animal round worm (from swine) is known to cause an intestinal infection in man, which is a vague-mild gastroenteritis (B) Hookworm causes anemia and general debilitation-Roundworms cause enteritis and	(A)–1. primarily (B)–Hookworm-cat, dog –Roundworm-swine, horse, cow, dog, cat	(A)–Intestinal tracts of infected animals and canine, swine man –Soil (B)–1 and 3 (C)–Roundworm or hook-worm-Ingestion of ova in feces or soil (hand-mouth contact) –Hookworm or free living forms –Skin penetration by larvae	(A)–The zoonotic significance of animal nematodes in agriculture is questionable –The most significant problem is soil contamination with feces from persons infected with human parasitic nematodes –Agricultural workers exposed to this soil would be exposed to human parasite infections –Close direct contact by agricultural workers in fields fertilized by feces of livestock dogs or cats could result in visceral larval migrans or intestinal infection with *A. summ*–Close direct contact with livestock and their environment could result in larval migrans or intestinal infections (B) Worldwide mainly in warm, moist climates	–Personal protection e.g boots and gloves when working in soil contaminated with animal or human feces –Avoid use of night soil for fertilizer –Avoid use of animal manure from infected animals as fertilizer if close direct soil contact by unprotected workers is required –Practice excellent sanitation in the animal environment –Practice excellent personal hygiene –Treat livestock dogs, cats man for parasites

Table 1. Parasitic Infections (Continued)

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American Leishmaniasis (Cutaneous Leishmaniasis)	*Leishmania mexicana* *L. brasiliensis* *L. peruviana* *L. tropica*	(A)–Nodules in the skin of exposed areas –The number of nodules, location and tendency to metastasize depend on the infecting species –Mucocutaneous form (caused by *L. mexicana pifanoi*) is most severe form, with tendency to spread to mucous membranes of nose, mouth rectum, and genitalia (B)–Skin ulcerations	(A)–1. (B)–rice rat, two toed sloth, domestic dog, various other wild mammals	(A)–Maintained in nature by various small mammal reservoirs and phlebotomus fly vectors -specific reservoir with specific organism (B)–2 (C) Bites from phlebotomus flies	(A)–Agricultural workers whose activities brings them in contact with the endemic cycle in nature (eg) forest workers, chicle gum tappers, cattlemen other farm workers (B)–Southern Mexico, Central America, Trainidad, and most countries of S. America –Each species of Leishmania has its own rather limited geographic location	–Area insecticides around temporary camps or work locations –Protective clothing –Insect repellants –Control of domestic dogs for the form that occurs in Peru (Uta)
Schistosomiasis (Bilharziasis)	–*Schistosoma haematobium* *S. mansoni* *S. japonicum* several other animal pathogenic species	(A)–Chronic debilitating disease causing lowered capacity for work, absenteism, increasing vulnerability to other infections –Adult forms of the parasite lodge in the mesenteric vessels of the colon and rectum (*S. mansoni* and *S. Japonicum*) or urinary bladder (*S. haemotobium*) –Complications include liver fibrosis and chronic urinary	(A) 1, 2 and 3, depending on specific species and strain of schistsome (B)–Varies with specific species of and strain of schistosome and geographic location –Many species of wild and domestic mammals including rodents, marsupials, non-human primates, cattle, and swine –Various wild and domestic avian species	(A)- The infection is maintained by cycling between various species of snails (intermediate host) and man and various other mammals (primary host– Man is the only reservoir for *S. haemato ium* –Man primarily, and possibly wild rodents and baboons serve as secondary reservoir for *S. mansoni* –Man and various domestic and wild animals species serve as reservoirs for *S.*	(A)–Agricultural workers who have direct and prolonged skin contact with contaminated water (eg.) rice paddy workers, agricultural workers with irrigated crops, or working with the irrigation –The disease is not entirely agricultural, because it can occur by recreational or other types of water contact (B)–*S. mansoni*. Africa, South America,	–Development of irrigation systems, migration and population concentration that exceeds sanitary services are all factors to contend with –Environmental sanitation is critical (ie) sanitary disposal of urine and feces (eg.) provision of latrines for workers -provide sanitary water for personal

Table 1. Parasitic Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
		bladder infection –Non-human animal schistosome species cause either a mild or non-patent infection in man –Avian schistosome species cause only dermatitis in exposed individuals (B) Health effects for animals are variable but generally similar to man		*japonicum* –Various domestic and wild animal species are reservoirs for the several animal schistosome species (B)–4 (C)–*Cercaria* escape from snail and penetrate skin of the primary host. The parasite localizes in small blood vessels of the intestine or bladder –Eggs are then shed in feces or urine-Snails are infected to start the cycle over again.	Carribbean Islands –*S. japonicum*–China, Japan, Phillipines, Indonesia, Laos, Cambodia and –*S. haematobium*, Africa, Middle East, India	use-control snails by ecological changes, biological chemical methods –Mass examination and treatment of exposed populations –Pre-employment examinations and treatment of infected persons before hiring –Public

Table 1. Fungal Infections

Dermatophytosis (Ringworm, taenia, dermatomycosis)	–*Trichophyton verrucosum* –*T. equinum* –*T. mentagrophytes* –*Microsporum canis* –*M. nanum* *M. gallinaciae*	(A)–Skin infection of variable severity –Crusty inflamed lesions that tend to clear centrally-pustules may develop in the active portion of the lesion –Lesions usually occur on face, arms, and head (B)–Similar to man except lesions usually much less	(A)–1. (B)–Most animal species have their own fungal agents which cause skin infections. The infected animal species important in agriculture includes: cattle, goats, sheep, horse, rat, swine, and chicken	(A)–*T. verrucosum*-(cattle mainly, sheep and goats also possible –*T. equinum* - horse –*T. mentagrophytes* (Rat) –*M. canis* - (Dog, cat) –*M. nanum* - (Swine) –*M. gallinaciae* (Chicken) (B)–The environment (barns, feed bunks, corals, etc) may also serve as a reservoir,	(A)–Farmers and livestock handlers –Persons who milk infected animals are particularly at risk –Children are at greater risk than adults (B) Worldwide	–Practice excellent animal health programs (eg.) sound nutrition, excellent environmental sanitation, prevent over-crowding –Isolate infected animals –Wear protective gloves and clothing when handling

Table 1. Fungal Infections (Continued)

Disease (Common names)	Etiologic Agents	Health Effects (A) Human (B) Animal	Animal Hosts (A) 1. Zooanthroponosis 2. Anthropozoonosis 3. Amphixenosis (B) Specific Animals Infected	Mechanisms of Transmission (A) Reservoir (B) 1. Direct-zoonosis 2. Meta-zoonosis 3. Sapro-zoonosis 4. Cyclo-zoonosis (C) Specific mechanisms	Epidemiology (A) Populations at Risk (B) Geographic Distribution	Prevention or Control
		inflamed and dry –May be patches of hair loss –May be subclinical infections		because the organism lives for long periods of time off the host. (C) Close direct contact of bare skin to infected animals or their environment		infected animals -practice good personal hygiene
Histoplasmosis	*Histoplasma capsulatum*	(A)–Often sublinical –Variable, depending on dose and immune response of the individual –Usually a febrile illness with influenza-like symptoms, cough, pneumonitis, usually recovery in 2-3 weeks –Chronic forms may be extremely severe and very difficult to treat, with chronic pneumonitis, liver infections, bone infections or other tissues (B)–Often subclinical –Similar to human illness	(A)–None of above. Animal relationship to humans comes from the fact that the organism grows particularly well in soil contaminated with fecal material of birds or bats. These species may also act to distribute the organism in nature (B)–Most animals have subclinical infections –Dogs are the primary animal species that develop illness	(A)–Soil-particularly that contaminated by aged feces of birds or bats. (B)–3 (C)–Inhalation by producing aerosols of the organism during disturbance of soil that contains the organism (eg.) cleaning or razing old chicken coops, working in areas where old bird roosts have been	(A)–Farmers as well as other persons who live and work in endemic areas of the infection (B) Worldwide, in specific localities where soil and climatic conditions are favorable for growth of the organism	–Wetting down soil and wearing a good particle filtering respirator when working in dusty environment conductive for growth of the organism (eg.) old bird roosts, old poultry house, etc.

Meat Hygiene

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Chapter 12
Occupational Injuries and Infections

INJURIES

It is understandable that in a sphere where floors are often slippery because of fat and blood deposits, where livestock are handled and where machinery and knives are in constant use, injuries frequently occur.

By far the commonest injuries are cuts and abrasions incurred while using knives. Excessive force with a sharp knife or a slip when making an incision can result in a serious wound. Delayed treatment can result in sepsis and arthritis.

The Health and Safety at Work Act 1974 requires that all employers in Britain ensure as far as is reasonably practicable, the health, safety and welfare at work of their employees. Specific requirements relating to first-aid arrangements are laid down in the Factories Act of 1961. A first-aid box or cupboard must be provided (more than one if there are more than 150 workers) in every factory. Its contents must conform to certain standards and a responsible person must be in charge. If the factory employs more than 150 people, this person must be either a registered or enrolled nurse or the holder of a certificate in first-aid training issued during the previous three years by an approved organization. The siting of first-aid boxes, maintenance of records, situation of ambulance rooms and referring of cases to a doctor or hospital, etc., are dealt with by the Factories Act 1961. In areas where knives are used, especially boning-out departments, adequate protection against knife injuries must be provided and failure to comply may involve employers in prosecution under the 1974 Act.

Regulations made under the 1974 Health and Safety at Work Act and effective from 1981 lay down the accidents which are reportable directly to the Health and Safety Executive. These relate to deaths, major injury and other dangerous occurrences as defined by the Act. If the injured person goes to hospital, a report is only necessary if he/she is detained for more than 24 hours, other than for observation. In all cases completion of the 'Accident Book' is necessary.

Because of the high number of hand-tool accidents which occur in the UK meat industry (over 1000 in 1981) inspectors in the Health and Safety Executive carried out an investigation in 1981 into the nature of knife accidents in meat and fish plants.

Out of 254 instances of knife injuries examined 75 (29.5%) involved personnel with more than five years experience of boning-out. In 169 (66.5%) instances there was no protection provided for the non-knife hand and in 228 (89.8%) cases there was no protection for the wrist and forearm. Butcher/boners appeared to be most prone to injury, but slaughterers were involved in about one-third of the total instances.

It is a sad reflection that injury could have been prevented in 213 or 83.9% of the cases, and also that in 20% of the accidents the operatives were wearing plastic or rubber aprons capable of being easily penetrated by a knife.

Usually the non-knife hand is injured, which would tend to indicate that knife-slip is the most frequent immediate cause of injury. Good knife design, proper handle guards and adequate protection for the non-knife hand, wrist and forearm together with the use of an apron of chainmail are essential items for protecting butcher/boners. Many personnel resist the use of gloves and aprons because of their weight and awkwardness in use. A lightweight glove made of high-strength aramid and nylon with a steel core and which is washable is now available, but although extremely cut-resistant, is not cut-proof.

There can be no doubt that the safety of personnel is of the utmost importance because of the injury, pain, possible infection and the time off work involved. Death from knife wounds is not unknown in the meat industry nor is septic arthritis resulting in deformity of finger joints due to lack of proper treatment at the time of the injury.

A survey of meat handlers affected with *skin sepsis* in North Yorkshire over a period of five years (1979–84) showed that out of a total of 467 cases the lesions included septic cuts and scratches, paronychia (inflammation of the skin fold at the side of a nail), abscess and associated lymphadenitis as well as infections of pierced ears and tattoos. Organisms isolated included beta-haemolytic streptococci (*Str. pyogenes* in 203 episodes) and *Staphylococcus aureus* in 170 episodes.

A condition of *acute erythema* of the hands and wrists sometimes occurs in persons engaged in the handling and trimming of pancreas. Susceptible individuals are affected when no protection is worn and the lesion is an extremely painful one, marked reddening of the skin occurring.

A well equipped first-aid room with a qualified nurse is essential, especially in the larger establishment. An industrial nurse can also make a significant contribution to the standards of hygiene in a meat plant. Close liaison with the medical profession can lead to a high standard of preventive medicine materially benefiting staff welfare and working conditions.

Especially in cutting and boning rooms, safety gloves and aprons made of chain mail or similar material are necessary. There should be a high standard of cleanliness and tidiness of working, with no organic or other material lying on floors to cause falls. Machinery should always be efficiently maintained and dangerous working parts should be adequately encased. Since it is not unusual for carcases or trolleys to fall off overhead round or flat bars it is wise to provide staff with safety helmets. Equipment must be properly handled by staff and frequent advice about safety and the necessity for clean, tidy working conditions should be an essential part of all meat-trade activities. Plastic waterproof footwear with microcellular soles is of great value in preventing slipping on wet floors, and well designed protective clothing changed at least daily is essential.

ZOONOSES

While injuries of various types including electrocution are common, workers in the meat industry, especially in the slaughtering sector, are at particular risk in acquiring certain zoonoses (diseases and infections which are naturally transmitted between vertebrate animals and man). These include anthrax, brucellosis, contagious pustular dermatitis, erysipelas, leptospirosis, listeriosis, louping-ill, ornithosis, psittacosis, Q-fever, ringworm, salmonellosis, streptococcal meningitis, TB and tularaemia.

Anthrax

There has been a significant decrease in the number of reported cases of anthrax in Great Britain in recent years. In England and Wales in the period 1961–65 there were 56 cases with four deaths while in the years 1976–80 only 14 cases were reported, with no deaths.

The disease was made notifiable under the Public Health Act in December 1960 and the decline in incidence was most noticeable in those persons employed in the wool, hair and bristle trades. This was mainly due to the introduction in 1965 of vaccination and in 1978 to labelling of the unsterilized product.

However, workers in these particular trades, those handling bone flour and even those not in associated occupational trades are still at risk. The fact that anthrax is not necessarily associated with sudden death in the animal means that great vigilance is required and that veterinary ante-mortem inspection is essential.

Cutaneous anthrax appears to occur more often on the hands and arms of meat handlers while the face and neck are more often affected in workers employed in other industries (Fig. 12.1).

Brucellosis

While personnel engaged in the actual handling of livestock, dressing of carcases, gut and tripe and disposal of rejected material and hides are at greatest risk, all abattoir staff are at hazard, especially when many reactor animals are slaughtered as in an eradication scheme. In some instances of human infection the actual mode of infection has been difficult to explain.

In 1966, a study in Edinburgh revealed antibodies to *Brucella abortus* in 12.5% of tested abattoir workers and (presumably from drinking unpasteurized milk from infected herds) in 1% of the population there.

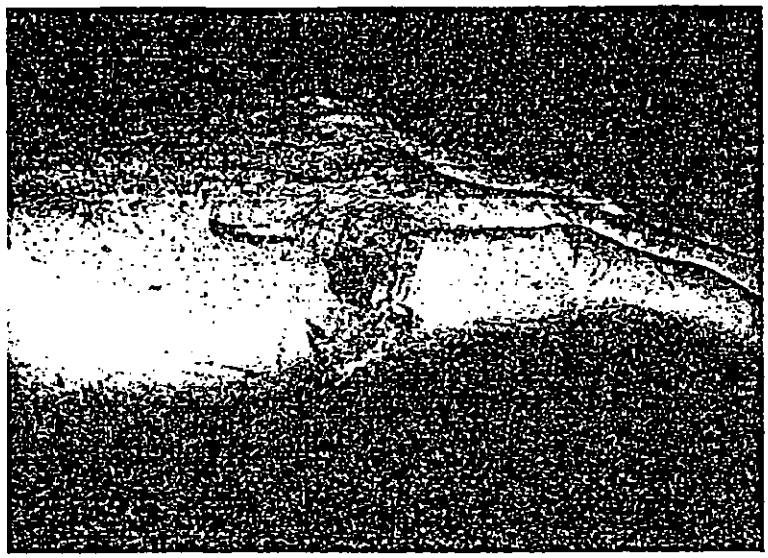

Fig. 12.1 Anthrax. Malignant pustule on a human hand. (By courtesy of Dr J. S. Matthews, Royal Victoria Hospital, Belfast)

In the UK the introduction in 1967 of voluntary schemes for the testing and removal of reactors from individual herds followed by area eradication in 1975 and compulsory eradication in 1979 has ensured a marked decline in the incidence of bovine brucellosis with a parallel reduction in the human infection.

Nevertheless pockets of animal infection remain, as they do in tuberculosis, with the occurrence of a few human cases. One such case occurred in Scotland in 1985 when a slaughterman who acquired infection was awarded £42,200 damages against his employers who had failed to provide him with adequate protective clothing.

Special care is needed when slaughtering and dressing *Brucella* reactor animals. These animals should be spread over several abattoirs, thus decreasing the risk of infection of personnel. It is not enough to arrange for the removal of such animals from farms without paying close attention to their slaughter and the needs of operatives employed in abattoirs.

Known *Brucella* reactor stock must be handled with care from reception onwards, with strict attention to hygiene at all stages. The uteri and udders should not be handled with bare hands, but with hooks or other suitable instruments. They must not be incised but consigned immediately as rejected offal and disposed of with care for inedible purposes. Masks and rubber gloves have been recommended for staff, but currently present practical problems. Hands and arms must be washed frequently, preferably using a bactericidal soap.

Contagious pustular dermatitis (Plate I, Fig. 1)

Also called contagious ecthyma or 'orf', the lesions of contagious pustular dermatitis occur fairly frequently in abattoir workers mainly on the hands, wrists, forearms and sometimes the face. The early vesicle stage is seldom seen, however, and the presentation is a chronic, raised circular weal very red in colour, often found on the ulnar border of the hands. The actual handling or slaughtering of livestock is not necessarily the cause; the condition has been reported in engineering staff concerned with equipment maintenance. Although orf in sheep is most prevalent in spring and early summer, cases have been recorded in abattoir workers in mid-winter, suggesting a virus carrier state in sheep.

Contagious pustular dermatitis in sheep and goats is a disease worldwide in distribution caused by DNA virus of the *Parapoxvirus* genus of poxviruses. Lesions of the lips of lambs (mostly up to one year old) and udders of ewes are usually seen, but a more serious form with high mortality may involve the tongue, palate, lungs and digestive tract.

Between 1975 and 1981 in Scotland there were 344 reports of orf in human beings, most lesions occurring on the hands and forearms, and most cases affecting adults, especially men. In 49 cases those affected were abattoir workers, butchers or meat handlers. It is likely that the actual number of cases greatly exceeds this figure since many of the lesions, although intractable to treatment, are of minor importance.

Sensible protective precautions should be exercised, i.e. strict hygiene and prompt and suitable treatment of cuts on hands and arms. Infected animals should be handled carefully in the lairage, and other staff warned of the danger.

Erysipelas

Erysipelas infection occurs through skin abrasion or more rarely by ingestion. The disease is most common in abattoir workers, fish handlers and those in the fish-meal industry (the bacilli, probably originating from sewage, have been found on the skin of many salt-water fish).

Several forms of the condition may occur: a mild, localized, cutaneous infection usually involving the fingers, with or without arthritic symptoms (erysipeloid of Rosenbach); a diffuse or generalized skin eruption with arthritic and constitutional symptoms; and a septicaemic form with endocarditis which may or may not be accompanied by skin and arthritic lesions. Arthritis, meningitis and brain abscesses have also been associated with *Erysipelothrix insidiosa* (*rhusiopathiae*) infection.

The localized skin lesion, or erysipeloid, is characterized by swelling, erythema and pain at the site of inoculation. The erythema is reddish-purple in colour and possesses a well defined raised zone which extends peripherally as the central portion subsides. Haemorrhagic vesicles may occur on occasions at the site. Similar erythematous lesions may appear elsewhere on the hands and wrists with the disappearance of the original lesion. Alternatively the lesions may spread by contiguity. The duration of the disease is about three weeks. The severe diffuse or generalized skin eruption has been known to last for many months and even as long as two years. The septicaemic form, usually of shorter duration, possesses symptoms similar to those occurring in the septicaemic condition in pigs – skin eruption, arthritis and endocarditis.

Leptospirosis (haemorrhagic jaundice, canicola fever, Weil's disease)

In certain parts of the world leptospirosis is an important disease in the livestock industry, e.g. parts of North and South America, Russia, Europe and the Near East, but not in the British Isles. Clinical cases in man do occur from time to time and are almost always associated with rats, in whose urine the leptospires are shed. Hedgehogs, voles, shrews, skunks, opossums, bandicoots, certain reptiles, amphibians and fish also act as natural reservoirs of infection.

In addition to abattoir workers, livestock handlers, veterinary surgeons, poultry and fish handlers, sewer and canal workers, etc., are liable to infection. At least 103 different serotypes of leptospire have been recorded in livestock, occurring in two main complexes: *Leptospira interrogans* including most of the mammalian strains and *L. biflexa* including the non-pathogenic saprophytic types.

Of the 120 cases of human leptospirosis occurring in England and Wales during 1983 most were of the *icterohaemorrhagiae* serogroup, followed by *hebdomadis* and *canicola* infections, with four deaths occurring.

Leptospirosis causing abortion in cattle was common in England in the early winter of 1984. *L. interrogans* servovar *hardjo* and *L. bratislava* have mainly involved with 'flu-like illness occurring in farm personnel.

The reservoir of infection includes farm and pet animals (cattle, horses, sheep, pigs and dogs) and a wide range of wild animals, rats and other rodents acting as normal carrier hosts. The size and movement of the rat population may increase the risk of exposure of human beings to infective material, the disease in man being more prevalent during the late summer and autumn months. Warm humid conditions tend to favour the growth of leptospires.

Although infection usually takes place through the skin with the urine of infected animals, especially if the skin is cut or abraded, infection may also occur through inhalation or ingestion of infective material.

It is interesting to note that because of improved personal and environmental hygiene standards leptospirosis is not now common in miners, sewer workers and fish cleaners who were at one time commonly infected.

The adoption of hygiene precautions – a *sine qua non* for all zoonoses – the reduction of the rat population and the prompt treatment of clinical cases in man have reduced the hazard of leptospirosis.

Listeriosis

Listeria monocytogenes is a ubiquitous organism. It can be shed from the intestine in animals (domestic and wild) and man without any apparent clinical symptoms. Most human cases are associated with sources other than animals. Infection is mainly neonatal, but direct contact with infective material e.g. aborted fetuses, contaminated soil, etc., as well as ingestion and inhalation may also be modes of transmission. In a few cases infection has occurred in man as a result of eating infected meat. The organism has been more frequently isolated from the faeces of abattoir workers than from any other classes of people, although the exact reason for this is not understood.

As in animals, the disease takes the form of an encephalitis or abortion, occurring in adults and in the neonatal period. Mortality rates may be as high as 42%.

Louping ill

An incidence of louping ill infection of 8.3% was detected in Scottish abattoir workers in 1966. The frequency of cuts and other abrasions sustained by abattoir staff undoubtedly predisposes to this infection. It is caused by an arbovirus and transmitted by ticks (*Ixodes ricinus, Ipersalcatus, I. cookei, Rhipicephalus appendiculatus*). Louping ill is an acute encephalomyelitis of sheep which is occasionally transmitted to man by the bite of an infective tick or by the consumption of milk from infected animals.

Avian psittacosis and ornithosis (chlamydiosis) (parrot fever)

Both diseases are transmissible to man, psittacosis from birds of the psittacine order (parakeets, parrots, etc.) and ornithosis from birds other than psittacines. The disease is world wide in distribution and affects a wide variety of birds. Among domestic poultry it is most common in ducks, turkeys and pigeons, which are the main sources of human infection.

Persons may become infected more than once and, while the disease is usually mild, it can be severe. Human infection occurs by inhalation following exposure to infective aerosols or dust-infected bird droppings. *Chlamydia psittaci* may be responsible for cases of conjunctivitis in persons working in the poultry industry, especially in dust-laden atmospheres.

The first recorded outbreak of ornithosis in the UK occurred in the winter and spring of 1979–80 and was associated with commercially reared ducks, some cases involving workers in a duck processing plant and others occurring in 15 out of 46 veterinary surgeons attending a training course on the supervision of poultry processing plants.

A survey of workers in the British duck industry has indicated a past exposure to infection rate (based on results of complement fixation (CF) tests on blood samples) of 11%. The workers employed on evisceration lines in duck processing plants showed the highest titres to the CF test.

Cases of ornithosis originating from ducks have also occurred in Czechoslovakia and Denmark. In the former country it was said that covering the evisceration lines and improving the ventilation by the installation of extractor fans had solved the problem.

While the annual number of human cases arising from psittacine birds has been decreasing since the implementation of the Importation of Captive Birds Order of 1976, the overall number of ornithosis cases has been rising.

Symptoms in humans include gastrointestinal pain and vomiting, headache, insomnia and pneumonia. Mild attacks of the disease may be mistaken for influenza. Recovery is usually complete, but convalescence may be prolonged.

The disease responds well to tetracyclines and antibiotic prophylaxis with chlortetracycline is advocated for the control of the disease. Satisfactory standards of ventilation and the prevention of dusty environments are of value, as are dust masks where necessary.

General control is a difficult problem. Where infection is suspected in dead birds it is recommended to wet the feathers with disinfectant.

Q Fever (query fever)

In the 1966 study of Scottish abattoir workers 28.1% had antibodies to phase 2 antigen of *Coxiella burnetii*, the cause of Q fever. A survey in 1953 showed a 2.13% incidence in the general population. In 1966 in Northern Ireland 28.3% of abattoir workers were positive and 24.4% of veterinarians, although there had been no evidence of Q fever in animals or humans 10 years previously.

Q fever was first officially recognized in the United Kingdom in 1949 and is now routinely tested for in the differential diagnosis of cases of pneumonia and pyrexia of unknown origin in man. Between 1975 and 1980 an average of 100 cases annually were reported to the Public Health Laboratory Service in England and Wales. Outbreaks are rare, but often the source of infection is difficult to establish. Cattle and sheep are usually considered to be the main reservoirs of infection.

In recent years in Australia Q fever has been such a serious cause of illness among abattoir workers that vaccination of susceptible personnel was tried. 924 non-immune volunteers were inoculated with a *Coxiella burnetii* phase 1 vaccine and while 34 cases of Q fever occurred in 1349 unvaccinated workers, none occurred in the vaccinated subjects in the following 18 months.

The disease in man is an acute febrile disease with sudden onset, malaise, anorexia and weakness lasting for 1–2 weeks. Pneumonia is present and the mortality rate is low. Death is most often due to endocarditis, and the severity of the disease increases with age. Infections without symptoms are sometimes observed.

In some countries the disease is officially classified as occupational. It is transmitted by the bites of ticks and by the inhalation of infected dust, but rarely by the ingestion of contaminated meat and milk. *C. burnetii* remains infective in wool, cotton and farm dust for very long periods. The disease in farm animals occurs most often in ruminants, especially goats, sheep and cattle, but many wild animals as well as farm stock may act as reservoirs.

C. burnetii can multiply in the genital tract and mammary gland of cattle, sheep and goats, and apparently healthy stock are known to shed large numbers of the organism in milk, urine, faeces and especially the placenta and fetal fluids. These animals appear to be able to harbour the infection without ill-effects although cases of bronchopneumonia and abortion due to Q fever have been occasionally recorded.

Ringworm (tinea capitis, kerion, favus)

Ringworm is a disease caused by a closely related group of fungi known as dermatophytes and may occur in workers handling and slaughtering cattle during the winter when animals are normally affected (Plate I, Fig. 2).

Diagnosis is best carried out by the microscopic examination of affected hairs when fungal hyphae and arthrospores will be seen after the hairs have been treated with 20–30% potassium hydroxide.

As with contagious pustular dermatitis, infection is most commonly by direct contact with infected animals but may also occur through indirect contact. Since ringworm spores can exist on animals' skins without causing any lesions, such animals may be important sources of infection. As for many human skin affections injuries in the form of cuts, abrasions and maceration of the superficial skin layers are probably predisposing factors (Fig. 12.2).

The common forms of ringworm in cattle are *Trichophyton verrucosum* and less commonly *T. mentagrophytes*.

Streptococcal meningitis

A disease of pigs caused by *Streptococcus suis* type 2 and characterized by meningitis has been recognized in the United Kingdom and the Netherlands since 1973. Recent surveys have shown that the disease is widespread in pigs in the United Kingdom, especially in the south and east.

Since the first outbreak in 1973 there was an increasing number of new outbreaks recorded to a peak in 1976 after which there was an apparent decline but this may have been due to veterinary surgeons diagnosing the disease without recourse to veterinary inves-

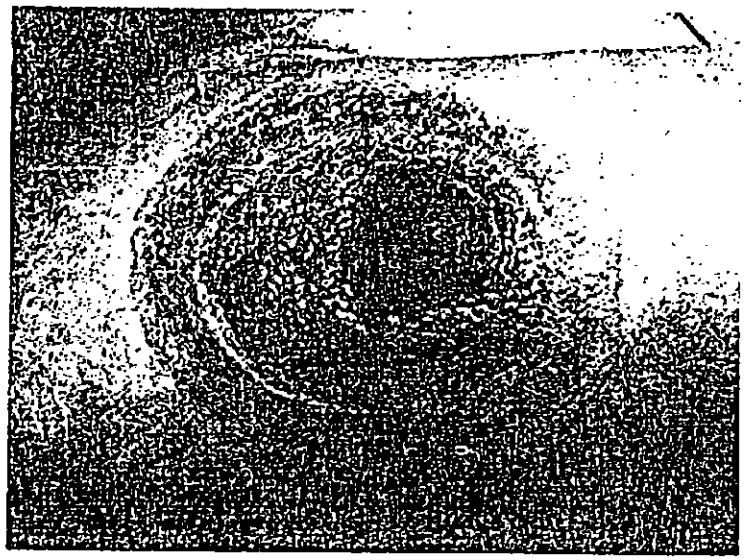

Fig. 12.2 Bovine ringworm on human leg. (By courtesy of Dr J. S. Matthews, Royal Victoria Hospital, Belfast)

tigation centre aid, cases thereby not being officially recorded.

The disease usually occurs after weaning and when pigs are mixed, the organism apparently being conveyed by healthy adult carrier pigs in the nasopharynx. However, it is possible that human carriers may on occasions be involved.

Since 1975 there have been 14 reports of sickness in people due to *S. suis* type 2 (group R) in England, Wales and Ireland. The persons affected were abattoir workers (5), meat factory workers (3), butchers (2), farmers (2) and one veterinary surgeon. In one case (a woman) there was no history of any occupational involvement. Ten of the patients developed meningitis, other symptoms being bacteraemia and arthritis, bacteraemia and lymphangitis.

Streptococcus suis type 2 appears to be endemic in many pig herds in the British Isles and causes sporadic outbreaks of meningitis in growing pigs, being precipitated probably by stress. In man it takes the form of a febrile condition with severe headache, numbness of the fingers, foot pain, rigors and erythema, but usually no symptoms of meningitis. The condition responds slowly to treatment with antibiotics over a period of several days.

Streptococcal skin infection

Outbreaks of a skin infection due to *Streptococcus pyogenes* have occurred among workers in meat processing factories, the first one being reported in Yorkshire in 1978. In this particular instance there was an attack rate as high as 44% in one particular department (packing). Altogether, there were 103 episodes of infection in 82 workers out of a total staff complement of 347 in a poultry processing factory.

Meat handlers appear to be particularly susceptible to streptococcal skin sepsis which takes the form of impetigenous or eczematous lesions, infection round the nail fold and infected lacerations. Second, and even third, episodes of infection may occur.

Repeated irritation with water and detergents, skin wounds and abrasions are probably the main predisposing causes.

Control measures include the adoption of high standards of personal and environmental hygiene, the wearing of gloves, prompt and efficient attention to cuts, regular cleaning and disinfection of door handles, aprons, gloves, knives and swing door surfaces.

Tetanus (lockjaw)

While abattoir workers are probably no more at risk from this infection than other occupations, nevertheless in an industry where livestock are handled and where wounds, often deep penetrating ones, occur, the possibility of tetanus occurring is a very real one.

There were 19 notifications of tetanus in England and Wales in 1969 and 18 in 1980,

the annual fluctuations ranging from 15 to 24 in the intervening years. Deaths due to tetanus ranged from one to ten a year and were higher in persons over 45 years of age and in males.

The actual number of cases of tetanus is probably four to five times those notified.

Tularaemia (rabbit fever, deerfly fever)

In addition to the handling of infected hares, rabbits, sheep and other animals, infection may be acquired through the inhalation of contaminated dust from hay and straw, from contaminated water and tick and mosquito bites. Workers in agriculture, wool shearers, rabbit butchers, fur trappers and those in related occupations may become infected. The cause is *Francisella (Pasteurella) tularensis*.

Since the infection occurs naturally in hares, ground squirrels, rabbits (especially the cottontail), voles and muskrats, with sporadic cases in domestic animals (especially sheep) in which it may be epizootic, control has to be directed towards avoidance of infection from these species. The rat-proofing of homes in endemic areas in America, Europe and Eurasia is recommended and the adequate cooking of meat and boiling of water.

The disease in man takes two main forms, a glandular or ulceroglandular form and, less commonly, typhoidal and pneumonic form. The first sign is usually a papule at the site of initial infection, often a finger, which ulcerates. Infection spreads to the associated lymph nodes which swell (lymphadenitis). The disease is accompanied by fever, headaches and muscular pains and lasts for about two to four weeks. Mortality rates are generally less than 5% and mainly associated with the typhoidal and pneumonic forms, which are the more serious and are accompanied by an exhausting feverish illness.

Some 2000 cases of tularaemia are reported each year in the United States. The disease responds well to treatment with streptomycin, tetracycline or chloramphenicol. (See also Pasteurellosis.)

Miscellaneous conditions

Animal-related allergies, in which rhinitis, asthma and skin rashes are the commonest symptoms, may occur in susceptible individuals working with livestock, or with fodder, e.g. farmer's lung due to exposure to mouldy hay.

More recently in the United States it has been shown that exposure to faecal bacteria and Gram-negative bacterial endotoxins found in dust may cause eye and nose irritation, productive cough, breathlessness, chest tightness, headache and nausea.

Prevention of occupational diseases

1 Where possible, the elimination of the disease in domestic animals.
2. Efficient veterinary ante-mortem inspection, especially with casualties, and the immedate alerting of staff to all disease hazards.
3 High standards of personal and environmental hygiene.
4 Vaccination of staff where appropriate.
5 Prompt and effective treatment of cuts and bruises.
6 Proper abattoir construction and layout with good staff facilities and ventilation.
7 Education of workers as to the nature of zoonoses and how to minimize the risk of infection by the careful handling of potentially infected stock, carcases and offal.
8 Close liaison with medical expertise.

production delays and condemnations.

To develop an effective sanitation programme it is necessary to:

1 identify needs and defects;
2 establish detailed cleaning instructions for all areas and equipment;
3 set up a working programme;
4 ensure that all personnel receive proper training in hygiene, environmental and personal;
5 evaluate efficiency.

Inspection by a responsible and competent individual should include a pre-operations and an operational inspection. The ultimate aim must be to achieve a physically, chemically and microbiologically clean environment; this to denote one free from pathogenic bacteria and undesirable numbers of other microorganisms and free from any undesirable odours.

The effectiveness of any cleaning programme is made easier by ensuring proper initial meat plant and equipment design. The cleaning process is rendered more thorough by the provision of smooth impervious surfaces, the avoidance of awkward nooks and crannies and the use of efficient cleaning machinery and detergents/sanitizers.

An integral item of any good sanitation scheme should be a *Sanitation Report* which details the state of the various plant areas and the action taken by the Inspector, copies being given to management and to Government officials, if necessary. The Sanitation Report is completed daily and rendered weekly.

Automated cleaning systems

Extensive research by the chemical industry and cleaning equipment manufacturers, especially in the United States, has produced several automated systems to cope with what is probably the most important problem in the food industry – sanitation. Three main types of these automated cleaning systems have been developed: cleaning-in-place system (CIP), central cleaning system (CCS) and self-contained cleaning system (SCCS).

The cleaning-in-place system was first developed for the dairy industry. It is a closed system in which cleaning compounds are circulated by a pump through a series of pipes to the components to be cleansed. Although it can be tapped for external cleaning it is basically designed for cleaning internal surfaces only. At present it has a limited application in the meat industry, although it can be used for the internal cleaning of mixers, choppers and other equipment that necessitates the use of tanks. Food plants that process fluids other than milk utilize the CIP system extensively.

Central cleaning systems have a central pumping source supplying cleaning solutions under pressure to remote locations in a meat plant. The unit should be capable of achieving pressures of 35–49 kgf/cm^2 and a flow of 136–181 litres/min. In one CCS the cleaning materials may be mixed centrally and delivered to the various points through one manifold, the plant water supply being used for rinsing. In the other CCS the detergent is transported through a separate manifold to each remote station where it is mixed with the high-pressure water system as required and used through a cleaning gun. With these two separate lines, which are, of course, more costly, both pressure wash and pressure rinse can be carried out.

The self-contained system has the pumping source and chemical spray systems contained in one unit and may or may not have facilities for foam production. Some units produce hot water while others employ a steam-mixing valve or utilize the separate hot-water system of the plant. Some self-contained systems are able to use an alkaline cleaner, an acid cleaner and a sanitizer at each remote station. Some forms of this automated cleaning equipment are portable and can be removed from one location to another, being connected to an electrical or air and water source of power. It is a flexible system in that if a pump fails, a unit from another area can be used, whereas in the CCS the entire sanitation process stops if this eventuality should occur.

Continuous cleaning of viscera conveyors and other equipment in contact with edible material is another essential task.

EMPLOYEES

Important though the plant layout design and facilities are, they must be combined with a

high standard of personal hygiene and responsibility towards cleanliness in the employees themselves. Most countries require food plant employees to have periodic medical examinations and to report the occurrence of certain diseases which might be responsible for the development of food-poisoning outbreaks. A sound training in the theory and practice of good hygiene is essential and operatives should have all the necessary facilities to achieve a high standard of personal cleanliness and a clean, workmanlike job.

Training in the various techniques associated with meat plant operations is essential for efficient, humane treatment of animals and for carcase meat of high quality. As in all areas of the food industry there must always be an awareness among employees of the vital importance of sound hygiene practices and personal cleanliness. There is no point in having a first-class factory with elaborate equipment if it is not matched by efficient staff able and willing to adopt good practices designed to prevent contamination and deterioration of meat as well as ill-health in themselves and the consuming public.

The responsibility for meat hygiene in an abattoir rests with top management, although in many areas, e.g. local authorities in Britain, this is not well designated. If control of the abattoir is divided between those responsible for operatives and those concerned with meat inspection there is often a hiatus between the two which can result in low hygiene standards. While productivity is important it must be secondary to the demands of hygiene. All too often, however, production managers are concerned with throughput at the expense of hygiene and legislation is often too permissive.

Top management has a duty to ensure that their hygiene policies are made clear to managers and supervisors, especially line supervisors who are in immediate control of operatives. While it is essential to have a hygiene section and a hygiene officer possessing adequate authority, the essentials of hygiene must be inherent in all members of staff.

All managers need to be fully familiar with current meat hygiene legislation and up to date with new innovations, especially those immediately concerned with sanitation. It is also the duty of management to ensure that their hygiene policies are made known to supervisors and communicated to all personnel. The presence of a fully qualified nurse and a properly equipped first-aid room can assist materially in achieving high hygiene standards, as can the use of a laboratory.

Use may be made of suitable posters, supplemented by lectures, films, suggestion schemes, competitions, discussion groups, etc. Each employee should be given a hygiene booklet (which may be combined with one on safety) when he begins employment.

While modular training schemes initiated by the Food, Drink and Tobacco Industry Training Board operate in Britain, it is considered that suitable meat training centres for staff engaged in this sector are necessary in order to deal fully with the important areas of animal welfare, specialized techniques, skills, occupational hazards, machinery, equipment and premises, commodity value, food poisoning, etc. Different levels of training in the various functions listed above are required for different staff members in a meat plant, but in relation to cleanliness, clothing, attitudes and behaviour the level of training is the same for all, from the company director to the latest recruit.

Basic training in hygiene on induction would include: the nature of hygiene; how it affects the operative, his or her colleagues and the consumer; hygiene practices; regulations and procedures of the meat plant; and health requirements of personnel. These items can be fully explained in a readable booklet given to the new employee in which the nature of viruses, bacteria, yeasts and moulds is explained, along with occupational hazards.

On the job training can deal with the use of equipment and tools and their sterilization; protective clothing; good housekeeping in relation to hygienic practices; accidents and their reporting; use of dressings and first-aid room, if available; and safety measures. A valuable adjunct in hygiene training is a visit to the laboratory where microorganisms can be viewed through the microscope and their growth observed on culture media, with an explanation of their basic physiology.

On-going training programmes are concerned mainly with furthering awareness of the need for good hygiene practices among personnel by way of posters, lectures, personal approach, etc.

Since cuts of various types are the most common form of injury (but not the only ones)

encountered in a meat plant the need for personal hygiene, hair and hand care, toilet, general cleanliness and prompt treatment of cuts, abrasions and other skin lesions must be stressed.

The elements of sanitation, refrigeration (with temperature, relative humidity and cold air speed) and the awareness of hazards for consumers (e.g. metallic objects and other foreign bodies in carcase or processed meat), reporting procedures and responsibilities also have to be communicated to employees.

UNIVERSITE DE MONTREAL

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Département de médecine du travail et d'hygiène du milieu

MEDECINE DU TRAVAIL
(MMD - 4317)

Responsable: Jules Brodeur

ABATTOIRS ET ETABLISSEMENTS DE TRANSFORMATION DES VIANDES

23 janvier 1979: Exposé relatif à la visite de ces types d'établissements et à la protection des travailleurs impliqués.

A.M. 10:00; Salle 3070.

P.M. 2:00 Visite d'observation
Canada Packers Limitée
1260 rue Mill, Montréal.

Professeur: Jacques Nantel
343 - 7001 ou 6144

e
Groupe III

1. L'HYGIENE DES VIANDES

Vaste secteur de la santé communautaire, l'hygiène des aliments a pour objet l'étude des moyens propres à assurer au consommateur des aliments dont la qualité répond le mieux à ses besoins, ou du moins satisfait aux normes considérées comme acceptables au point de vue sanitaire. Elle englobe l'hygiène des viandes qui par l'importance, la multiplicité et souvent le caractère particulier de ses variables a conquis sa propre identité. En effet, les méthodes à suivre pour qu'elle atteigne ses objectifs varient considérablement de celles jugées adéquates pour la plupart des autres aliments. Les animaux étant sujets à certaines affections qui les rendent impropres à la consommation humaine, non seulement la viande doit avoir une apparence normale mais encore faut-il qu'elle provienne d'animaux sains au moment de l'abattage et qu'elle soit produite dans des conditions qui assurent l'élimination du matériel non acceptable pour la consommation de même que la prévention de sa contamination et de son adultération. De là ce caractère particulier à l'hygiène des viandes.

1.1. Principaux éléments de l'hygiène des viandes

1.1.1. Examen ante-mortem des animaux destinés à l'abattage

Buts:
- Autoriser l'abattage des animaux sains.
- Prohiber l'abattage des animaux malades, s'il y a lieu les classer comme "retenus" (suspects) d'où une attention spéciale portée à l'examen post-mortem.
- Hâter l'abattage des animaux accidentés, etc. etc.

1.1.2. Examen post-mortem des animaux

Pour le dépistage des maladies et autres conditions indésirables des carcasses. Cette inspection permet également le contrôle des conditions sanitaires des opérations durant l'abattage et l'habillage (dressing) c'est-à-dire l'ensemble des opérations que subit la carcasse dans le but de préparer la viande.

1.1.3. Hygiène de l'environnement (Sanitation)

Cet élément intéresse d'abord les environs de l'établissement (cour, bâtiments destinés à abriter remporairement les animaux, etc.), puis l'établissement lui-même (situation, construction des divers locaux, eau, égout, équipement). La santé, l'hygiène du personnel et les facilités à sa disposition sont incluses dans cet élément.

Pendant longtemps, ces contrôles eurent comme objectif de garantir que les produits étaient propres à la consommation, que

1.1.3. (suite)

la disposition des déchets ne mettait pas en danger la santé publique et que les établissements ne gênaient en rien les habitants du voisinage. Les années récentes furent marquées par une nouvelle approche concernant la sécurité des travailleurs et aujourd'hui, la législation de nombreux pays se préoccupe de protéger les travailleurs contre les risques auxquels ils sont exposés dans les abattoirs. L'hygiène de l'environnement est précisément l'élément dans lequel s'est développé et sur lequel s'est greffé ce nouvel aspect. Il est inclus dans la " santé du travailleur ".

1.1.4. Disposition du matériel impropre à la consommation

Tout ce qui est condamné par l'inspecteur doit être détruit promptement ou utilisé à des fins jugées acceptables autres que la consommation humaine (fondoirs (rendering) tel Lomex Inc.) et cela sous la surveillance de l'autorité responsable (fédérale, provinciale, etc.).

1.1.5. Réinspection

En quittant le département de l'abattage, la viande ne fait que démarrer sur la voie qui la conduit au consommateur. Pendant tout son trajet, elle doit demeurer constamment sous observation (conditions salubres durant les transformations, l'entreposage, le transport, etc.).

1.1.6. Adultérations, falsifications, etc.

L'industrie de la viande est avant tout une entreprise commerciale, la tentation de substituer un ingrédient d'un produit carné par un autre moins dispendieux est à redouter. Il en va de même pour l'addition en excès de certaines substances de peu de valeur (eau, gras, produits farineux, etc.). La possibilité d'ajouter des ingrédients toxiques à la viande ou à ses produits n'est pas à rejeter. Il est évident que cette pratique altère sa qualité, voire son inocuité (C.E.C.O.). Il arrive que l'acheteur soit induit en erreur par une étiquette portant des indications fausses ou vagues, par l'apparence même du produit ou encore par le contenant dans lequel il est empaqueté (origine, identité, composition, qualité, quantité, etc.). Un contrôle rigoureux s'impose ici comme ailleurs si on veut assurer au consommateur la protection à laquelle il a droit.

1.1.7. Législation

La réalisation d'un programme d'hygiène des viandes n'est possible que moyennant une législation adéquate sur l'inspection des viandes et des produits carnés que complète une règlementation précise, facile d'application et conçue avec prévoyance.

On voit que le terme "Protection du consommateur" appliqué à l'identification des objectifs d'un programme d'hygiène des viandes doit avoir une signification qui englobe tous les aspects inclus dans l'intérêt que lui porte le consommateur. Si l'on s'en tenait au côté santé humaine seulement, le programme ne couvrirait qu'un secteur de son champ d'action et ne gagnerait certes pas la confiance et la faveur du public.

1.2. Organismes responsables de l'hygiène des viandes au Québec

1.2.1. Fédéraux

a) Ministère de l'agriculture: Direction de l'hygiène vétérinaire.

- Division de l'inspection des viandes*
- Division des laboratoires
- Division des maladies contagieuses

N.B. Contrôle plus de 90% des viandes sur le marché canadien. Proportion semblable au Québec.

*Loi et règlements sur "l'inspection des viandes " (Ch. 36, 1955) et sur l'abattage sans cruauté des animaux destinés à l'alimentation (Ch. 44, 1959).

b) Ministère de la santé et du bien-être social

- Directorat des aliments et drogues.
  (Loi des aliments et drogues)

1.2.2. Provincial

Ministère de l'agriculture: Division des produits carnés.

En voie de réorganisation.

Loi 43, Ch. 35 (règlements) 1977.

Abattoirs "plan A" avec inspection des viandes et "plan B" avec inspection sanitaire seulement (non des viandes). Il s'agit de petits abattoirs, 300 environ.

1.2.3. C.U.M. (Communauté urbaine de Montréal, etc.)

Service de l'assainissement de l'air et de l'inspection des aliments. Responsabilités limitées à son territoire.

Règlement No. 32, 1972, relatif aux aliments.

1.3. Les établissements

1.3.1. ABATTOIRS

Au sens légal du mot (loi fédérale) l'expression "ETABLISSEMENT" signifie un endroit dans lequel

- les animaux sont abattus
- la viande est trasnformée
- les volailles sont abattues, éviscérées ou préparées, et dont la production de l'avis du Ministre justifie la fourniture des services d'inspection du ministère sous le régime des présents règlements.

Au Québec, on distingue des établissements où l'on procède à l'abattage des animaux et où on transforme la viande de ces derniers. C'est le cas des établissements que nous visiterons demain et qui bénéficient du système fédéral:

Canada Packers: Animaux abattus: veaux, porcs, moutons.
Transformations: des plus variées.

Abattoir du Nord: Animaux abattus: Boeuf
Transformations: plus limitées.

D'autres établissements ne procèdent qu'à l'une ou l'autre de ces deux grandes opérations. De plus, il y a des abattoirs spéciaux pour les équidés de même que pour la volaille. Enfin il existe aussi une catégorie spéciale d'abattoirs " clos d'équarissage" . On y tue et transforme la carcasse des animaux dont la viande n'est pas destinée à la consommation humaine mais à la préparation d'aliments pour chiens, chats ou d'autres produits.

1.3.2. Types d'abattoirs

C'est par leurs dimensions et leur capacité de production que se distinguent les abattoirs. Les installations modestes se rencontrent surtout dans les zones rurales ou les petites agglomérations. Trop souvent, les bâtiments sont délabrés et les installations primitives, les conditions sanitaires déplorables, faute de traitement des résidus solides et liquides qui s'y accumulent, dégageant une odeur repoussante qui attire

les rongeurs et les mouches. Au Québec on compte actuellement plus de 300 petits abattoirs qui sont soumis à 1 ou 2 inspections sanitaires par mois, la viande en provenant n'étant pas inspectée. En général le personnel y est très restreint.

Les grands abattoirs sont généralement situés dans les villes et les régions urbanisées où ils sont soumis à une règlementation stricte qui les place sous la surveillance de l'autorité municipale et dans plusieurs cas (Montréal) d'un ou plusieurs ministères. Dans ces établissements le travail est beaucoup plus spécialisé, c'est la chaîne de production ou chaque travailleur n'exécute qu'une seule opération. On tend de plus en plus à rationaliser et à automatiser le travail des abattoirs.

1.3.3. Types de bâtiments

Plusieurs règlementations fixent en détail les caractéristiques des établissements.

Elles concernent:

a) le site de l'établissement
b) les enclos et s'il y a lieu les bâtiments de réception et d'attente des animaux vivants
c) la construction elle-même de l'abattoir
   - particularités des divers locaux, leur agencement
   - les matériaux utilisés (plancher, murs, plafond, etc.
   - l'alimentation en eau potable
   - la disposition des eaux usées, des produits non comestibles
   - l'éclairage naturel, artificiel
   - la ventilation, le chauffage, etc.
   - les commodités (sanitaires) à la disposition des travailleurs
   - l'appareillage et l'équipement nécessaires à la bonne conduite des opérations
   - la construction et la capacité des chambres de réfrigération (34° à 36° F ou 1.1° à 2.2° C) etc. etc..

Certaines normes (dites générales) sont applicables à tous les établissements, d'autres sont particulières aux abattoirs de bétail, de volaille, aux salles de transformations, etc.

En somme l'établissement doit être construit, aménagé et équipé selon les règles de l'art et de l'hygiène pour assurer des conditions d'hygiène et de sécurité irréprochables. La tendance actuelle est aux abattoirs sans étage. Les anciens abattoirs étaient le plus souvent des édifices à plusieurs étages, l'abattage étant pratiqué au niveau le plus élevé et les autres opérations exécutées aux étages inférieures (fonctionnement par gravité).

1.4 Techniques d'abattage et d'habillage

L'abattage ou la mise à mort des animaux de boucherie doit être effectué suivant une méthode rationnelle et humaine l L'opération doit être facile à réaliser et ne présentera pas de risques de danger pour le travailleur. Tout en étant économique, la méthode visera à atténuer au maximum les souffrances de l'animal. Le sang étant particulièrement réceptif à la contamination, les microorganismes sont beaucoup plus aptes à pénétrer et à se multiplier avec rapidité dans un tissu gorgé de sang. Une bonne technique d'abattage visera donc une saignée aussi parfaite que possible de l'animal (72% à 75% du sang éliminé.).

1.4.1. Méthodes d'abattage

1.4.1.1. Abattage sans étourdissement préalable à la saignée de l'animal (Shechita, Kosher):
- l'animal est tout simplement saigné dans la caisse d'abattage, selon le rite israélite ou musulman.

1.4.1.2. Abattage avec étourdissement de l'animal avant la saignée:
- l'animal est rendu inconscient
  - masse (usage interdit dans les grands abattoirs)
  - maillet (veaux etc.)
  - pistolet à percuteur (projectile captif)
  - appareil électrique
  - gaz carbonique (air + 55% de CO_2)

1.4.1.3. Abattage par énervation: Stylet plongé entre l'occipital et la première vertèbre cervicale. Le bulbe rachidien est touché, l'animal s'effondre sur le coup.

1.4.2. Technique de l'habillage et de l'inspection post-mortem

L'habillage est l'ensemble des opérations que subit la carcasse dans le but de préparer la viande.

1.4.2.1. BOEUF

- Etourdissement (suivant le cas)
- Saignée (une fois suspendue à un monorail quand l'animal a été étourdi).
- Tête détachée de la carcasse, identifiée, lavée et préparée pour l'inspection.
  Examen: propreté, anomalies, incisions répétées des ganglions lymphatiques, des masséters, examen de la langue (palpation, etc.) La tête est retenue jusqu'à ce que l'inspection de la carcasse correspondante soit terminée

- Eviscération, inspection des viscères
- La peau est enlevée mécaniquement de la carcasse et dirigée à la salle de traitement des cuirs.
- Section longitudinale de la carcasse (scie mécanique) et mise en forme (scribing).

Inspection de la carcasse (Rail inspection position)

-Examen des surfaces (propreté etc.) -palpation des ganglions lymphatiques superficiels (préscapulaires, précruraux, inguinaux superfisiels etc.), reins, cavité pelvienne, etc.

C'est l'inspection dite de routine.

Dans le cas des animaux classés "retenus" à l'antémortem et des reacteurs à la tuberculine, la carcasse est dirigée sur un monorail d'évitement où l'on procède à un examen plus complet (ganglions superficiels et profonds incisés, etc. etc.).

Les animaux positifs à la brucellose sont groupés et abattus à la fin de chaque période d'abattage ce qui facilite leur identification et par conséquent la prévention. Ils sont soumis à l'examen de routine avec les précautions qui s'imposent.

- Les carcasses normales sont lavées, estampillées (coupes de gros) et recouvertes d'un drap humide. Mise en chambre froide (34° à 38° F,1.1 à 3.3°C) N.B. La viande gèle à 29.5° F.

1.4.2.2. VEAUX

- Etourdissement (ou non)
- Saignée (sur le rail)
- Habillage avec ou sans la peau. Identification.
- Tête enlevée et inspectée.
- Lavage de la carcasse.
- Eviscération. Examen de la carcasse et des viscères
- Lavage final et mise en chambre froide.

N.B. La vente de veaux immatures est défendue. Leur viande contient trop d'eau, trop d'os, a peu de valeur calorifique et un goût fade. La Loi prévoit 3 semaines d'âge et un développement satisfaisant de la carcasse.

1.4.2.3. PORCS

- Etourdissement (électricité, CO_2, etc.)
- Saignée sur le rail.
- Echaudage (59° à 63° C) (138° à 145° F)

Cuve vidée quotidiennement, bien lavée. Plus souvent si nécessaire.

Epilation mécanique, poils restant brulés, douche, rasage final au besoin.

1.4.2.3. (suite)

Inspection: Propreté générale, anomalies, etc.
Tête: incisions des ganglions sous-maxillaires

- Eviscération: Rectum dégagé, ligaturé, ouverture ventrale de la carcasse.

Inspection des viscères, de la carcasse sur le rail.
- Estampillage et mise en chambre froide.

1.4.2.4. MOUTON

- Etourdissement ou non.
- Saignée
- Peau enlevée avec beaucoup de précautions (laine colle)
- Eviscération
- Inspection des viscères, de la carcasse sur le rail
- Lavage final, tête détachée de la carcasse.

Durant les opérations, les parties destinées à la consommation sont acheminées vers les chambres de réfrigération ou les départements où elles doivent subir des transformations. Les produits non consommables sont évacués vers le service destiné à leur traitement, section qui doit être totalement séparée des autres services de l'abattoir.

1.5. Risques pour le travailleur

1.5.1. Le MICROCLIMAT

Les abattoirs sont des locaux très humides où la température varie fortement d'un endroit à l'autre. Ces conditions résultent de l'utilisation de la vapeur dans plusieurs opérations et des grandes quantités d'eau froide et chaude déversées sur les planchers. Dans la salle d'abattage il fait généralement très chaud alors qu'à l'autre extrême on a les chambres froides (0 à 5° C). Dans les salles de grandes dimensions et le plus souvent sans cloisons l'air est très turbulent d'où plusieurs zones de travail présentent les unes par rapport aux autres des différences de température importantes. Une odeur caractéristiques règne dans les abattoirs (sang, vomissures, viscères, urine, excréments d'animaux, etc.). Elle peut envahir tout l'établissement et se répandre aux environs si des mesures pour la réduire ne sont pas prises. L'élimination rapide des résidus et des déchets, leur entreposage dans des conditions convenables de même qu'un système de ventilation adéquat et la propreté des locaux contribuent à l'amélioration du microclimat.

1.5.2. Les ACCIDENTS

1.5.2.1. Blessures causées par un animal, dans la cour, les locaux d'attente, durant le trajet de ces endroits à la salle d'abattage, au moment ou peu après l'étourdissement, lorsque la carcasse est hissée sur le monorail. Le travailleur y est fréquemment exposé.

1.5.2.2. Abrasions et coupures, au mains, au corps, par les couteaux et autres instruments tranchants utilisés, les scies mécaniques, etc. Ces blessures sont les plus fréquemment rencontrées.

1.5.2.3. Blessures oculaires: par des esquilles projetées lors du débitage des os.

1.5.2.4. Lombalgies, dues aux efforts faits pour soulever ou porter les demi-carcasses, les coupes de gros, etc.

1.5.2.5. Chutes: Les planchers rendus glissants par le sang, la graisse, l'eau répandue et parfois les déchets qui les jonchent s'y prêtent trop souvent admirablement.

1.5.2.6. Brûlures, échaudures, là où l'on emploi de la vapeur (conduites) ou encore des cuves chauffées à la vapeur; où on procède à la fonte des graisses, etc.

1.5.2.7. Accidents résultants d'un système électrique défectueux (isolation défectueuse, etc.)

1.5.3. Les ZOONOSES

En dépit du grand nombre d'animaux abattus et conséquemment de carcasses habillées, les cas de zoonoses semblent plutôt rares. Je dis semble parce qu'à mon avis la déclaration des cas fait trop souvent défaut.

a) Brucellose

Serait la plus courante dans les pays où le cheptel est affecté. Au Canada on procède présentement à l'éradication de cette maladie. Trois cas de fièvre ondulante furent déclarés en 1977 or il semble qu'il y en ait eu une quinzaine dans un seul abattoir. Les réacteurs sont identifiés et abattus à la fin de chaque période d'abattage ce qui facilite la prévention.

b) Tuberculose

Risque grave dans certains pays.
Au Canada: éradication.
Les animaux âgés sont les plus souvent atteints (vaches).

c) Ornithose

Risque dans les abattoirs de volaille, principalement à la réception des oiseaux (poussières contaminées, etc.). Le travailleur contracte la maladie à partir des oiseaux vivants malades plutôt que de leur carcasse.

d) Pasteurellose (Tularémie)

Rare dans les abattoirs.
Se transmet surtout à la faveur d'une blessure de la peau ou par la piqûre d'un tique. C'est plus souvent le cas d'un chasseur qui dépouille un lapin ou un chevreuil.

e) Leptospirose

Rare dans les grands abattoirs.
Chez des bouchers,on a identifié des infections à L. ictérohaemorrhagiae probablement contractées lors de la manipulation de viandes ou d'abats contaminés par des rats.

f) Erysipéloide (Rouget du porc)

Occasionnelle.
Par blessure de la peau (porcs, dindons).

g) Fièvre charbonneuse (Charbon)

Très rare au Canada et au Québec, et on peut dire absente dans les grands abattoirs.
Dans les pays où l'incidence de la maladie chez les animaux est plus élevée, les ouvriers des petits abattoirs y sont plus exposés que ceux des grands établissements. L'évolution de la maladie étant très rapide, les animaux affectés n'atteignent pas ces établissements.

h) Fièvre Q ("query fever") Fièvre de Queensland.

Quelques cas furent rapportés au Québec chez des ouvriers d'abattoirs (voie aérienne).

En fait si l'on donne au terme "manipulations" une signification suffisamment large, il est possible de classer un grand nombre de zoonoses parmi les maladies susceptibles d'être transmises à l'homme par les viandes. Lors des opérations d'abattage, d'habillage ou d'apprêt des animaux pour la table, les microorganismes infectieux ont toutes sortes de possibilités pour se transmettre à l'homme par des voies autres que le tube gastro-intestinal, notamment par l'arbre respiratoire (gouttelettes, poussières infectées) ou par la peau (inoculation directe, piqûre d'insecte, etc.). Il nous semble que les infections professionnelles contractées par les manipulateurs de viande doivent être incluses dans une étude des maladies transmises par les viandes, sans égard pour la voie de transmission.

1.5.4. AUTRES conditions pathologiques

a) Le catharre chronique, la sinusite et la bronchite sont très fréquents.

b) Dermatoses fréquentes.

c) Pemphigus des bouchers. Rare dans les grands abattoirs.

d) Folliculite: Occasionnelle chez les travailleurs exposés à la grande chaleur.

1.5.5. PREVENTION PRIMAIRE

1.5.5.1. Prévention des accidents

a) Planchers bien drainés, exempts d'eau, propres (absence de déchets, etc.). Utilisation de sable, de sels calcaires sur le plancher pour qu'il ne soit pas glissant, là où ça s'impose (salle d'abattage, etc.).

b) Manutention des charges lourdes par des moyens mécaniques.

c) Installations électriques conformes aux normes prévues par la règlementation.

d) Durant la découpe de la viande, la main qui ne tient pas le couteau doit être protégée au moyen d'un gantelet en mailles d'acier.

e) Couteaux munis d'une garde, rangés dans des étuis.

f) Personnel convenablement formé à l'utilisation des instruments tranchants qui conviennent à chaque opération et instruit de leur aiguisage et leur entretien.

g) Toutes les scies mécaniques utilisées doivent être pourvues du type de protecteur adéquat. L'ouvrier doit connaître à fond les méthodes qui permettent leur utilisation sans risque.

h) Protection adéquate de la machinerie employée (hachoir, échaudoirs, machine à dépiler les porcs, etc. etc.).

1.5.5.2. Vêtements de protection

a) Tous les travailleurs devraient porter des combinaisons et des couvre-chefs appropriés. Casque de sécurité pour le personnel exposé (salle d'abattage, etc.)

b) Protection de la face et des yeux chaque fois que nécessaire (débitage des os à la scie, traitement des cuirs par les acides, etc.).

c) Les bouchers qui désossent à la main en tirant le couteau vers eux porteront un tablier abdominal spécial (cuir très épais, cuir renforcé de mailles d'acier, matière plastique très épaisse et souple.

1.5.5.3. Hygiène

Dans l'abattoir, l'hygiène et la propreté doivent atteindre un niveau qui satisfait tant aux conditions sévères que doit remplir la viande pour être reconnue propre à la consommation qu'au point de vue protection des travailleurs.

1.5.5.3. (suite)

a) Parois intérieures faciles à laver. Le revêtement des planchers doit être imputrescible, résistant au sang, à l'eau, au dégats mécaniques, et antidérapant.
Le lavage au jet des planchers et des murs avec de l'eau sous pression doit être fait à la fin du travail, (entrecoupé de lavages intermédiaires chaque fois que nécessaire).
Il faut utiliser de l'eau chaude là où il y a des dépôts graisseux (salle d'abattage, etc.).
L'addition d'un désinfectant à l'eau est recommandé périodiquement.

b) Evacuation des déchets et des eaux usées suivant une méthode sanitaire (mini-usine d'épuration, etc.).

1.5.5.4. Installations sanitaires et services sociaux

Le caractère exceptionnellement salissant des travaux exécutés dans les abattoirs exige des installations sanitaires de premier ordre.
- Lavabos à pédale, eau chaude, froide, distributeur de savon liquide, serviettes individuelles, en nombre suffisant.
- Douches - Cabinets de toilette bien ventilés, séparés des locaux destinés aux opérations - vestiaire - etc.

- Réfectoire en dehors de la zone de travail (interdiction de boire, fumer ou mangersur les lieux de travail.

1.5.5.5. Services médicaux

- Examen médicaux d'embauchage et périodiques obligatoires pour tous les travailleurs.
- Médecin chargé de visiter fréquemment l'abattoir, infirmière plein-temps, etc.

N.B. Faute d'une infirmière chargée d'administrer les premier soins, il est indispensable que des travailleurs aient reçu une bonne formation de secouriste. C'est surtout le cas des petits abattoirs.

1.5.5.6. Législation

Aujourd'hui, presque tous les pays ont une règlementation détaillée des abattoirs, soit au titre de la santé communautaire ou plus précisément celui de la salubrité des aliments. Très souvent, les dispositions de sécurité et d'hygiène du code du travail s'appliquent aussi aux abattoirs. Le trafic international des viandes est important

1.5.5.6. (suite)

et les abattoirs d'un pays exportateur sont parfois sous la surveillance d'un expert des services du pays importateur qui veille à ce que les normes exigées par son pays soient respectées (France - Canada).

Dans la plupart des pays, la règlementation des abattoirs touche tous les aspects des travaux exécutés et s'accompagne de contrôles très stricts. En général les établissements sont déclarés et enregistrés sous licence.

1.5.5.7. L'éducation sanitaire des travailleurs

Comme dans beaucoup d'autres secteurs de l'industrie (et aussi le grand public) l'éducation sanitaire des travailleurs d'abattoirs reste à faire. C'est un aspect essentiel à la réussite d'un programme d'hygiène industrielle ou de médecine du travail. On doit viser non seulement à informer le travailleur mais aussi à influer sur son comportement de manière à ce qu'une fois instruit il approuve les recommandations qui lui sont faites et agisse de façon a jouir d'une protection maximale.

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Infections Due to *Erysipelothrix*

Infections caused by the gram-positive bacillus *Erysipelothrix insidiosa* (also called *E. rhusiopathiae*) consist of a distinctive skin lesion (erysipeloid) and, in rare cases, endocarditis. The etiologic agent morphologically resembles *L. monocytogenes* and diphtheroids.

EPIDEMIOLOGY AND PATHOGENESIS

E. insidiosa is not a member of the commensal flora of humans. Natural infections occur in mammals such as swine, cattle, and sheep and in domestic fowl. The organism has also been isolated in fish and shellfish.[68] Human infections have been observed among agricultural workers, slaughterhouse workers, fish handlers and fishermen, kitchen workers, and veterinarians. Most infections attributable to *E. insidiosa* occur in the summer and early fall. Infection results when the organism enters through an abrasion while the individual is handling contaminated animals or organic materials.

MANIFESTATIONS

Erysipeloid

The erysipeloid lesion, which is characteristically painful, raised, and violaceous, develops two to seven days after injury. It usually appears on a finger or on the hand.[69] The margin of the lesion is sharply defined and tends to spread peripherally at a slow pace as the central portion fades. Swelling and stiffness of adjacent joints may occur. Occasionally, vesicles containing serosanguineous fluid are present in the area of spreading inflammation. Neither suppuration nor desquamation occurs. Usually, there is no fever or systemic symptoms. Lymphangitis and lymphadenitis are uncommon.

Septicemia and Endocarditis

Septicemia and endocarditis are very uncommon. In one study, for example, no cases were observed among 500 patients with erysipeloid.[69] Endocarditis has occurred on both deformed and normal heart valves, and the clinical course may be acute or subacute; most often, the aortic valve is involved.[70] About 40 percent of patients with *Erysipelothrix* endocarditis have erysipeloid of the hand. Septic shock is rare.[71]

DIAGNOSIS

The clinical features and the proper epidemiological setting provide the provisional diagnosis. Erysipeloid must be distinguished from erysipelas; the latter usually is more erythematous and progresses much faster. Culture of the erysipeloid lesion surface or of a simple aspirate generally does not yield *E. insidiosa*, but culture of a small skin punch biopsy taken from the advancing edge of the lesion will often reveal the organism. A morphologically similar lesion of unknown etiology termed seal finger has been described among aquarium workers.[72]

TREATMENT

Usually, erysipeloid is self-limited and resolves in about three weeks. Treatment with 600,000 units I.M. of procaine penicillin G daily for seven days or one injection of 1.2 million units I.M. of benzathine penicillin G will produce improvement in 48 hours. In contrast, seal finger responds best to tetracycline.[72] In the penicillin-allergic patient, 0.25 to 0.50 g of erythromycin given orally four times daily for seven days is a satisfactory alternative.

Treatment of *Erysipelothrix* endocarditis with six to 20 million units I.V. of penicillin G daily for four to six weeks has been generally successful.

Source: SIMON, H.B., "Infections due to Erysipelothrix", Scientific American Medicine, chap. 7, (IV), p.8, (1991).

listériose

+ retrait préventif prouvé { avortement spontané, ménengite de naissance pour bébé mort né

6 - LISTERIOSE

La bactérie Listeria monocytogenes peut se retrouver dans des produits laitiers, les végétaux, les poissons et les produits de la viande. Elle croît bien dans la nourriture réfrigérée et est plus résistante à la chaleur que la plupart des bactéries. Les personnes les plus à risque sont les immunodéprimés, les femmes enceintes et leur foetus. La méningite, l'avortement spontané et la septicémie sont les manifestations primaires de la maladie.

La transmission au foetus survient dans la deuxième moitié de la grossesse par voie systémique ou par aspiration de liquide amniotique. L'infection peut se contracter en période périnatale.

La listériose se contracte par l'ingestion et il semble que les contaminations au Canada auraient été le plus souvent occupationnelles ou environnementales. Selon Schlech il y aurait 5% de porteurs dans la population générale. On a aussi rapporté que 29% des travailleurs de la volaille et 77% des travailleurs de laboratoire de santé portaient dans leurs selles le L. monocytogenes.

Les sources sont variées : ensilage de mauvaise qualité, végétation, sol, rivières, vase, déchet d'abattoir, lait de vaches normales ou infectées et excréments humains. L'organisme a aussi été isolé chez une grande variété d'animaux.

Surveillance environnementale et médicale

La surveillance de cet agent infectieux n'est pas encore généralisée pour la population. Dans les milieux de travail à risque, des prélèvements et des cultures devront être faits au besoin. Les décisions pour le retrait préventif de la travailleuse enceinte ou qui allaite devront être basées sur ces évaluations si on désire retirer la travailleuse avec preuve à l'appui.

Listériose

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* Articles joints

Current Review

Listeria monocytogenes: a foodborne pathogen

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Listeriosis, caused by *Listeria monocytogenes*, appears to be increasing in incidence worldwide. The disease is of great concern to the food industry. A recent outbreak in California was linked to the consumption of Mexican-style soft cheese and involved more than 300 cases, 30% of which were fatal. *L. monocytogenes* can be found in a variety of dairy products, leafy vegetables, fish and meat products. It can grow in refrigerated foods and is more heat resistant than most vegetative microbes. The epidemiologic features of listeriosis are poorly understood, and the minimum infectious dose is unknown. Those predisposed to listeriosis include immunocompromised people and pregnant women and their fetuses. Meningitis, spontaneous abortion and septicemia are the primary manifestations of the disease. Early recognition is critical for successful treatment, and ampicillin is the preferred drug. Listeriosis should be considered in any febrile patient with neurologic symptoms of unknown origin, as well as in women with unexplained recurrent miscarriages, premature labour or fetal death. A food source should be the prime suspect if any isolated case or outbreak occurs.

La fréquence des infections à *Listeria monocytogenes* est en augmentation apparente dans le monde entier et inquiète fort l'industrie alimentaire. Une épidémie récente en Californie, de plus de 300 cas dont 30% mortels, était reliée à l'ingestion d'un fromage à pâte molle de type mexicain. Ce microbe se trouve dans nombre de produits laitiers, de légumes dont on consomme les feuilles, de poissons et de viandes. Il peut se multiplier sous réfrigération et se montre plus résistant à la chaleur que la plupart des microbes végétatifs. Les caractéristiques épidémiologiques des listérioses sont mal comprises; la dose infectieuse minimale n'a pas été déterminée. Sont prédisposés à la listériose les sujets immunocompromis et les gestantes et leurs foetus. Elle se manifeste surtout par des méningites, des fausses-couches et des septicémies. Le diagnostic précoce est de première importance pour le succès du traitement, qui se fait de préférence par l'ampicilline. Il faut penser à une listériose devant tout malade fiévreux qui présente des symptômes neurologiques de cause inconnue et chez toute femme accusant des fausses-couches, des naissances prématurées ou des morts-nés à répétition et inexpliqués. Que le cas soit isolé ou qu'il s'agisse d'une épidémie, il faut chercher surtout du côté d'une contamination alimentaire.

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At least four outbreaks of listeriosis have been associated with food within the last 7 years.[1-4] *Listeria monocytogenes*, first identified in 1926, by Murray and associates,[5] has suddenly emerged as a significant pathogen that can be found in a variety of foods. These outbreaks and the recorded incidence rates among humans probably represent only a small proportion of the actual cases. This review should stimulate attempts in Canada to link the diagnosed cases of listeriosis with the consumption of specific contaminated foods.

Historical review

The first confirmed case of *L. monocytogenes* infection in Canada was reported in 1951 in a pregnant woman who had been in the country for 1 year after emigrating from Russia.[6,7] Since then reported cases in Canada have been sporadic except for an outbreak of 41 cases in Nova Scotia

in 1981.[4] A total of 381 cases have now been documented in Canada (Laboratory Centre for Disease Control [LCDC], Department of National Health and Welfare, Ottawa: unpublished data).[6-8] Infections are reported throughout the year but occur more frequently in the summer. Some reports have suggested an increased incidence rate among people who are immunocompromised,[8] but the findings have been inconclusive.

Except for the outbreak in Nova Scotia, which involved contaminated raw cabbage, food consumption has not been implicated as a possible mode of transmission in Canada. Given the ubiquitous nature of the organism, environmental or occupational exposure is usually the source of infection. Between 1971 and 1984, 28 deaths were attributed to listeriosis, 7 being reported in 1984 (LCDC: unpublished data). There was a slight increase in the number of cases between 1982 and 1984, but this may have been due to the Nova Scotia outbreak and not a real increase in incidence. Data on the population at risk are unavailable; therefore, risk-specific attack rates cannot yet be calculated.

The studies of Schlech and colleagues[4] have suggested that *L. monocytogenes* is carried by 5% of the general population. Fecal carriage has been reported in 29% of poultry workers and in 77% of public health laboratory workers involved in *L. monocytogenes* isolation.[9] The public health importance of human fecal carriage is not known.

Biologic features

L. monocytogenes is a gram-positive, microaerophilic, asporogenic bacillus that has a characteristic tumbling motility between 20°C and 25°C and that produces slight β-hemolysis on sheep-blood agar. It can grow at a variety of temperatures, from 1°C to 45°C,[10] and thus can thrive in foods kept at refrigeration temperatures.

In the laboratory *Listeria* can frequently be missed or misidentified.[11,12] One must be careful not to overlook *Listeria* as a contaminating organism, especially when symptoms and conditions suggest listeriosis. The characteristics that distinguish *Listeria* from other morphologically similar organisms are listed in Table I.

There are 16 recognized serotypes,[10,13] given that there are at least 15 different "O" (or somatic) antigens and 5 "H" (or flagellar) antigens. Serotypes 1/2a, 1/2b and 4b account for more than 90% of the cases reported worldwide.[14]

A phage-typing system has helped in the epidemiologic investigations of foodborne outbreaks of listeriosis. The major system now used allows identification of 54% of the serogroup 1/2 strains and 77% of the serogroup 4 strains of *L. monocytogenes*.[15] However, a recent report has suggested that the phage type of a given *Listeria* strain can change with time.[16] Thus, the current phage-typing system must be modified, or an alternative to phage-typing must be developed. Several researchers at the Centers for Disease Control (CDC), Atlanta, are investigating a method that involves isoenzymes to differentiate the strains.

Source

L. monocytogenes can be isolated from a variety of sources: poor-quality silage, vegetation, soil, sewage, stream water, mud, slaughter-house waste, milk of normal and mastitic cows, and feces of healthy humans. In addition, the organism has been isolated from at least 37 species of mammals and 17 species of fowl, flies, ticks, fish and crustaceans.[10,14]

Pathogenicity

The tests for pathogenicity include the ability to cause keratoconjunctivitis in guinea pigs (Anton's test), toxicity in chick embryos and death in mice.[17]

Virulence factors

Many potential virulence factors have been identified in the literature; these may or may not be important to the overall pathogenicity of *L. monocytogenes*.[18] The more important factors appear to be a monocytosis-producing agent,[5,19] a lipopolysaccharide-like material,[20-23] hemoly-

Table I — Characteristics of *Listeria monocytogenes* and morphologically similar microorganisms

Organism	Morphologic features	Characteristic: Motility (at 22°C)	Hemolysis	Catalase production	Salicin fermentation	Trehalose fermentation
L. monocytogenes	Coccoid, rods	+	β	+	+	+
Erysipelothrix rhusiopathiae	Slender rods	−	α	−	−	−
Lactobacillus	Rods	−	α	−	+	+
Corynebacterium	Rods	+/−	−	+	+	+
Kurthia	Pleomorphic filamentous	+	−	+	−	+
Streptococcus	Cocci	+/−	+/−	−	+/−	+/−

sin(s)[24-26] and oxygen species such as hydrogen peroxide and superoxide.[27,28]

Heat resistance

An early study by Bearns and Girard[29] showed that *L. monocytogenes* may be able to survive pasteurization if present in fresh milk at concentrations of more than 5×10^4 organisms/ml. More recent studies have shown that the organism can survive the heat associated with the spray-drying of skim milk and the manufacturing of cottage cheese.[30,31] Conversely, Bradshaw and collaborators[32] and one of us (J.M.F.: unpublished data, 1987) found that *L. monocytogenes* could not withstand pasteurizing temperatures.

The organism may be able to survive pasteurization because it resides within leukocytes, which apparently provide some form of protection. To test this hypothesis, the milk from cows inoculated with *Listeria* was subjected to pasteurizing temperatures;[33] *Listeria* was found to survive pasteurization in some instances, but how closely the experiments resembled natural conditions is unknown. Studies of the milk from cows that are naturally infected with *L. monocytogenes* are under way at the Health Protection Branch.

Outbreaks of foodborne infection

A large outbreak in Halle, East Germany, between 1949 and 1957 was linked to the consumption of unpasteurized milk (sour milk, creams and cottage cheese were also considered possible sources);[34] this appears to be one of the first documented reports of listeriosis linked to food consumption.

From 1979 to 1985 four food-associated outbreaks were reported in North America (Table II). Of the 23 patients described by Ho and coworkers[3] 5 died; however, only 2 died from listeriosis. Interestingly, the use of antacids was found to be a risk factor for listeriosis; the neutralization of gastric acids may play an important role in the initial survival of the organism after ingestion.

The cabbage responsible for the outbreak in the Maritimes in 1981[4] had been grown in fields fertilized with compost and raw manure from a flock of sheep known to have had listeriosis.

Table II — Documented outbreaks of listeriosis associated with food in North America

Location, year	Food	No. of cases (and deaths)
Boston, 1979[3]	Lettuce, celery tomatoes	23 (5)
Nova Scotia, 1981[4]	Coleslaw	41 (18)
Massachusetts, 1983[2]	Pasteurized milk	49 (14)
California, 1985[1]	Mexican-style soft cheese	314 (105)

In the outbreak linked to pasteurized milk in Massachusetts in 1983[2] the milk in the bulk tank of one of the farms supplying the incriminated processing plant contained *L. monocytogenes* serotype 4b, which was also identified in 32 of the 40 isolates from cases.

In the spring of 1985 there was a large outbreak of listeriosis centred in California that was linked to the consumption of a Mexican-style soft cheese produced by a company in California.[1] Investigation of the manufacturing plant revealed that some of the raw milk might not have been pasteurized. It was extremely fortunate that most of the cases involved mothers and their infants who presented to the same hospital; otherwise, the outbreak might have been missed.

All four of the food-related outbreaks in North America were caused by *L. monocytogenes* serotype 4b; this serotype may therefore be more pathogenic than the others.[3]

Food surveys

The California outbreak in 1985 prompted surveys of various cheeses sold in the United States and Canada. *L. monocytogenes* was detected in soft and semisoft cheeses from two manufacturers in the United States, one manufacturer in Canada and four plants in France.[35,36] In addition, recent surveys of dairy products in the United States have resulted in recalls of certain ice creams, sherbets, chocolate milk and ice-milk products.[37,38] The Health Protection Branch failed to identify any contaminated cheese produced in Canada; however, two brands of semisoft cheese from France were found to be contamined with *L. monocytogenes* (J.M.F.: unpublished data, 1986).

Listeria has now been found in raw and possibly pasteurized milk,[2,39] cheeses,[35,36] ice cream, sherbet, chocolate milk and ice-milk products,[37,38] leafy vegetables,[3,4] fish,[14] raw meats and chicken,[18] and fermented sausage.[40]

Listeriosis in humans

People predisposed to *Listeria* infection include pregnant women and their fetuses, newborns, recipients of immunosuppressive or corticosteroid therapy, those with underlying diseases such as cancer, hepatitis and alcoholism, and those undergoing long-term hemodialysis.[41] Neonatal listeriosis accounts for the largest recognized group of infections due to *L. monocytogenes*.[42]

The primary manifestations of listeriosis include meningitis, spontaneous abortion and septicemia. Peritonitis, local abscess formation, endocarditis, urethritis, endophthalmitis, conjunctivitis, hepatitis, arthritis and cutaneous lesions have also been reported.[14,41,43,44]

Pregnant women with listeriosis present with a mild illness that resembles influenza. The fetus is

usually aborted spontaneously if it is infected during the first trimester; if infection occurs later in the pregnancy the fetus may be stillborn or the newborn baby acutely ill. In neonatal listeriosis two distinct clinical syndromes are usually present. An early-onset syndrome, which is primarily septicemic, is associated with low birthweight, and is characterized by increased neonatal mortality rates (30%) and a higher frequency of reported obstetric complications. The late-onset or meningitic form of the disease occurs in infants of normal birthweight and is characterized by a low death rate (10%) and no obstetric complications.[42]

CDC has now classified listeriosis as a reportable disease; LCDC is trying to follow suit. Available data indicate that *L. monocytogenes* is infrequently identified as a human pathogen. Most infections are probably asymptomatic and develop in vaginal, cervical or intestinal tissues.[6] The incidence rate is increasing worldwide,[18,41,45] possibly because of the increased awareness of the disease, the frequency of organ transplantation, the increasing number of cancer patients and the increasing size of the elderly population.

Although there is no general agreement on the best therapy for listeriosis, ampicillin, with or without an aminoglycoside, is still recommended.[46] Trimethoprim–sulfamethoxazole was found to be effective in controlling meningitis due to *L. monocytogenes*.[47]

Immune response

Protection against listeriosis clearly seems to rely on cellular rather than humoral immunity.[48] In mice resistance against infection is regulated genetically and can be divided into three phases.[49] The first phase depends on the presence of fixed or resident macrophages in the tissue. Studies have shown that the macrophages will destroy about 90% of the organisms that are present initially; the remaining bacteria grow logarithmically within susceptible macrophages in the liver and the spleen, maximal numbers being reached 48 to 72 hours after the initial exposure.[50]

The second phase of resistance in mice involves the accumulation of monocyte-derived inflammatory macrophages. There is a prompt influx of these cells, which are able to control the rapid bacterial growth. Susceptible mice have a shortage of these macrophages at the site of infection. The inflammatory response seems to be triggered by the listerial resistance gene.[51]

The third phase of resistance results in the elimination of the organism and depends on the accumulation of immunologically activated macrophages.[52,53]

Serologic tests

Although a number of tests have been described for the serologic diagnosis of listeriosis, the agglutination assay remains the standard method of detecting antibodies to *L. monocytogenes*.[54-56]

The use of serologic tests for diagnosing *Listeria* infections seems to be of limited value, however. Newborns and immunocompromised people may not show an increased antibody titre. *L. monocytogenes* antigens will cross-react with the antigens of other gram-positive bacteria[57,58] (most notably *Staphylococcus aureus* and *Streptococcus faecalis*); therefore, even patients with no previous exposure to *Listeria* may have a substantial *Listeria* agglutination titre. There appears to be no change in the antibody production from IgG to IgM during the course of infection; therefore, IgM cannot be used as an indicator of recent infection.[56]

Detection of *Listeria* in foods

There is no acceptable method being used to isolate *Listeria* from foods, although several promising new methods have been described.[39,59-62] The cold enrichment procedure,[63] in which samples are kept at 4°C and subcultured weekly for up to 6 months, still appears to be the most sensitive method. However, a more rapid and sensitive test must be developed to detect *Listeria* in foods.

Surveillance in Canada

Listeriosis is a notifiable disease in only two provinces, neither of which has to report the cases to LCDC. However, contact between federal and provincial laboratories is constant, so that recording of confirmed cases is probably good. Less severe illness possibly goes undiagnosed, and early termination of pregnancy without fetal sepsis, or unsuspected cases ending in stillbirth, do occur. The difficulty in identification and the lack of specificity of the serologic tests have resulted in an incomplete epidemiologic picture of listeriosis in Canada.

A surveillance program for *L. monocytogenes* infection in Canada is being planned by the Department of National Health and Welfare to determine the public health importance of food contamination. A specific objective is to identify infected patients and their surrounding controls by variables that may lead to an elaboration of important links between infection and specific foods. A reference laboratory will be established to assist with identification of the organism and with subtyping (serotyping, phage typing and isoenzyme typing) for epidemiologic purposes.

Overview

Even though the source of most *Listeria* infections is unknown, the evidence of foodborne transmission in humans is now quite convincing.

The organisms' chances of survival increase if the gastric acidity is reduced because of antacids or if the food provides some protection against the gastric acid.[3,64] Once in the intestine the bacteria possibly are taken up by M cells (membranous epithelial cells) and transported to the underlying lymphoid tissue, where they are destroyed by monocytes.[65,66] The ability of an organism to be transported by M cells has been considered to be a positive virulence factor, as it allows easy entry into the body.[67]

Only a few people actually acquire listeriosis; in healthy people the infection is apparently controlled by activated macrophages, but occasionally illness develops.

Because of the lack of information on the rate of contamination of foods and on the risk of invasive disease among susceptible people exposed to the organism, it is difficult to recommend the avoidance of particular foods by high-risk groups. However, the often fatal consequences in these groups, the ability of *L. monocytogenes* to grow in refrigerated foods and the possible survival of organisms in some heat-treated products should be of serious concern to health professionals.

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Meetings

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Sept. 14–16, 1988

21st Annual Conference of the Human Factors Association of Canada
Four Seasons Hotel, Edmonton
Dr. Shrawan Kumar, conference chairman, Department of Physical Therapy, University of Alberta, Edmonton, Alta. T6G 2G4

October

Oct. 2, 1988

3rd Annual Conference on Physician Manpower
Hôtel Meridien, Montreal
Abstract deadline is May 13, 1988
Eva Ryten, Association of Canadian Medical Colleges, 1006–151 Slater St., Ottawa, Ont. K1P 5N1; (613) 237-0070

Oct. 3–4, 1988

Annual Meeting of the Association of Canadian Medical Colleges and the Association of Canadian Teaching Hospitals
Hôtel Meridien, Montreal
Janet Watt-Lafleur, executive secretary, Association of Canadian Medical Colleges, 1006–151 Slater St., Ottawa, Ont. K1P 5N1; (613) 237-0070

Oct. 16–17, 1988

15th Annual Meeting of the Canadian Sex Research Forum
Glenerin Inn, Mississauga, Ont.
Abstract deadline is May 31, 1988
Dr. R.W.D. Stevenson, executive director, Canadian Sex Research Forum, Sexual Medicine Unit, Shaughnessy Hospital, 4500 Oak St., Vancouver, BC V6H 3N1; (604) 875-2027

Oct. 24–26, 1988

Physician Manager Institute 1988: Leadership Skills Development
Prince of Wales Hotel, Niagara-on-the-Lake, Ont.
Chuck Shields, Canadian College of Health Service Executives, 201–17 York St., Ottawa, Ont. K1N 5S7, (613) 235-7218; or Alexandra Harrison, Canadian Medical Association, PO Box 8650, Ottawa, Ont. K1G 0G8, (613) 731-9331

November

Nov. 13–20, 1988

Toronto Stroke Workshop in Jerusalem
This meeting has been rescheduled for Sept. 14–16, 1988 in Toronto. See September items for details.

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Biological Aerosols: A Review of Airborne Contamination and its Measurement in Dairy Processing Plants

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ABSTRACT

Processing plant air is a source of post-pasteurization contamination of dairy products. Little is known about the extent to which biological aerosols contaminate pasteurized products, however evidence indicates that air within a packaging area is a critical control point for both pathogens and spoilage microorganisms. Consequently, it is important to understand the characteristics of biological aerosols, learn how to control their occurrence, and discover practical and valid monitoring methods. Methods used for monitoring viable particles in air include the use of sedimentation plates, impingers, slit and sieve impactors, filters, and centrifugal samplers. Each of these methods has limitations on its usefulness for dairy plant air monitoring. Microorganisms are often injured due to the stresses of the aerosolized state and consequently may not grow on selective media. Sampling methods such as impingement and filtration which subject the organisms to additional stress may cause sufficient injury to prevent growth on non-selective media. However, gentler collection methods such as centrifugal samplers may not generate enough force to collect the smallest viable particles. Aerosols are generated within the dairy plant by worker activity, sink and floor drains, water spraying, and air conditioning systems. Environmental sanitation, air filtration, air flow control, and control over personnel cleanliness and activity are useful control measures. The adoption of "clean room" design principles for a packaging area will aid in controlling biological aerosols in new dairy processing plants.

Air has been recognized as a source of microbial contamination in dairy processing plants since the early 1900's. Recently, increased emphasis is being given to improving air quality in dairy plants as a means of enhancing product safety and increasing shelf-life. Air quality in the packaging area is a critical control point in the processing of dairy products. Therefore methods for monitoring air should be established along with appropriate limits on viable particle levels.

The various proposed monitoring methods each have limitations that the user should be aware of. Monitoring effectiveness depends to a great extent on the monitoring methods used and the nature of the aerosol present. Although at this time, there are no clear cut answers to the dairy industry's air monitoring challenge, this paper will summarize the available information for making judgments regarding research, quality control methodology and industry standards.

BIOLOGICAL AEROSOLS

An aerosol can be defined as a suspension of microscopic solid or liquid particles in air or gas such as smoke, fog or mist. Biological aerosols include bacteria, yeasts, molds, spores of bacteria and molds, viruses and pollen. The size of aerosol particles generally range from 0.5 to 50 μm. Particle size is the major factor influencing aerodynamic behavior.

Aerodynamic behavior of aerosols

Aerosols exhibit complex aerodynamic behavior resulting from a combination of physical influences that include Brownian motion, electrical gradient, gravitational field, inertial force, electromagnetic radiation, particle density, thermal gradients, hygroscopicity and humidity. Some of these physical forces such as gravitational field, electrical gradient, inertial force and thermal gradients are taken advantage of in aerosol sampling. Behavior of microbiological aerosols is governed by both physical and biological attributes. The physical factors control where, how and in what quantities the particles reach a particular landing site. Molecular motion, gravitational, thermal and electrostatic fields play important roles as does humidity. Inertial forces and fluid dynamics are primary influences in the landing process while interactions with electromagnetic radiation can be utilized for particle sizing, observation and analysis. This topic has been reviewed by Cox *(20)*.

Biological injury resulting from the aerosol condition

The most important biological attribute of an aerosol is the degree of sublethal or lethal damage to the biological particles dispersed in the air. Biological stresses occur during aerosol generation (artificial or natural), aerosol dispersal, and aerosol collection or landing. These stresses are generally assumed to be sublethal when considered individually.

[1]*Animal and Dairy Science Department*

but when combined with other environmental stresses such as dehydration, hydration, irradiation, oxidation from oxygen or ozone, and effects of various pollutants, the result is often lethal. Stersky et al. *(68)* measured the inactivation of *Salmonella newbrunswick* aerosolized under various conditions. Distilled water dissemination in the first 20 min resulted in D-values ranging from 41 min at 21°C and 30% relative humidity (RH) to 206 min at 10°C and 90% RH. Skim milk dissemination at 10°C resulted in D-values ranging from 245 min to 404 min at 90% and 30% RH and at 21°C from 164 to 470 min. Aerosolization is stressful for most vegetative cells so additional stresses from collection procedures and growth media must be minimized. Aerosolized organisms have been subjected to mechanical or physiological damage which reduces recovery on selective media. Stersky and Hedrick *(66)* tested the growth inhibition of various combinations of selective media on airborne bacteria. The ratio of *Escherichia coli* colonies on violet red bile (VRB), desoxycholate (DES), MacConkey (MAC) agar with overlay, standard plate count agar (SPC) overlay on VRB, and SPC overlay on DES to the colonies on SPC was less than 4%. Eosin methylene blue agar showed excellent recovery (122%) compared to SPC. Tergitol and endo agar recovered 23 and 40% respectively. Recovery of *Pseudomonas* spp. on modified selective media was greater than that of coliforms. Recovery rates of airborne *Salmonella newbrunswick* ranged from <1% on *Salmonella-Shigella* agar to 118% on MAC/SPC. Recovery rates were somewhat improved by impinging onto SPC agar followed by overlaying with the selective media. Recommended non-selective media for overall microbial recovery include trypticase soy agar, brain-heart infusion agar and Meuller-Hinton agar. These media may also be fortified with blood to neutralize anti-microbial compounds that may be carried into the sampler *(44)*.

Collection fluids are used for some types of aerosol samplers (liquid impingers). The selection of a liquid collection medium is dependent upon the particular organism being isolated. In quantitative studies a medium must be employed which will minimize both multiplication and death of the organism. The common collection media include buffered gelatin *(71)*, phosphate buffer *(48,75)*, 2% peptone water *(22)*, nutrient broth *(25)* and gelatin-milk broth *(46)*.

Factors involved in experimental techniques

Research on biological aerosols often includes generation, storing and collection of aerosols. Some factors in addition to sublethal injury which will influence experimental results are as follows: *Strain of microorganism.* Vegetative cells are more susceptible than spores to aerosol stress. There may be substantial strain variation for any given species. *Growth conditions.* The growth medium and growth phase influence susceptibility of the microorganism to aerosol stress. *Aerosol generation.* The degree of shear stress influences viability, especially for vegetative cells. If high viability aerosols are to be generated artificially, a low shear force aerosol generator such as spinning top, vibrating needle, or Berglund-Liu vibrating orifice aerosol generator should be chosen *(20)*. Two fluid (air-liquid) atomizers (e.g. Collision atomizer *(19)*) were first choice dispersers in the past, but they impose high shear stress. Aerosols behave differently when generated by wet and dry methods. *Aerosol particle size.* Particle size continuously changes during aerosol storage and collection. Size may decrease through evaporation and collision, and may increase through agglomeration and absorption. *Spray fluids.* When the growth medium and the spray fluids are different, the spray fluid may affect viability. Stersky et al. *(68)* found that *Salmonella* which were aerosolized from skim milk had greater D-values than those aerosolized from distilled water. Aerosolization of coliforms with skim milk as opposed to distilled water resulted in growth of more colonies on selective media *(66)*. Spent culture fluids, di- and trisaccharides and the polyhydric alcohols, sorbitol and inositol provide the best protection from aerosol generated forces *(20)*. *Aerosol storage.* In order to study the fate of microbes in aerosol, the aerosol should be stored for an extended period of time under specific conditions such as known relative humidity, irradiation, etc. Special techniques or apparatus such as the vertical wind tunnel *(24)*, microthread apparatus *(51)*, or rotating drum *(30)* are required. *Aerosol collection methods.* Collection methods greatly influence the recovery of viable particles. A discussion of the principles applications, advantages and limitations of these methods follows.

AEROSOL SAMPLING METHODS

Methods for sampling airborne microorganisms are basically the same as the methods used to sample dust and other airborne particulates. Existing samplers have been modified for the recovery of living biological agents so that the viability of the microorganism is preserved without permitting growth. Dimmick and Akers *(23)* state "Ideally, an aerosol sampler for microbiological assay should be capable of counting the total number of living airborne particles in a unit volume of air, as well as determining the number of viable units per particle and the size of the particles containing such units. However, this presupposes that 100% of the airborne cells, living or dead, can be physically separated from air without killing them during or after sampling." Such a sampler has not yet been designed *(44)*.

Most of positive samplers (impingers, impactors, filters, etc.) need vacuum for sampling air. The vacuum pump exhaust must be isolated from the area being sampled, as it may cause erroneous results. Seven types of commercially available aerosol samplers are listed in Table 1.

Sedimentation methods

The exposure agar plate and microscopic slide exposure methods rely on the force of gravity (if the microorganism containing particles are greater than 10 μm) and air currents (all sizes by random chance) to deposit particles on a non-selective or selective agar surface. Results

TABLE 1. *Commercial sources of aerosol samplers.*

Impingers

All-Glass Impinger 30 and Pre-Impinger; Ace Glass, Inc., P.O. Box 688, Vineland, NJ 08360.

Midget Impinger with Personal Air Sampler; Supelco Inc., Supelco Park, Bellefonte, PA 16823-0048.

May 3-stage Glass Impinger; A. W. Dixon Co., 30 Anerly Station Road, London S.E.20, England.

Impactors (slit type)

Casella single slit and four slit sampler; BGI Incorporated, Air Sampling Instruments, 58 Guinan Street, Waltham, MA 02154.

Mattson-Garvin air sampler; Mattson Garvin Company, 130 Atlantic Drive, Maitland, FL 32751.

New Brunswick STA Air Sampler; New Brunswick Scientific Company, Inc., P.O. Box 986, 44 Talmadge Road, Edison, NJ 08817.

Impactors (sieve type)

Andersen 6-stage, and 2-stage samplers; Andersen Samplers, Inc., 4215-C Wendell Drive, Atlanta, GA 30336.

Ross-Microban sieve air sampler; Ross Industries, Midland, VA 22728.

Personal Particulate, Dust, Aerosol Collector; SKC Inc., 334 Valley View Road, Eighty Four, PA 15330.

Filtration samplers

Millipore membrane filterfield monitor; Millipore Corporation, Bedford, MA 01730.

Gelman membrane filter air sampler; Gelman Sciences Inc., 600 S. Wagner Road, Ann Arbor, MI 48106.

MSF 37 monitor; Micro Filtration Systems, 6800 Sierra Court, Dublin, CA 94568.

Satorius MD8 Air Sampler; Satorius Filters Inc., 30940 San Clemente St., Bldg., D, Hayward, CA 94544.

Centrifugal samplers

RCS Centrifugal sampler; Folex-Biotest-Schleussner, Inc., 6 Daniel Road East, Fairfield, NJ 07006.

Electrostatic precipitation samplers

LVS sampler; Sci-Med Environmental Systems Inc., 8050 Wallace Road, Eden Prairie, MN 55344.

General Electric electrostatic air sampler; General Electric Co., Lamp Components & Technical Products Div., 21800 Tungsten Road, Cleveland, OH 44117.

Thermal precipitation samplers

Thermal precipitator, hot wire; Casella London Ltd., Regent House, Britannia Walk, London N1 7ND.

are obtained as cfu or particles/min. Particle size distribution may be obtained by direct microscopic examination.

The 15th edition of Standard Methods for the Examination of Dairy Products *(14)* classifies sedimentation as a Class D method and recommends 15 min exposure of standard size (90 mm diam) Petri plates containing Standard Methods Agar or a selective medium. After exposure, plates are incubated according to the appropriate procedure. In addition, microscope slides coated with agar can be exposed and particles counted using a microscope. This technique is only used for total particulate counts.

Limitations. Sedimentation methods are easy, inexpensive, and collect particles in their original state. The major disadvantages are their inability to measure airborne microorganisms quantitatively, i.e. number of viable particles/cu ft, and the relatively long sampling period that is required. Viable aerosol counts by this method are not at all, or only weakly correlated with the counts determined by other quantitative methods *(61)*. Air movement will influence the deposition of the particles so that particle-size distribution may indicate a greater number of large particles than is actually present.

Impinger methods. Impinger methods use a liquid (simple salt solutions, with additives such as proteins, antifoam, or antifreeze) for collection. When the air is dispersed through the liquid, particles in the air are entrapped. Quantitation of airborne microorganisms is accomplished by diluting and plating the collection fluid or by using a membrane filtration plating technique when the expected microbial load is low. In high velocity liquid impingers, air is drawn through a small jet and is directed against a liquid surface with the resulting collection of suspended particles in the liquid.

All Glass Impinger-30 sampler. The All Glass Impinger-30 (AGI-30, Ace Glass Inc.) sampler is a high velocity impinger widely used for air sample collection (Fig. 1). The jet is held 30 mm above the impinger base and consists of a short piece of capillary tube designed to reduce cell injury. The AGI-30 sampler operates by drawing aerosols through an inlet tube curved to simulate the nasal passage *(20)*. This makes it especially useful for studying the respiratory infection potential of airborne microorganisms. The usual sampling rate is 12.5 L/min. When it is used for recovering total airborne microorganisms from the environment, the curved inlet tube should be washed with a known amount of collecting fluid after sampling since larger particles (i.e. over 15 μm diam) are collected on the tube wall by inertial force.

Impingement methods are highly efficient for particles greater than 1 μm when high jet velocities are used.

This is a Class B method in the 15th edition of Standard Methods for the Examination of Dairy Products *(14)*.

Limitations. The impinger is inexpensive and simple to operate, but viability loss may occur due to the amount of shear force involved in collection. The air stream approaches sonic velocity when particulates impinge on the collection fluid, resulting in almost complete collection of suspended particles; however, this condition tends to cause the destruction of vegetative cells *(1)* or may result in overestimation due to the dispersion of dust particles and the breaking up of clumps of bacteria *(61)*. Another limitation is that the glassware should be sterilized before each sampling. Also, the apparatus is easily broken.

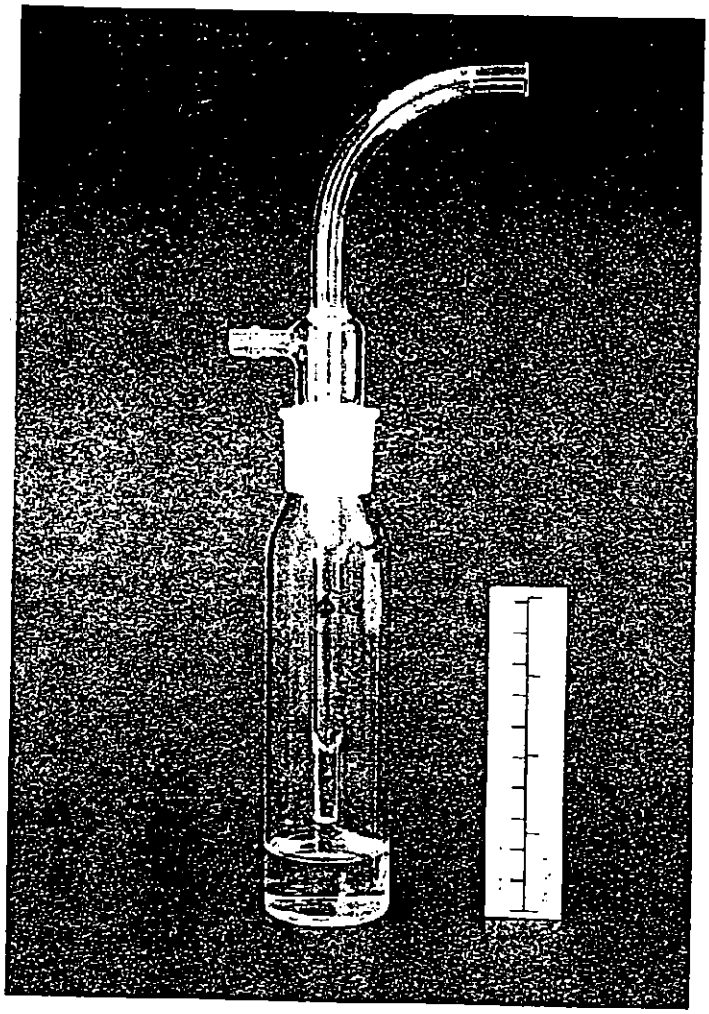

Figure 1. *The All Glass Impinger-30 (AGI-30).*

Impaction methods. Impaction usually involves the collection of microbial aerosols on an agar surface, but dry or coated surfaces may be used for special purposes such as particle size determination. An impactor consists of an air jet that is directed over the impaction plate so that particles collide with and stick onto the surface. There are two types of impactors, slit samplers (e.g. Casella slit sampler) and sieve samplers (e.g. Andersen multistage sieve sampler, Fig. 2).

This is also a Class B method in the 15th edition of Standard Methods for the Examination of Dairy Products *(14)*.

Slit sampler. The slit sampler usually has a tapered slit which produces a jet stream when the air is sampled by vacuum. The slit sampler may have a turn-table for rotating the agar plate so that aerosol particles are distributed evenly on the agar surface. Some slit samplers have a timing device on the turn-table which allows continuous monitoring of airborne viable particles count (e.g. New Brunswick STA sampler). These samplers will collect particles which are greater than 0.5 μm in size *(44)*.

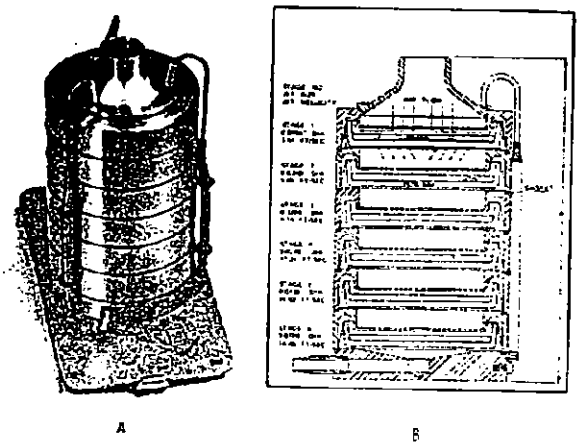

Figure 2. *A. Andersen Multistage Sieve Sampler. B. Schematic cross-section of the Andersen sampler. (Courtesy of Andersen Samplers Inc.).*

Sieve sampler. Sieve samplers are operated by drawing air through a large number of small, evenly spaced holes drilled in a metal plate (sieve). The suspended particles are impacted on an agar surface located a few millimeters below the perforated plate. There are single stage (e.g. Ross Microban sampler) and multistage sieve samplers (e.g. Andersen sampler). A multistage sieve sampler consists of a series (2, 6 or 8) of stacked sieves and plates each with successively smaller holes. This causes increased particle velocity as air flows through the apparatus. Large particles impact at the initial stage and small particles follow the air flow until accelerated sufficiently to impact at a later stage (Fig. 2.B).

When the concentration of viable particles in an aerosol is high, one sieve hole may allow more than one viable particle to pass through resulting in the formation of single colony from two or more viable particles. This inaccuracy can be corrected by reducing sampling time or by using either the microscopic method or a "positive hole" method for enumeration. The microscopic method involves counting particles through a dissecting type microscope before colonies merge. The "positive hole" methods, designed for the Andersen 2-stage and 6-stage sampler, are essentially a count of the jets which delivered viable particles to the Petri plates. This count is converted to a viable particle count by the use of the "positive hole" conversion tables *(4,47)*.

The multistage sieve sampler provides particle size distribution information. The usefulness of this information in plant sanitation programs has yet to be determined.

Limitations. Usually, impaction methods give higher particle recovery than other methods *(27,69,70)*. Impaction results in low sampling stresses and after collection sample manipulation is not required. Multistage sieve samplers are cumbersome to handle and are expensive. The exact volume of agar must be poured into all plates aseptically so that the gap between the sieve and agar surface meets the manufacturer's specification. The inside of the sampler and even the outside of pre-poured agar plates should

be maintained sterile until sampling, as they can contribute to contamination.

Filtration methods. Filters are widely used for aerosol sampling due to low cost and simplicity of operation. The air filtration apparatus consists of cellulose fiber, sodium alginate, glass fiber, gelatin membrane filter (GMF, pore size 3 μm) or synthetic membrane filters (pore size 0.45 or 0.22 μm) mounted in an appropriate holder and connected to a vacuum source through a flow rate controller (e.g. critical orifice). After a fiber filter is used, the whole filter or a section of it is agitated in a suitable liquid until the particles are uniformly dispersed. Aliquots of the suspension are then assayed by appropriate bacteriological techniques. Membrane filters can either be treated similar to fiber filters or directly placed on an agar surface and incubated.

Gelatin membrane filtration method. The gelatin membrane is water soluble so that it can easily be diluted for plating or be solubilized on top of a nutrient medium resulting in bacteria colonies that are easily counted. However, this hygroscopic property causes difficulties in sampling due to swelling of the membrane when the relative humidity is over 90% *(64)*. The large number of pores present in these membranes allows a large volume of air to be sampled during a short time (2.7 L of air/min/cm^2/500 mm water column).

Limitations. Filtration methods are good for enumerating mold or bacterial spores. They may not be effective for counting vegetative cells because of the stress of cell dehydration produced during sampling *(26)*. The shorter sampling times used in gelatin membrane filtration may reduce this stress.

Centrifugal methods. Centrifugal force can be used to propel aerosol particles onto a collection surface. When the aerosol is spun in a circular path at high velocity, the suspended particles impact on the collecting surface by a force proportional to the particle's velocity and mass. Centrifugal samplers do not generate high velocity jet flow during sampling, so less stress is imposed on airborne microbes as compared to impingement and impaction methods. Centrifugal samplers are simple and easy to operate and may be less expensive than impactor types. Generally, centrifugal samplers can rapidly sample a high volume of air resulting in more representative sampling.

Limitations. Some devices may not generate sufficient centrifugal force to propel small particles onto the collection surface. The recovery efficiency of these samplers depends on the particle size being sampled and the amount of centrifugal force generated.

Biotest Reuter centrifugal air sampler. The Reuter centrifugal air sampler (RCS sampler, Biotest Diagnostics Co.) is battery operated, portable, light in weight (2.5 lb.) and convenient to use (Fig. 3). A plastic strip containing a culture medium lines the impeller drum. Air from a distance of at least 40 cm is sucked into the sampler by means of an impeller. Air enters the impeller drum concentrically from a conical sampling area. It is set in rotation, and the aerosol impacted by centrifugal force onto the agar surface. Air then leaves the sampling drum in a spiral outside the cone of entering air. After the sample has been taken, the agar strips are incubated and the colonies counted. The sampler has a self-timer for sampling from 30 s to 8 min. The actual sampling rate is 280 L/min. However, the manufacturer has published an effective sampling rate or separation volume of 40 L/min for 4 μm particles, a value derived from an attempt to reconcile the actual number of viable particles collected from an air sample with measurements involving airflow direction, air velocity and available collecting surface area. Clark et al. *(18)* indicated the effective sampling volume of the RCS sampler will vary widely depending on aerosol particle size. Consequently, the results obtained by using this sampler must be interpreted with considerable caution. Macher and First *(49)* measured the collection efficiency of RCS sampler and found improved efficiency with increasing particle size. Particles larger than 15 μm are almost 100% collected, those in the 4 to 6 μm range are collected at 55 - 75% efficiency and particles smaller than 1 μm pass through the sampler without significant retention. Although RCS sampler does not accurately estimate total viable particle concentration, Placencia and Oxborrow *(58)* recommended this sampler for good manufacturing practices investigations. These investigators found that the RCS sampler will collect more viable particles than a slit sampler and it could detect the difference in the environmental quality of each medical device manufacturing facility tested. In addition, the RCS sampler effectively detects various types of microorganisms *(58)*.

Electrostatic precipitation methods

Aerosol particles can be ionized and collected on either a positively or negatively charged surface. Electrostatic precipitators employ various solid collection surfaces such as agar or glass. During ionization of the air sample, oxides

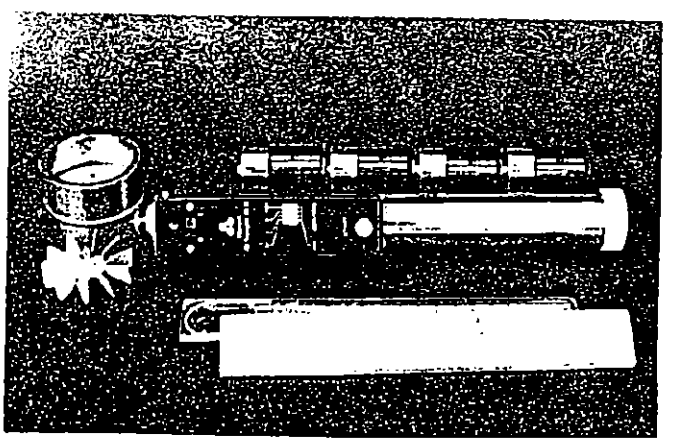

Figure 3. *The Biotest RCS sampler.*

of nitrogen and ozone are produced which may be toxic to microorganisms. These samplers have a high sampling rate, high collection efficiency, and low resistance to air flow. They are mechanically complex and must be handled carefully. Although several electrostatic precipitators are manufactured specifically for sampling microbial aerosols, they are not widely used for this purpose *(74)*.

Thermal precipitation methods

Thermal precipitation methods recover particles based on thermophoresis principles in which particles move away from a hot surface toward a colder surface by a force proportional to the temperature gradient. These samplers can be used for the determination of particle size distribution, though they are more effective when collecting small particles (less than 1 µm). However, they are not in common use since precise adjustments are required and air sampling rates are quite low (300-400 ml/min). The aerosol particles are usually collected on a glass coverslip or electron microscope grid, and are subsequently sized and counted microscopically *(74)*.

Additional information on aerosol samplers can be found in the following references *(1,3,20,23,31,35,50,69,74)*.

Comparison studies on aerosol samplers

Millipore and absorbent cotton samplers more efficiently recovered mold spores than the AGI-30 sampler *(65)*. Fields et al. *(27)* recommended the use of the membrane filter field (MF) monitor for estimating airborne microorganisms after comparing it with the Reyniers slit air sampler for microbiological laboratory and clean room environment testing. These results showed that a significantly higher number of microorganisms were recovered by the Reyniers slit sampler with a high degree of consistency. The MF sampler detected 79% of the concentration measured by the Reyniers slit sampler and the types of microorganisms identified from both sampling methods were similar. Chatigny *(17)* concluded that .4 µm Millipore filter as an air sampler of small particles may be somewhat more efficient than the AGI-30 sampler, but viable recovery will usually be lower except in the case of bacterial spores or fungi. Similarly, the Litton (LVS) large volume electrostatic sampler is from 40 to 70% as efficient as the AGI-30 sampler, but it has a sampling rate approximately 100 times greater than the AGI-30 sampler.

The Andersen 2-stage impactor was more effective than the May 3-stage glass impinger for recovering *Escherichia coli* from aerosol in a waste water plant environment *(75)*. Curtis et al. *(21)* compared the Andersen 8-stage and 2-stage air samplers for recovery of viable organisms. They found that the 2-stage disposable air sampler gave lower values for airborne bacterial colony-forming particles than did the 8-stage viable air sampler in either a swine barn or a classroom. When Lembke et al. *(46)* tried to devise a method to determine the precision of the AGI-30 sampler and the Andersen 6-stage air sampler over a wide range of aerosol concentrations inside a municipal solid-waste recovery system, they found a high degree of variability associated with both types of air sampling devices. They indicated that slippage of particles from one stage to another stage, particle fragmentation or agglomeration, and wall losses in Andersen 6-stage air sampler, and processing technique in AGI-30 sampler may account for some of the variance. An Andersen 6-stage sampler, a Casella slit sampler, an AGI-30 sampler, and a filter sampler with gelatin membrane filters or ordinary membrane filters were tested for collection efficiency with a bacterial aerosol in laboratory experiment, in field experiments, and in experiments with skin fragment sampling *(48)*. The Andersen sampler gave the highest bacterial counts in all environments tested. The slit sampler gave significantly lower counts only in the aerosol experiments and in one of the field experiments. The filters performed efficient sampling in skin fragment experiments only.

Radmore and Lück *(61)* compared exposure plate, liquid impinger and gelatin membrane filtration (GMF) methods. Air counts determined by exposure of agar plates were not at all, or only weakly correlated with the counts determined by two other methods. The relationship between the liquid impinger and GMF methods were also not very consistent ($r=0.75$). At levels above 1000 microorganisms/m^3, the impinger method yielded counts up to 6 times higher than the GMF method. They explained this was probably a result of the dispersion of dust particles and the breaking up of chains and clumps of bacteria during the bubbling of air through the impingement liquid.

In comparative studies of airborne microbial recovery rate *(22,58,59)*, the RCS sampler was found to be significantly more efficient than a slit sampler or a liquid impinger. The RCS sampler samples air the shape of a sphere with a diameter of 1.3 ft--representing an air volume of about 1.2 cu ft versus only 0.5 cu ft dimension of air sampled by the slit sampler *(22)*.

Comparison studies of air sampling devices indicate that there is often no obvious choice of the correct sampler to use. A multistage sieve sampler such as the Andersen may be most efficient at viable particle recovery but it is not suitable for taking repeated sampling on a routine basis and requires a vacuum source. Filter samplers work well for quality control monitoring of molds and bacterial spores, but bacterial recovery is questionable, depending on the extent of dehydration that occurs during sampling. In addition, a vacuum source is required. The RCS sampler is convenient to use, creates its own air flow and recovers bacteria as well as molds. Even though the RCS sampler does not recover the smallest viable particles, it is still useful for determining relative air quality on a routine basis. Slit samplers may not be as convenient to use as the RCS sampler, especially if a vacuum source is required. However, slit samplers are more efficient at recovering small particles.

SAMPLING AND MEASUREMENT STANDARDS

Standard Methods for the Examination of Dairy Products

The 15th edition of the Standard Methods for the

Examination of Dairy Products *(14)* lists no Class A standard method for testing the microbiological quality of air in dairy environments, though there are methods designated as Class D and B. Favero et al. *(26)* introduced air sampling strategies and various air sampling methods in "Compendium of Methods for the Microbiological Examination of Foods." They pointed out that the first and the most important decision is whether air sampling at any level is required. If it is, then quantitative and qualitative guidelines should be established which relate numbers and types of microorganisms per volume of air to critical levels of product contamination.

NASA air cleanliness standards

Favero et al. *(26)* also suggested that the NASA air cleanliness standards may be used as a reference point after experiments to determine suitability. The "NASA Standards for Clean Rooms and Work Stations for the Microbially Controlled Environment" *(54)* defines three air cleanliness classes (Table 2). According to the standards, the collection methods must conform to "Standard Procedures for the Microbiological Examination of Space Hardware (NHB 5340.1 or revisions thereof)" which specifies use of a slit sampler.

Federal standard 209C

Federal standard 209C for "Clean Rooms and Work Station Requirements, Controlled Environment" establishes standard classes of air cleanliness for airborne particulate levels in clean rooms and clean zones. These classes are based only on particle enumeration and place more emphasis on small particles which are not necessarily viable *(29)*. This standard is not useful for food plant applications.

Standard reference samplers

Brachman et al. *(9)* recommended the AGI-30 sampler as a standard reference sampler because of historical use, economics, availability and its simple design. On the other hand, the American Conference of Governmental Industrial Hygienists Committee on Bioaerosols *(2)* used the Andersen multistage air sampler as the reference sampler for its committee activities and reports. In the pharmaceutical industry, the slit sampler is the most widely used device for monitoring sterile manufacturing and quality control environments *(1)*.

TABLE 2. *NASA air cleanliness classes*[1].

Test	Class, English (Metric) System		
	100 (3.5)	10,000 (350)	100,000 (3500)
Max. No. of .5 µm and larger Particles per cu ft (per liter)	100 (3.5)	10,000 (350)	100,000 (3500)
Max. No. of 5 µm and larger Particles per cu ft (per liter)	[2]	65 (2.3)	700 (25)
Max. No. of Viable Particles per cu. ft. (per liter)	0.1 (0.0035)	0.5 (0.0176)	2.5 (0.0884)
Avg. No. of Viable Particles per sq. ft. (per M^2) per week	1,200 (12900)	6,000 (64600)	30,000 (323000)

[1]NASA standards for clean rooms and work stations for the microbially controlled environment *(54)*.
[2]Statistically unreliable except when a large number of samplings is taken.

BIOLOGICAL AEROSOLS IN DAIRY PROCESSING PLANTS

Research on the importance of biological aerosols in food processing environments is limited and has dealt primarily with the dairy industry. Most research since Olson and Hammer's *(56)* initial contribution has been related to the numbers, types, and sources of airborne microorganisms in the dairy plant *(12,16,37,38,39,45,55,57,70)*. Little research has been reported on the relationship of product quality to air quality *(5,11,13,57)* or control of airborne microorganisms *(8,36,38,39,40,56,67)*. Although investigators have used different methodology, their studies indicate that bacteria, yeasts and molds are continuously falling from the air in the dairy plant environment. It is evident that microbial contamination of dairy products and equipment from the air is to be expected under normal operating conditions.

Types and populations of microorganisms

Data on levels of microorganisms in dairy plants obtained using various methods is presented in Table 3-6. Large variations in viable particle levels are found even when similar samplers and locations are compared. These variations are due in part to differences in facility design, air flow, personnel activity and degree of environmental sanitation.

Sunga et al. *(70)* used both a Casella slit sampler and an Andersen (6-stage sieve) sampler to test dairy processing areas. Both samplers produced similar results with about 68% of the total determinations producing bacterial counts of over 30 organisms/5 cu ft and a very low population of probable *Staphylococcus* spp., coliforms and yeasts.

TABLE 3. *Levels of microorganisms found in air of dairy plants by exposure agar plate method using 90mm plate (data adjusted to 15 min exposure).*

Locations	Bacteria range (mean)	Yeasts range (mean)	Molds range (mean)	Ref. No.
	cfu			
Market milk areas	1.8-185.8 (46.5)	0-6.3 (1.1)	0.8-64 (13.8)	56
Butter areas	4.5-129 (41.6)	0-5.3 (1.1)	0.5-75.5 (15.1)	
Cheese areas	3-171.5 (36.2)	0-10.8 (1.1)	0.8-71.5 (12.1)	
3 dairies	1.5-825	N.D.[1]	N.D.	16
Dairy factories	>4500[2]	N.D.	N.D.	45

[1]No data available.
[2]Maximum counts.

TABLE 4. *Levels of microorganisms found in air of pasteurized milk processing areas using quantitative sampling methods.*

Sampler	Bacteria range (mean)	Yeasts range (mean)	Molds range (mean)	Ref. No.
	----------cfu per m^3 of air----------			
Casella	66-334 (195)	12-181 (70)	51-293 (145)	33
Casella	141-3143 (1105)		0-4462[1] (1088)	34
Casella	*[2]	0-141 (8)	0-127 (30)	70
Andersen	*[2]	0-7 (6)	92-205 (138)	
Andersen	(3260±5283)[3,4]		(1812±3814)[4]	12
Andersen	(3200)[3]		(1400)	13
GMF[5]	(953)		(258)[1]	61

[1]Yeasts and molds count.
[2]Low levels of *Staphylococcus* spp. and coliforms detected.
[3]Non-molds count.
[4]Expressed as mean±standard deviation.
[5]Gelatin membrane filtration method.

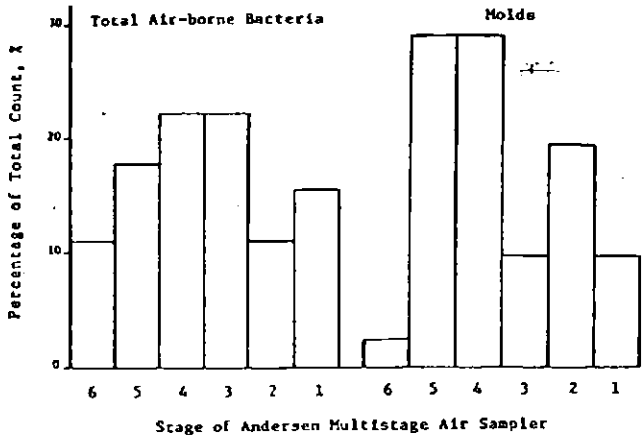

Figure 4. *Viable particle size distribution of total bacterial counts from various food packaging areas (70). The ranges of particle size collected on each stage are: stage 1; > 9.2 μm stage 2; 5.5-9.2 μm stage 3; 3.3-5.5 μm stage 4; 2.0-3.3 μm stage 5; 1.0-2.0 μm stage 6; <1.0 μm.*

Cannon *(12)* reported on the viable particle counts of air samples from fluid milk plants with the use of the Andersen sampler. He obtained a mean count of 92.3/cu ft of non-mold colonies and 51.3/cu ft of mold colonies. From non-mold colonies, 25% of these were Gram negative rods and 24% of cultures grew in trypticase soy broth in 5 d at 10°C.

In subsequent study, Cannon *(13)* sampled the air in the milk processing areas of 10 dairy plants and found an average of 32 non-molds and 14 molds/10 L. The bacteria isolated were primarily micrococci, Gram-negative rods (excluding coliform), bacilli, and corynebacteria. He also found a few streptococci, coliform and lactobacilli. Twenty-five percent of the isolates grew at 10°C in 5 d indicating refrigerated spoilage potential.

Radmore and Lück *(61)* analyzed 209 samples from 31 dairy factories. An average of 12.5% of the total count consisted of thermoduric organisms and 4 of the 209 air samples contained *Enterobacteriaceae*. None of the samples produced viable *Staphylococcus aureus*.

Olson and Hammer *(56)*, and Cannon *(12)* concluded that bacteria were the most numerous and yeasts the least numerous in processing plant air. On the other hand, Heldman et al. *(37)* reported that molds were the most numerous with yeasts still being the least numerous. Microbial populations can vary widely within and among plants

TABLE 5. *Levels of microorganisms found in air of cheese processing areas using quantitative sampling methods.*

Locations	Sampler	Bacteria range (mean)	Yeasts range (mean)	Molds range (mean)	Y&M[1] range (mean)	Ref. No.
		----------cfu per m^3 of air----------				
Cottage cheese areas	Casella	109-242 (158)	13-212 (62)	133-2361 (786)		33
	Casella	N.D.[2]	0-7 (1.4)	7-318 (57)		70
	Andersen	N.D.	0-113 (37)	7-127 (126)		
	Andersen	565-3037[3]	N.D.	N.D.		11
Cheese areas	slit sampler	24.7-2354[4]	N.D.	N.D.		57
	Casella	106-24791 (4086)			35-3496 (1056)	34
overall	GMF[5]	(986)			(396)	61
production		(1683)			(649)	
packaging		(2244)			(881)	
store		(133)			(172)	
starter room		(701)			(35)	

[1]Yeasts and molds count.
[2]No data available.
[3]Total viable particles count.
[4]Lactobacilli on 2% plain agar, over which a layer of selective acetate agar medium.
[5]Gelatin membrane filtration method.

TABLE 6. *Levels of microorganisms found in air of other dairy processing areas using quantitative sampling methods.*

Locations	Sampler	Bacteria range (mean)	Yeasts range (mean)	Molds range (mean)	Y&M[1] range, (mean)	Ref. No.
		cfu per m³ of air				
Butter area	Casella	102-371 (218)	10-182 (85)	119-1951 (486)		33
	Casella	388-4662 (1596)			141-918 (434)	34
	Casella	*[2]	0-28 (7.8)	7-388 (88)		70
	Andersen	*[2]	0-14 (8.5)	106-212 (131)		
	GMF[3]	(5902)			(611)	61
Dry milk areas	Casella	283-2119 (1095)			106-2966 (1021)	34
overall	GMF[3]	(1766)			(802)	61
production		(2911)			(542)	
packaging		(1274)			(589)	
other areas		(2296)			(802)	
Ice cream areas	Casella	353-883 (579)			141-565 (297)	34
	Casella	*[2]	0-14 (2.1)	0-42.4 (25.4)		70
	Andersen	*[2]	0-14 (4.2)	14-113 (65.0)		
Condensed milk areas	GMF[3]	(221)			(94.6)	61
production		(1117)			(925)	
packaging		(13.0)			(0)	
storage tank		(50.5)			(20.5)	
Dairy factories	slit sampler	18000[4,5]				45
	RCS[6]	10-15000[5]				63

[1]Yeasts and molds count.
[2]Low levels of *Staphylococcus* spp. and coliforms detected.
[3]Gelatin membrane filtration count.
[4]Maximum counts.
[5]Total viable particles count.
[6]Biotest RCS centrifugal air sampler.

(12,16,56,70), and on a day to day basis within the same plant *(37)*.

Rossmoore et al. *(63)* frequently isolated species of *Pseudomonas, Serratia, Klebsiella, Sarcina; Micrococcus, Staphylococcus, Fusarium, Aspergillus, Rhisopus, Penicillium, Chladosporium, Candida, Kluyveromyces, Rhodotorula* and *Saccharomyces* from the air of dairy plants.

Size distribution of viable particles

Since aerosol sampler performance depends on the size of particles being sampled, information on particle size distribution in dairy plants is useful. Sunga et al. *(70)* determined the size distribution of viable particles recovered from a dairy processing environment. These data are summarized in Fig. 4. Forty-four percent of total viable airborne bacteria were in the particle size range of 2.0-5.5 µm. Fifty-eight percent of the molds were in the range of 1.0-3.3 µm.

Eleven percent of non-molds and 2.4% of molds were found in particles less than 1 µm. It is apparent from these data that samplers which do not recover the smallest particles (i.e. RCS sampler) will often underestimate the total amount of air contamination. Whether this underestimation is of quality control significance has not been determined.

Factors affecting airborne microbial types and populations

The airborne microbial population within a dairy plant exhibits no distinct seasonal variation in type or number *(16,56)*. Also machine activity has no apparent effect on airborne microbial counts *(37)*.

Cerna *(16)* concluded that the major factor affecting airborne microbial populations in different dairies is the presence of workers, their numbers and activity. Heldman et al. *(37)* also reported an association between airborne bacteria counts and worker activity. One experiment of Hedrick et al. *(33)* showed that a medium sized man confined to a 5 cu ft area and inactive, shed, with a uniform soiled by 4 h of normal wear, 110 bacteria colonies/ 5 cu ft; without clothes, 20 colonies; and immediately after a shower (without clothes), 3 colonies. Additional human contributions to airborne populations may be attributed to coughing, sneezing, speaking or exhaling *(35)*. Drains add large numbers of bacteria and a few yeasts and molds to the

air during flooding, especially after being idle overnight *(33)*. The general quality of plant sanitation, the location of the dairy, quality of ventilation and degree of personal hygiene were found by Cerna *(16)* to be important factors in determining processing plant air quality. Hedrick et al. *(33)* indicated that the cleanliness of the storage area and precautions of unpacking supplies in processing and packaging areas are also important.

Perry et al. *(57)* studied airborne contamination of cheese with lactobacilli. They selectively isolated and identified similar lactobacilli from the air and cheeses. "Cheese types" of lactobacilli were found in the air some months before and after the cheese was made, which indicates contamination of the air from other sources within the dairy. Naylor and Sharpe *(55)* compared possible sources of lactobacilli contamination and concluded that air was the major source.

Air quality and shelf-life of products

Angevine *(5)* used exposed plates of pasteurized skim milk followed by a Moseley keeping quality test *(52)* for estimating the air quality in a cottage cheeses processing room area. His data indicate that poor air quality was the cause of unsatisfactory shelf-life. In another study, the shelf-life of cottage cheese negatively correlated (r=-0.642) with the viable particle counts of cheese processing room air. The coefficient of determination indicated that air contamination contributed approximately 40% to the variation in shelf-life *(11)*.

Cannon *(13)* did not find a relationship between airborne microbial populations and keeping quality of the packaged milk. This was probably because the contamination of milk from sources other than air was sufficient to overshadow any airborne contamination.

A special packaging system, the 'long-life machine' (designed by Ex-Cell-O Co., Walled Lake, MI), encloses the filling chamber with fitted fiber glass covers and is designed to eliminate the need for a defoamer. This system protects products from airborne contamination and may extend the shelf-life of whole milk by 7 d. The SPC for whole milk run on this machine did not reach 20,000 cfu/ml for 18 d, whereas the same milk packaged by a standard machine exceeded 20,000 cfu/ml after 12 d *(43)*. This data shows the extent to which airborne contamination may influence the shelf-life of product made from high quality raw milk.

Routes of airborne product contamination

Any point at which product is exposed to air is a possible route for airborne contamination. Air for mixing raw milk held in silos and for removing product from pipelines is often a source of contamination *(41)*. Exposure of products at the filler and via vacuum defoamers are also important sources *(15)*. For ice cream, compressed air introduced for overrun and exposure during filling lead to contamination. Dry products have intimate contact with air during spray drying and instantization *(36)*. Cottage cheese is exposed when open vats are used and during filling *(5,11)*. Ripened cheeses are exposed by using open cheese vats and during packaging. Whenever product comes into contact with large volumes of air, the air should be filtered. Often, these filters are not properly maintained resulting in reduced effectiveness.

Proposed guidelines of air quality in dairy processing and packaging areas

Mossel *(53)* developed the following formula for calculating acceptable viable particle levels:

Limit (microorganisms per cu ft) = P/100 x N/V where P is what one regards as a significant percentage increase in the count of microorganisms being considered; N is the geometric mean of the acceptable level of microorganisms in the food per g, and V is total volume of air (cu ft) passing over or through 1 g of the food in the course of processing. The usefulness of this formula has not been determined.

Hedrick *(32)* recommended the maximum levels of viable particles for air in various processing situations based on feasibility as well as desirability (Table 7).

Radmore et al. *(62)* proposed air quality guidelines based on data collected from a simulated filling operation. This approach may be valuable, but the usefulness of the guidelines has not been demonstrated. In addition, these proposed guidelines are based upon limited data with a high degree of variability.

Importance of microbial air quality

Two of the most important objectives of dairy processing are maintenance of product safety and acceptable shelf-life. These objectives are closely related since they are strongly influenced by post-pasteurization contamination. Potential sources of post-pasteurization contamination include air, the filling machine, improperly cleaned equipment and worn equipment as important possibilities. Air is usually considered the least important of these sources. Hedrick and Heldman *(34)* concluded that airborne contamination was of most importance in the manufacture of cultured milk products, followed by powder milk, cheese, market milk, ice cream and butter manufacturing in decreasing order of importance. More recently, the ice cream industry is emphasizing the control of air quality as means of preventing contamination of product with *Listeria*. The FDA and Milk Industry Foundation / International Ice Cream Association *(28)* recently issued guidelines for controlling environmental contamination in dairy plants. They indicate

TABLE 7. *Recommended maximum levels for air in various processing situations based on data from a Casella slit sampler.* (32).

Types of product	Standard Plate Count per 10 L	Yeast & Mold Count per 10 L
Milk and cream	1.8	0.7
Butter	3.6	1.8
Dried milk	2.8	1.8
Cultured milk and cream and cottage cheese	1.8	1.4
Ripened cheese	3.6	4.3

that airborne contamination is strongly suspected as a vehicle for pathogens entering into products.

An important part of the FDA Dairy Initiative Inspections has been the sampling of finished products for the presence of *Listeria, Yersinia, Salmonella,* and *Campylobacter*. None of these pathogens can survive the pasteurization process. As of 1986 the FDA found 26 plants which produced contaminated products *(72)*. Among the 26, eight contained pathogenic *Listeria* in their packaged products. Since these potential pathogens do not survive pasteurization, these plants probably have post-pasteurization contamination problems *(6,7,72)*. Dirty fillers and aerosols have been reported as the source of pathogen contamination *(72)*.

In one study *(12)*, about 25% of non-mold colonies from the air of a fluid milk plant were Gram negative rods and 24% of total colonies isolated could grow in 5 d at 10°C. Though the origin of these Gram negative rods is not clear, their presence in the air of the packaging area is of both public health and product shelf life significance. Plakhotya *(60)* found that *Salmonella* in an aerosol condition could survive up to 4.5 h, indicating the potential for airborne dissemination.

Controlling air quality in food processing areas

Aerosols of bactericidal or viricidal agents have been used in dairy industry for controlling airborne bacteria and bacteriophage. These agents have included various forms of chlorine, glycol, alcohols and quaternary ammonium compounds *(8,10)*. Fogging must be limited because of potential health effects on exposed workers. For example, a chlorine fog of 500 ppm will reduce airborne microflora, but over 10 ppm causes excessive human discomfort *(32)*. In addition, fogging will be less effective if the source of the aerosol is not controlled. Aerosols often originate from unclean surfaces as previously discussed.

Ultra-violet radiation can be used to decrease airborne microflora, but its use is also limited by worker safety.

The use of laminar air flow with HEPA (high efficiency particulate air) filters is highly recommended at critical points *(35,36,40)*. HEPA filters remove 100% of particles that are greater than 0.3 μm in size and consequently will remove all viable bacteria.

Stersky et al. *(67)* used a bipolar-oriented electrical field to reduce the level of viable aerosolized microorganisms. They found that a field of 14K to 20K volts reduced the mean airborne population by 31 to 59% during regular forced ventilation, depending upon the microbial species.

Vickers *(73)* concluded that the adoption of design conditions used in 'clean air' rooms and environmentally controlled work stations for dairy packaging and other critical hygiene areas is required to ensure production of safe dairy products with long shelf-life. These design conditions include physical separation of critical and non-critical hygiene areas, the adoption of air-locks, pressurization of critical hygiene areas, and use of HEPA filters. also heating, ventilating and air conditioning (HVAC) systems should be designed for easy cleaning and must be adequately maintained *(28)*. The engineering aspect of air flow control within a dairy processing plant are discussed by Heldman and Hedrick *(35)*. New dairy processing facilities are being designed and operated using these clean room concepts *(42)*.

Considering the potential importance of the problem, there is little published research on air quality in modern food processing plants. Additional study is needed to propose reasonable air quality guidelines in dairy and food processing plants and to recommend appropriate monitoring methods. Closer attention to air quality at critical processing points is required to reduce the risk of product contamination, but little information is available on the extent of the current problem.

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Listeriosis

Listeriosis is a disease of animals and humans that is caused by *Listeria monocytogenes*. Human infection has diverse manifestations, the most frequent being meningitis and neonatal sepsis.

ETIOLOGY AND EPIDEMIOLOGY

L. monocytogenes, a thin gram-positive bacillus, grows readily under aerobic conditions on the usual laboratory media. Colonies are weakly β-hemolytic and therefore may resemble colonies of streptococci. On a Gram's stain of exudates or spinal fluid, listerias may be confused with diphtheroids; they may even be confused with pneumococci or streptococci because listerias exist in coccoid forms. There are seven serotypes, of which types 1b and 4b are the most common causes of listeriosis in humans; serotyping may be of some value in epidemiological study of case clusters.

L. monocytogenes is a saprophyte found very extensively in plants and soil; it is also present in the intestinal tract of many species of animals and birds.[37] Both reservoirs are potential sources of exposure for humans, but the former appears to be more important because a history of animal exposure is lacking in most patients. *Listeria* can proliferate in refrigerated foods, and the organisms are more heat resistant than many other nonsporulating microbes. Several outbreaks suggest that food-borne transmission of listeriosis may be the most common route of human infection; contaminated dairy products are particularly suspect. An outbreak affecting more than 140 persons in California in 1985 was traced to the consumption of a Mexican-style cheese that was contaminated with *L. monocytogenes* type 4b; 48 deaths and stillbirths occurred.[38,39] Other large outbreaks of epidemic listeriosis have been linked to the ingestion of cabbage[40] or pasteurized milk[41] contaminated with this organism. *Listeria* can be cultured from about five percent of unpasteurized milk samples and from two percent of pasteurized milk samples.[42] Decreased gastric acidity may facilitate infection by ingested listerias.[43]

Occasionally, direct transmission from secretions of an infected animal occurs; for example, a veterinarian reportedly acquired listeriosis after attending an aborting dairy cow.[44] The prevalence of *L. monocytogenes* in human feces, which is about one percent in a random population but as high as 26 percent among household contacts of patients with listeriosis, does not suggest feces as a major source of the organism.[45]

PATHOGENESIS

Despite the ubiquity of *Listeria* organisms in the environment, human disease caused by *Listeria* is relatively uncommon. An estimated 800 to 1,700 cases occur in the United States each year, with an overall mortality of 19.1 percent.[46] Host factors are of major importance in determining susceptibility to listeriosis. There are two peak age groups for *Listeria* infections: infants during the first month of life and persons older than 70 years. Transmission of infection from mother to fetus may occur during the second half of pregnancy via the bacteremic route or possibly as a result of ingestion or aspiration of infected amniotic fluid. There is commonly a history of a nonspecific febrile illness in the mother before labor. The consequences of such infection are abortion, stillbirth, or an acutely ill neonate with pneumonia or disseminated infection during the first few days of life. Listeriosis may also be acquired during delivery, and then it may present as delayed-onset disease in neonates between three and 15 days of life.

Listeriosis may occur after infancy in otherwise healthy individuals, but in 50 to 75 percent of adult patients, there is an underlying predisposing factor. Such factors include neoplasm, particularly leukemia or lymphoma; a history of renal transplantation; a disease that has been treated with corticosteroids or cytotoxic drugs; a disease associated with impaired cell-mediated immunity, such as sarcoidosis; and cirrhosis of the liver.[47,48] Listeriosis has been surprisingly uncommon in patients infected with the human immunodeficiency virus (HIV), but 20 cases have been reported.[49]

CLINICAL FEATURES

Listeriosis during Pregnancy

In pregnant women, listeriosis most often occurs during the third trimester. It can produce a flulike syndrome characterized by fever, myalgias, and headache, often accompanied by abdominal cramps and diarrhea. Pregnant women with listeriosis usually recover fully, even without therapy. However, amnionitis, premature labor, and septic abortion may result from bacteremic infection of the placenta and fetus. Listeriosis is estimated to cause 100 stillbirths each year in the United States.[50]

Neonatal Listeriosis

Neonatal listeriosis accounts for one fourth to one third of cases of listeriosis and is estimated to affect one in 20,000 births.[51] Onset may occur early or late in neonatal life. Infants may be acutely ill at birth and may die within hours as a result of disseminated listeriosis, which is also called granulomatosis infantiseptica. This condition is

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characterized by hepatosplenomegaly, thrombocytopenia, generalized skin papules, whitish pharyngeal patches, and pneumonia. Commonly, a stained smear of meconium will reveal gram-positive bacilli, suggesting the diagnosis. More common than disseminated listeriosis in neonates is listeriosis characterized by interstitial pneumonia and respiratory insufficiency in a premature infant in the first day of life. About half of these patients have bacteremia and positive endotracheal cultures. Mortality is about 50 percent.

Late-onset listeriosis is characterized by meningitis that occurs between seven and 28 days of life. *L. monocytogenes* is the third most common cause of neonatal bacterial meningitis (after *Escherichia coli* and group B streptococcus),[52] accounting for five to 15 percent of the cases.[53] The CSF shows variable cell counts of 100 to 9,000/mm^3; commonly, polymorphonuclear leukocytes predominate, but in 30 percent of patients, a relative lymphocytosis is noted.[54]

Listeriosis in Older Children and Adults

Listeriosis in older children and adults is most often an opportunistic infection, but it can also occur in healthy individuals.

Meningitis Meningitis is the most common form of listerial infection, occurring in 60 to 70 percent of patients with listeriosis. Usually, listerial meningitis is clinically indistinguishable from other types of bacterial meningitis; however, ataxia and tremors may be prominent and can provide a clue to the diagnosis.[55] In immunosuppressed patients, the manifestations of meningitis may be less apparent. Nuchal rigidity may be absent; fever, headache, and obtundation may be the principal manifestations. The presence of these symptoms indicates the urgent need for examination of the cerebrospinal fluid. Uncommonly, the onset of listerial meningitis is subacute (lasting several weeks), with malaise, fever, and headache. Hydrocephalus is likely to develop. In meningitis acquired after the first month of life, polymorphonuclear leukocytes predominate in the CSF cell count in almost all instances; the rare exception is the patient with a subacute course.[56]

Rarely, listerial infection affects the brain without directly invading the subarachnoid space. This form of bacterial encephalitis has a propensity for producing pontobulbar involvement, with a clinical picture resembling polioencephalitis. Histologically, extensive areas of necrosis and suppuration are found in the pons and medulla. The CSF formula shows a few cells, predominantly lymphocytes, and a normal glucose level. Listerial brain abscesses are rare, occurring principally in immunosuppressed patients; blood cultures are positive in almost all cases.[57]

Bacteremia Bacteremia without meningitis or obvious focal infection occurs in five to 30 percent of cases of listeriosis in adults. No specific clinical features distinguish the disorder from other septicemic illnesses. The diagnosis is made by isolation of the organism from blood. Endocarditis[58] and myocarditis[59] may occur.

Miscellaneous infections Septic arthritis,[60] osteomyelitis,[61] peritonitis, cholecystitis, and localized abscesses caused by *L. monocytogenes* occasionally occur. Primary cutaneous listeriosis characterized by red, tender papular lesions with pustular centers has been reported in veterinarians. An infectious mononucleosis–like disease has been described but is evidently extremely rare in the United States. An acute febrile illness resembling severe hepatitis has been reported, consisting of listerial bacteremia and miliary abscesses of the liver.[62]

DIAGNOSIS

As a cause of neonatal sepsis, listeriosis must be differentiated from syphilis, toxoplasmosis, and infections with cytomegalovirus, herpesvirus, and group B *Streptococcus*. *L. monocytogenes* must be distinguished from other bacterial and fungal causes of meningitis in both normal and immunosuppressed patients. Only isolation of the organism will provide an etiologic diagnosis. The presence of thin gram-positive bacilli in smears of gastric or tracheal aspirates from newborns or in smears of spinal fluid from patients with meningitis strongly suggests the diagnosis. A diphtheroidlike organism isolated on a smear should not be construed as a contaminant in such a situation, and further bacteriologic definition is required. There is no reliable serodiagnostic test for listeriosis.

MANAGEMENT

Ampicillin is the treatment of choice for listerial infections, including meningitis.[63] In vitro data have shown that ampicillin and aminoglycosides have a synergistic bactericidal effect against *L. monocytogenes*,[64] but there is no evidence, at this time, of the clinical superiority of this combination over ampicillin alone in the treatment of listerial meningitis. Ampicillin is administered to adults in a daily dosage of 12 g I.V. in divided doses every four hours.

It has not been determined which antibiotics are preferred as alternatives to ampicillin for the treatment of penicillin-allergic patients with listeriosis. Traditionally, it has been recommended that tetracycline or erythromycin be administered in very high doses. Trimethoprim-sulfamethoxazole is more active than these agents in vitro and is bactericidal against most strains of *Listeria*.[65] It has been used successfully in treating penicillin-allergic patients with listeriosis,[66] but clinical experience is scant. Vancomycin has on occasion been used successfully to treat cases of listerial bacteremia.[67]

Because of the frequency of relapse, treatment of listerial meningitis with ampicillin should be continued for at least 10 days after the patient becomes afebrile, which is a longer period of treatment than that employed in the more common forms of bacterial meningitis. Treatment should be continued even longer in patients who have received alternative antibiotics.

Treatment of active or latent listerial infection in pregnancy, as confirmed by a positive cervical culture, is warranted. Ampicillin is the drug of choice and should be given in quantities large enough to ensure adequate levels in both mother and fetus—1.0 to 1.5 g orally every six hours for eight to 10 days.