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Health Risks Related to Shift Work

An Example of Time-Contingent Effects of Long-Term Stress

Margit Koller

Institute of Environmental Hygiene, University of Vienna (Director: Prof. DDr. Manfred Haider), Kinderspitalgasse 15, A-1095 Wien, Austria

Summary. In an oil refinery with a labour force of 1260 male blue-collar workers, 300 matched cases of permanent shift workers, day workers, and drop-outs were selected and split into four groups corresponding in age and years at work.

In terms of an overall score ("health score", computed from data concerning absence due to sickness, morbidity, distribution and severity of diseases, and subjective complaints) health was found to deteriorate with age, but to a different degree in the shift and day workers.

In shift workers, a steep decrease in score during the first years at work was followed by a continued slight decrease in middle age; from the age of 41 years onwards there was a further pronounced decrease in score. In day workers a stabilization in score was observed up to middle age, with a distinct decrease thereafter.

The difference in health parameters between the groups was only small in younger workers (up to 12 years at work), but became striking and significant with increasing age. In the permanent shift workers an increasing health risk was clearly indicated by increases in absence due to sickness, gastro-intestinal and cardiovascular diseases and unspecific health complaints (sleep disturbances, premature fatigue). A specific kind of behaviour during illness (e.g. less readiness to consult a doctor) was also observed in the shift workers. In the permanent day workers health risks were not strictly age-related. Whereas absence due to sickness was highest in young workers, morbidity for respiratory diseases and injuries was significantly elevated in the older workers; the frequency of subjective complaints increased up to middle age and decreased thereafter.

In drop-outs with considerable prior exposure to shift work, strikingly high rates of absence due to sickness and excess rates of cardiovascular diseases were observed.

Key words: Shift work – Health risks – Chronic stress – Absence due to sickness – Age-dependent diseases

Introduction

One of the most urgent aims of environmental and occupational medicine should be to clarify what sort of stress mechanisms may eventually lead to long-term suffering and chronic disease. At the moment we must rely on such evidence as can be gained from epidemiological studies, and from field studies conducted in particular industries.

To investigate chronic long-term stress effects, the night and shift work situation can be used to study on the one hand the development of disease, and on the other the efficiency of coping mechanisms leading to health stabilization.

In discussing the effects of shift work it must clearly be remembered that a certain proportion of the shift-working population does not show an obvious deterioration in health (13, 34, 37, 38] and that some people even prefer shift work to other kinds of work [43]. Therefore, we cannot expect to arrive at general, simple and causal explanations for adverse shift work effects. We must rather assume that shift work will under "certain adverse conditions" lead to complaints and to a deterioration in health, but that it is also possible for this process to be stopped by restabilization of feedback mechanisms, with the worker consequently adapting to the situation.

One useful conceptual description of "certain adverse conditions" in relation to night and shift work has been advanced by Colquhoun and Rutenfranz [7]: "The objective stress resulting from the disruption of physiological 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 psychological 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". Colquhoun and Rutenfranz include among these variables person-related, work-related and society-related factors.

This conceptual structure has the potential to explain differences observed between subjects exposed to the same stressors. Furthermore, the proposed interactional network of variables has obvious dynamic features in the course of time. We must therefore try to explore the time-contingent sequential development of the whole structure.

With different lengths of exposure to work and to de- and re-synchronization of physiological and psychological functions, habituational and sensitization mechanisms develop, which change qualitatively and quantitatively with time [8, 9, 10, 40, 44].

Maladaptation, which becomes apparent at different ages and after varying lengths of work exposure, certainly induces psychophysiological disturbances that vary both in magnitude and structure, and adequate as well as inadequate coping behaviour [22, 30] may result in connection with this.

A model for time-contingent destabilization, recently developed in our institute [12, 19–21], might the useful to test the importance of different factors within the interactional network of variables in relation to health in the course of time. The model indicates that three consecutive phases–adaptation, sensitiza-

tion and accumulation-are important in this development. In the course of exposure to shift work, some people are obviously able to stabilize their person-environment relationship at a new steady state (adaptation, first phase). Others may reach the sensitization phase (second phase), but overcome it successfully and do not exhibit complaints and symptoms related to work strain. A certain proportion finally reach a stage at which complaints and symptoms accumulate (third phase) and the probability of the manifestation of disease increases.

The aim of the present study was to apply this model of time-contingent destabilization by dividing the permanent shift workers, permanent day workers and drop-outs into four defined age groups of varying work experience, which in earlier findings [12] represented the breakpoints between the adaptation and sensitization phases or between the sensitization and accumulation phases. The effects of the above-described phases on health and the sequential development of diseases should be checked by objective health parameters.

Methods

Procedure

The field study was carried out in an Austrian oil refinery. Support was received both from the management and from the workers' representatives.[1]

The present investigation was designed as a control study for an almost identical one carried out 5 years earlier [17, 18]. Simultaneously it served as the second stage of a longitudinal prospective study.

The investigation was based on questionnaire and interview data, as well as on a medical check-up. The subjects selected filled in the questionnaire, came for interview, and had their medical check-up during normal working hours in the plant. Data obtained from the questionnaire included personal characteristics, vocational history and attitudes towards work, working conditions and work strain, family life and leisure-time activities. In the interview, morningness-eveningness, quality and quantity of sleep, eating and smoking habits, alcohol and coffee intake, amount of physical training, "illness behaviour" and unspecific and/or psychosomatic complaints were checked. (A full analysis of these data will be published later).

Both the questionnaire and interview were in part based on standardized and tested procedures [11, 14, 26-28] and in part developed by the author in cooperation with psychologists from the institute.[2]

The medical check-up included the taking of the full history (onset and duration of previous and present symptoms, diseases and injuries; quality and severity thereof; doctors' consultations, treatments and drug intake; hospitalizations and surgery) and the identification of risk factors and indicators. Information on absence from work due to illness was also elicited.

Selection of Men

From 1260 male blue-collar workers (855 shift workers and 405 day workers) a random sample of 230 shift workers and 110 day workers was selected with comparable environmental and working conditions.

Shift workers were subdivided into four groups with varying lengths of shift experience: group I up to 3 years on shift, group II from 4 to 12 years, group III from 13 to 22 years, and

[1] I am very obliged to Dr. Widder and Dr. Köck (personnel managers of the oil refinery) and to Mr. Bothe, Mr. Nemec and Mr. Seidl (workers' representatives) for their support and cooperation

[2] Dr. Renate Cervinka and Dr. Michael Kundi

Table 1. Characteristics of the permanent shift workers, permanent day workers and drop-outs included in the analyses, divided into four groups according to work experience

	Multiple matched cases		
	Shift workers	Day workers	Drop-outs
Group I			
n	62	23	
Age ($\bar{x} \pm SD$)	25.1±3.3	25.0±3.5	
Years working ($\bar{x} \pm SD$)	10.5±4.3	9.8±4.8	
Years on shift	0–3 years	–	
Group II			
n	87	23	12
Age ($\bar{x} \pm SD$)	34.4±5.7	33.6±4.3	33.1±4.7
Years working ($\bar{x} \pm SD$)	17.7±4.6	17.7±5.7	18.6±4.8
Years on shift	4–12 years	–	$\bar{x}$: 3.1±3.8
Group III			
n	38	12	
Age ($\bar{x} \pm SD$)	40.8±7.5	38.6±4.3	
Years working ($\bar{x} \pm SD$)	25.7±7.5	23.9±9.4	
Years on shift	13–22 years	–	
Group IV			
n	12	10	22
Age ($\bar{x} \pm SD$)	50.2±2.4	48.6±8.3	49.8±6.1
Years working ($\bar{x} \pm SD$)	35.1±7.5	33.8±4.3	32.7±5.4
Years on shift	23–40 years	–	$\bar{x}$: 12.1±6.3
Total (all groups)	199	68	34

group IV from 23 to 40 years on shift. Each day worker was then randomly assigned to 1, 2 or 3 shift workers corresponding in age and years at work. By this procedure, day workers were matched to shift workers with regard to age and years on work, leaving 68 day workers and 199 shift workers as matched groups (Table 1).

Moreover, 34 workers were identified who had changed within the plant, from shift work to day work. Reasons for doing so were mainly negative (health and/or family problems); this population was therefore labelled "drop-outs". Due to the small size of this group, the drop-outs were only assigned to groups I and II or groups III and IV.

Work Schedule

The vast majority of shift workers were working according to a swiftly rotating continuous 4-shift system with shorter morning and afternoon shifts (7 h), a longer night shift (10 h) and every 4 weeks one or two especially long day shifts (14 h) over the weekends (Table 2)–an average of 40 h work per week. Day workers started at 7 a.m. and left the plant at 3.30 p.m.

Statistical Procedures

The data obtained from the questionnaire and interview sheets were coded, then fed into a computer for statistical analyses, which were in part performed using programmes specially developed for this purpose.[3] The Brandt-Snedecor and chi-square tests were used for most frequency comparisons, but in some cases Fisher's exact probability test (for independent

[3] I am very obliged to Dr. Kundi for his statistical advice and for the complex statistical analysis

Table 2. General shift schedule

	Su	*Mo*	*Tu*	*We*	*Th*	*Fr*	*Sa*	*Su*	*Mo*	*Tu*	*We*	*Th*	*Fr*	*Sa*	*Su*	*Mo*	*Tu*	*We*	*Th*	*Fr*	*Sa*	*Su*	*Mo*	*Tu*	*We*	*Th*	*Fr*	*Sa*
1st–4th Week	LS	A	N	N	–	–	–	–	–	M	M	M	M	M	N	N	–	–	A	A	N	–	M	A	A	N	N	–
5th–8th Week	–	M	A	A	N	N	–	LS	A	N	N	–	–	–	–	–	M	M	M	M	LS	N	N	–	–	A	A	N
9th–12th Week	N	N	–	–	A	A	N	–	M	A	A	N	N	–	LS	A	N	N	–	–	–	–	–	M	M	M	M	LS
13th–16th Week	–	–	M	M	M	M	LS	N	N	–	–	A	A	N	–	M	A	A	N	N	–	LS	A	N	N	–	–	–

LS (Long shift) 0650–2050 (14 h)
M (Morning shift) 0650–1350 (7 h)
A (Afternoon shift) 1350–2050 (7 h)
N (Night shift) 2050–0650 (10 h)
– (Days off)

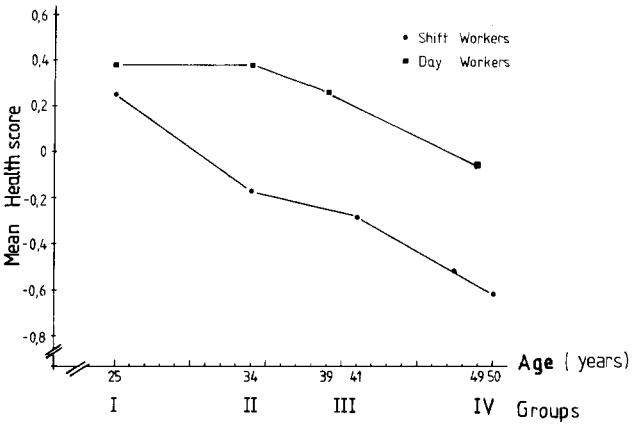

Fig. 1. Mean overall score of the present state of health, transformed according to McCall [24], for permanent shift workers and permanent day workers; populations are subdivided into four age groups with different lengths of work experience

measures) and McNemar's test for the significance of changes (for dependent ones) were used instead. Mean scores were compared by the *t*-test, or by its non-parametric analogue, the Mann-Whitney *U*-test; in some instances a modification of this test for classified data (the Raatz test) was used.

Health Score

The case histories of diseases and injuries were classified by a panel of physicians according to the ICD (International Classification of Disease [15]).

The information obtained from system reviews concerning severity, duration, doctor consultations, treatment, drug intake, hospitalizations and surgical interventions was quantified according to a procedure developed by the author [18], to produce an overall measure of the present health state expressed as a single number on a scale. The maximum on this scale (no diseases or symptoms) was set at 100, the minimum (several functional systems severely affected; irreparable severe dysfunctions, disablements) was set at 10. Scores on this scale were subjected to the McCall transformation before analysis [24]. This area transformation normalizes the scale in such a way that the resulting scale has a normal distribution with zero mean and unit variance.

Results

Mean Health Score in Permanent Shift and Day Workers

If health-impairing factors are different for shift and day workers and the total amount of stress also differs, the rate of deterioration in health state should be different for the two groups in the course of time. To test this hypothesis, permanent shift and day workers were split into four age groups (for mean age of the groups I–IV, see Table 1) and their mean overall health scores were compared. As Fig. 1. demonstrates, the deterioration in health with age is steeper in shift workers than in day workers, and the difference becomes more pronounced in older workers. In the course of time, shift workers develop a typical health score curve (which was also observed in an earlier study on shift work at the oil refin-

Table 3. Absence due to sickness of permanent shift workers, permanent day workers and drop-outs, subdivided into four groups according to work experience

	Shift workers (SW) $n=199$	Day workers (DW) $n=68$	Drop-outs (DO) $n=34$	Significance *U*-Test S_j-test Jonckheere
Total	15.7	15.3	27.2	SW, DW–DO<5%
Group I	9.9	21.4	16.7	
Group II	16.8	11.2		
Group III	18.2	13.4	34.4	
Group IV	21.2	14.0		SW: Group I-IV<5%

ery, [12]. After a steep decrease during the initial years at work, the rate of deterioration becomes moderate in middle age. A second steep decrease is observed from the age of 41 onwards.

Criteria for the Description of Health

A number of indices and criteria are used to define health and well-being operationally. In the study of shift work and health, a wide range of methods are used and the results are often contradictory.

Hence, it seemed useful to apply several criteria to the same populations in order to reveal discrepancies, and possibly to arrive at some explanations for the inconsistencies in the research findings.

Comparison of Rate of Absence due to Sickness for Permanent Shift and Day Workers, and Drop-outs. The average number of days of absence due to sickness per man per year amounts to approximately 15 in both shift workers and permanent day workers (Table 3). However, in day workers who dropped out of shift work the number greatly exceeds this. The difference is statistically significant. It follows that a comparison of shift workers with *all* day workers (permanent day workers plus drop-outs) would show an excess rate of absence in day workers.

Comparison of the number of sick days according to age groups shows that the lowest number occurred in young shift workers. However, a statistically significant rise can be observed in the number of sick days with increasing work exposure. A tendency towards a higher sickness rate is apparent in older drop-outs; no significant regular trend was noted in day workers.

The mean number of spells of absence (not included in Table 3) is highest in shift workers (1.58), followed by drop-outs (1.26) and permanent day workers (1.22).

Comparison of Illness Behaviour in Permanent Shift and Day Workers and Drop-outs. As "sickness absence" or registration of morbidity might depend on "illness behaviour" (i.e. varying degrees of willingness to consult a doctor, or to take sick leave, in shift and day workers) the ratios—of symptom prevalence to number of doctor consultations, and—of doctor consultations to confinement to bed were calculated for each population.

Table 4. Morbidity of permanent shift workers, permanent day workers and drop-outs according to disease class (ICD). Significance levels indicated in the last two columns; *t.* = tendency (significance level > 5% but < 10%)

Diseases	Shift workers (SW, $n=199$) %	Day workers (DW, $n=68$) %	Drop-outs (DO, $n=34$) %	Significance	
				Brandt & Snedecor test	CHI-square, Fisher test
ICD 240-279 endocrine and metabolic	3.5	1.5	2.9	n.s.	–
ICD 290-319 psychoses, psychoneuroses and disorders of personality	10.6	1.5	5.9	5%	SW-DW *t.*
ICD 320-389 of nervous system and sense organs	9.5	4.4	5.9	n.s.	–
ICD 390-459 of circulatory system	*19.9*	*7.4*	14.7	< 5%	SW-DW, < 5%
ICD 460-519 of respiratiory system	*31.2*	*45.6*	41.2	< 5%	SW-DW, < 5%
ICD 520-579 of digestive system	*30.1*	*13.2*	*14.7*	< 1%	SW-DW, < 1% SW-DO, *t.*
ICD 580-608 of genito-urinary system	1.5	4.4	2.9	n.s.	–
ICD 680-709 of skin and subcutaneous tissue	10.6	5.9	0.0	–	n.s.
ICD 710-739 of musculoskeletal system and connective tissue	23.6	14.7	26.5	n.s.	–
ICD E-800-959 accidents	15.6	23.5	11.8	n.s.	–

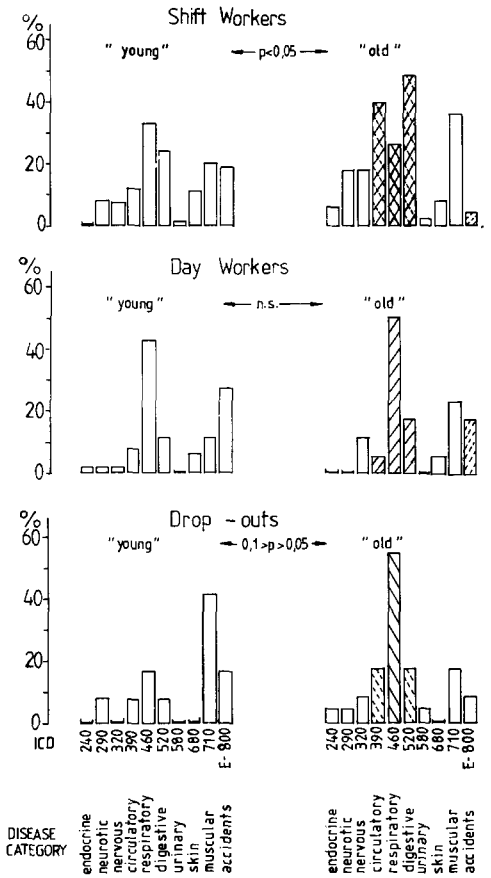

Fig. 2. Prevalence of diseases and accidents (ICD) in permanent shift workers, permanent day workers and drop-outs (%). Left columns ("young"): 0–12 years at work, i.e. groups I and II. Right columns ("old"): 13–40 years at work, i.e. groups III and IV. Significance of differences:
shift workers vs. day workers,
▨ = $P < 0.05$ ▨ = $P < 0.01$
shift workers vs. drop-outs,
▧ = $P < 0.05$ ▧ = $P < 0.01$
□ = n.s

The first ratio averaged 0.55 for shift workers, 0.95 for day workers, and 0.90 for drop-outs.

The second ratio averaged 0.70 for shift workers, 0.85 for day workers, and 0.90 for drop-outs.

The findings indicate different kinds of illness behaviour in shift and day working populations.

Comparison of Morbidity for Permanent Shift and Day Workers and Drop-outs. Having grouped diseases and accidents according to ICD [15], morbidity rates were calculated for the three populations (Table 4).

In permanent day workers, the highest proportion of diseases is in the respiratory system (significantly higher than in shift workers), whereas the shift-working population significantly exceeds permanent day workers in diseases of the digestive system and the circulatory system. Drop-outs are similar to permanent day workers as regards the prevalence of respiratory and digestive ailments. On the other hand, the percentage of drop-outs with circulatory diseases is twice as high as that in day workers but lower than that in shift workers.

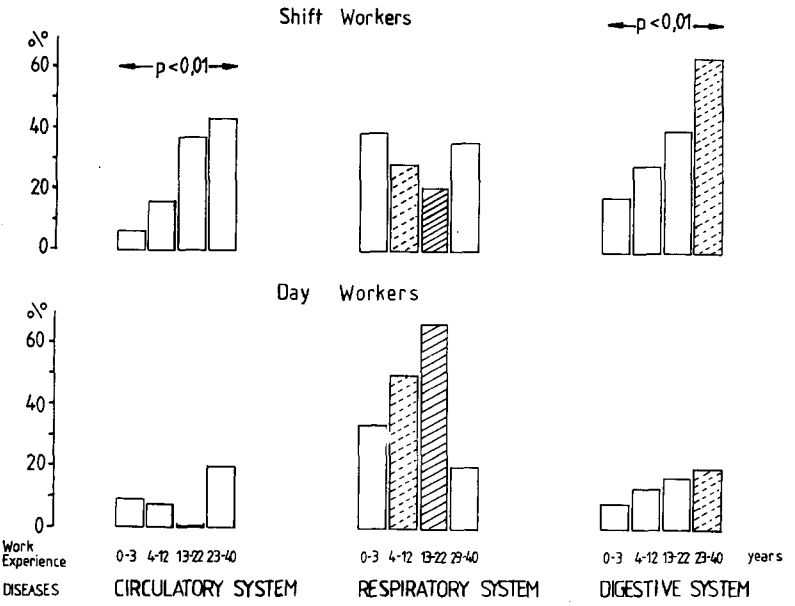

Fig. 3. Prevalence of diseases in the three discriminatory disease categories (see Fig. 2) for permanent shift workers and permanent day workers (%), subdivided into four groups according to work experience (see Table 1).
□ = n.s, ▨ = $P < 0.05$ ▨ = $P < 0.01$

The prevalence of psychoneurotic disturbance is highest in shift workers, the difference as compared to the day workers being near the significance level (t).

To analyse age-dependent health effects, frequencies of organ affections were summed separately for subpopulations of shift workers, day workers and drop-outs (Fig. 2). Between "young" and "old" shift workers, a significantly different distribution of disease frequencies was observed. ($P<0.05$, Raatz-Test). The same tendency was seen for drop-outs, but was not observed in day workers. Thus, the cluster of symptoms and illnesses changed markedly more with time in shift workers. Comparing the "young" workers of the three populations (left columns) revealed only a tendency towards a higher incidence of gastro-intestinal disease in shift workers as compared to day workers. This suggests that there is little difference in the general prevalence of *disease* in the younger age groups. However, in groups III and IV (right columns, older workers) several significant differences between workers can be observed. The older shift workers show an increased prevalence of circulatory and digestive diseases, which is statistically significant when compared to that in both permanent day workers and drop-outs (χ^2-test). In contrast, there is evidence in our data that the frequency of respiratory diseases is significantly elevated in both the older age groups of day workers and drop-outs, when compared to that in older shift workers (χ^2-test).

The accident rate is highest in older day workers, and it is significantly elevated in comparison to that for older shift workers.

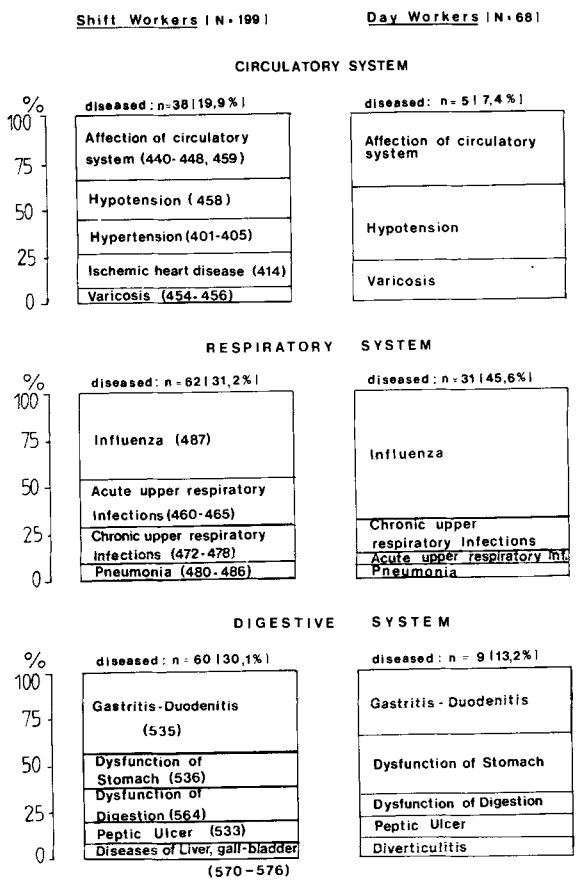

Fig. 4. Distribution of diseases (ICD) within the three discriminatory disease categories (in percent) of diseased shift workers and diseased permanent day workers

Figure 3 gives a more detailed picture of time-contingent effects on the manifestation of disease. Here, the development of disease in the three organ systems of most interest is demonstrated for the four groups of shift and day workers of different age and work experience (refer to Table 1). Whereas no systematic temporal trends are detectable in the day workers, increases in the frequency of both circulatory and digestive ailments with increasing age and work experience are obvious in the shift workers. These increases correlate with a significant rise in sickness absence (compare with Tabel 3). The excessive number of gastrointestinal disorders in shift workers as compared to day workers is statistically significant in the oldest group. In contrast, there is a statistically significant excessive prevalence of respiratory diseases in middle aged day workers, which one might not expect. As regards the organ systems not represented in Fig. 3, a striking rise in metabolic disorders is observable in shift workers over 50, which in the main is the result of manifest diabetes mellitus. Similarly, a moderate but consistent rise in debilities of the sense organs occurs, mainly hearing loss (permanent threshold shift due to noise) and defective vision. However, the small number of samples meant that the actual incidence of these diseases was too low for statistical analyses of the data.

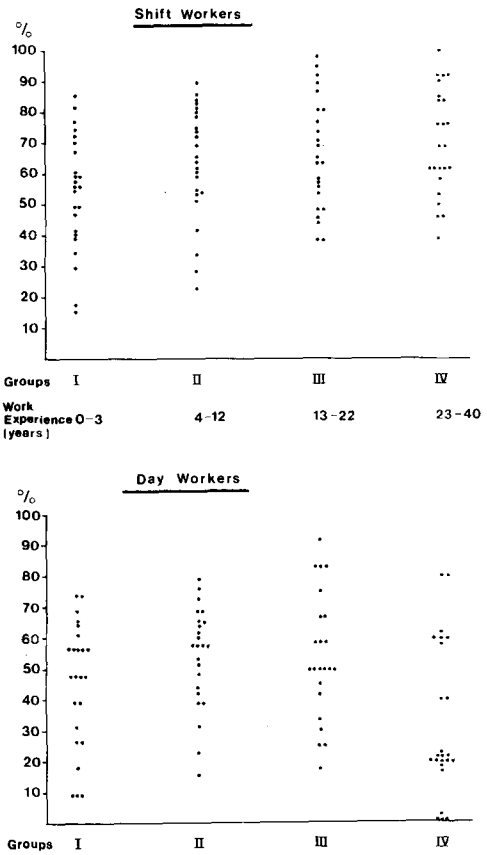

Fig. 5. Relative frequency of workers complaining of unspecific symptoms. Permanent shift workers (*upper part*) and permanent day workers (*lower part*) are split into four groups according to work experience. Each point represents a percentage of persons suffering from 1 of the 24 included symptoms. The symptoms are not specially visualized in this figure

Distribution of Diseases and Symptoms within Certain Disease Categories

Figure 4 compares the disease distribution within the circulatory, respiratory and digestive systems in permanent shift and day workers. Whereas the actual frequency of illnesses related to each of the systems is substantially different in shift and day workers, the distributions of these illnesses within disease categories, as well as their rank orders of occurrence, are not markedly different. Thus, although influenza is significantly more frequent in day workers, peptic ulcer, for example, is observable in both populations, and its relative frequency is similar.

Concerning drop-outs, the diagnoses which induced the change-over to day work were centred on the following diseases: epileptic seizures (2 cases), angina pectoris and myocardial infarction (4 cases), duodenal ulcer and gastric haemorrhage (4 cases), arthritis, spondilitis and muscular rheumatism (5 cases).

Comparison of Shift and Day Workers Regarding Severity of Diseases. Having classified the observed diseases by degree of severity (according to the information available concerning doctor consultations, drug intake, hospitalizations and surgical interventions) a comparison was made between permanent shift and day workers. No consistent difference was found, either for the total populations or for any of the four age groups considered separately.

Comparison of Unspecific/Psychosomatic Symptoms for Permanent Shift and Day Workers. In the course of the interview, subjects were asked about present complaints concerning well-being and health, using a list of 24 unspecific symptoms (headache, dizziness, abnormal sweating, trembling, restlessness, nervousness, anxiety, premature fatigue, sleep disturbances, chest pain, pain ascribed to the heart, palpitation, tachycardia, feelings of arrhythmia, epigastric pain, nausea, heart burn, discomfort, dysphagia, "bloating", constipation, diarrhoea, undue hunger, loss of appetite).

Except for the high amount of sleep disturbances in shift workers (rank 1: 86.1%), the rank orders of the most frequent complaints are similar for both populations. For shift workers, nervousness ranks second (84.8%), followed by premature fatigue (83.2%) and headache (83.0%). Day workers' complaints rank as follows: (1) headache (76.2%); (2) nervousness (75.7%); (3) premature fatigue (66.7%).

In Fig. 5, the frequencies of workers complaining of unspecific symptoms are plotted. Permanent shift and day workers are again grouped according to varying work experience. Each point presents a percentage of persons suffering from 1 of the 24 symptoms included. The symptoms are not specially visualized in this figure.

In the shift-working population, the overall frequency of complaints increases with age at a relatively constant rate. This trend is statistically significant (Jonckheere test, $P < 0.05$). A different, but not significant trend is seen in the day workers. Although there is, again, an increase in the proportion of workers with unspecific health complaints up to middle age, the number of workers with health complaints then declines.

Discussion

Conclusions about the state of health can be drawn from different indications. One frequently used is absence due to sickness, though this is not a reliable measure of morbidity. Some papers in the literature concerned with "sickness absence" suggest that there is no difference between shift and day workers [e.g. 16, 33], and some that the rate is actually lower in shift workers [4, 23, 38, 39, 42]. These findings may partly be explained by the excessively high rate of sickness absence attributable to respiratory diseases in older day workers. In addition, day workers with and without former shift experience have usually been regarded as one uniform group. This does not seem to be justified. Aanonsen [1] and Taylor and Pocock [37] point out, for example, that it is seldom that different age classes have been compared [41].

In our investigation, no difference in sickness absence could be found between permanent shift and day workers, but there was a significantly excessive rate in drop-outs. Had we regarded day workers and drop-outs as one population, a higher rate of sickness absence would have been seen in this combined group of day workers. Thus, according to the method used, either of the results cited in the literature could have been replicated.

It should not be assumed, from the absence of a difference in absenteeism between permanent shift and day workers, that the health risks of shift workers

are no different from those of day workers. Young shift workers seem to take only very few days of sick leave, but their sickness absence increases markedly with increasing work exposure. This increase does not occur in permanent day workers.

Drop-outs with considerable former shift experience show a strikingly high rate of sickness absence, even years after they have changed over to day work. It may be that the health destabilization effects resulting from the frequent time shifts associated with shift working have a long latency, or it may be that drop-outs are a population specifically at risk (a proposition discussed in an earlier paper of the author [18]).

On the whole it can be stated that the rate of sickness absence is not a reliable indicator of health, since a more accurate description of this parameter would be "absence from work *attributed* to sickness" [13]. Such absence may be influenced by many factors which have nothing to do with health or disease. Again, "illness behaviour" [11, 28]–which includes the threshold at which existing symptoms induce men to stay in bed, the acceptance of illness, and the point in time and degree of recovery at which they decide to return to work–might be different in different populations. This indeed seemed to be the case in the population we studied. The shift workers needed to be suffering from more symptoms before they consulted a doctor or stayed in bed. Another indication in the present study that illness behaviour is different in shift and day workers is the fact that the duration of sickness absence per spell is generally shorter in shift workers (as was the case in the study of Walker and de la Mare [41]), despite the finding that the severity of their symptoms and diseases does not appear to be different from that of day workers.

This altered behaviour in the shift workers may be due to a higher "esprit de corps", as Aanonsen [1] puts it, or to the fact that they are "a highly motivated elite group" (according to Taylor et al. [38]) and have a highly developed sense of solidarity. Other researchers consider that this difference in behaviour may arise from the fact that shift workers fear the consequences of their absenteeism more than day workers [29].

The analysis of illness distribution (Figs. 2, 3) according to age suggests that the differences in diseases between shift and day workers become more pronounced in older workers and that the significant decline in the state of health with time in shift workers is mainly due to gastro-intestinal and cardiovascular disorders. Thus, the two main sources of health risks for shift workers that are most frequently cited (1–4, 13, 23, 29, 34, 36, 39] were once again confirmed in our own investigation.

Published results relating to respiratory diseases in shift and day workers are rare, and show on the one hand higher sickness absence rates in shift workers [41] and on the other lower rates of bronchitis in shift workers [38]. The higher prevalence of respiratory ailments observed in our day worker population is considered to be due to a higher probability of microbe transmission in this population. Shift workers, because of their way of life, are less likely to come into contact with crowds (both on the way to and from work, and in their leisure time), and therefore infections from airborne diseases are less probable.

The results from the drop-outs show that their differential health state is similar to day workers in respect of infections of the respiratory (higher prevalence) and digestive (low prevalence) systems, but that they approximate to shift workers in their high prevalence of circulatory illnesses. Similar results are reported by Taylor and Pocock (higher cardiovascular mortality [37]) and Prosa (higher morbidity [29]).

When the various health data are summarized by one overall score, a different pattern of development with increasing work exposure can be observed in shift and day workers. Starting from almost the same level, the health and well-being of young shift workers deteriorate rapidly. This may be accounted for by the assumption that starting work and adaptation necessary are accompanied by increasing stress reactions, and that young shift workers are not able or willing to compensate adequately for these effects [22]. The rapid deterioration in health state may induce a number of people to leave shift work (as indicated in some studies, [1, 2, 31, 38]).

In the groups of middle age, the health state apparently becomes more stabilized in shift workers and stays so in day workers, but the level is consistenly lower in shift workers. Here the repeated stress of forced de- and resynchronizations of rhythms [5, 6, 32, 34] in combination with psychosocial stressors due to family and social problems [26] may play an important role.

The sharp decline in health state in shift workers older than 40-45 agrees with the findings of others [3, 9, 25]. According to our hypothesis, this severe deterioration may be the result of long-term sensitization processes after many years on shift work. At this point the body may reach a tolerance limit, beyond which events–even insignificant ones–may lead to destabilization and manifest disease.

To prevent adaptation disturbances and adverse health effects one should try to introduce counteracting measures in good time. In accordance with the destabilization phases described, one might propose the following.

During the initial years of shift work (adaptation phase), an advisory function would primarily be necessary, to provide information on the effects of biorhythmical shifts, the need for an adequate sleep regimen, concerning the discussion of qualitative and quantitative food intake during night shifts.

With longer shift experience (sensitization phase), medical care should be improved in the sense of "primary prevention". Groups should be formed for physical training, training in relaxation techniques, weight reduction etc.; emphasis should be laid on information concerning the adverse effects of stimulants, drug and alcohol abuse, and so on.

After 20-25 years of shift experience (accumulation phase), preventive cures should be provided for gastro-intestinal and cardiovasular disturbances. Moreover, additional free weeks should be included in the work schedule for rehabilitative measures, for instance in existing rehabilitation centres, to prevent serious health hazards.

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