SHIFT WORK RESEARCH ISSUES

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In the last ten years shift work has become, both for practical and theoretical reasons, a matter of increasing interest to a growing number of scientists in different countries, mostly in Europe. Because of this, a group of Institutes have organized several shift work symposia during this period, usually under the auspices of the International Association of Occupational Health. Our conference follows this tradition in many ways, because the selected themes (and indeed some of the individual speakers) are identical with those in previous symposia Oslo 1969 (Swensson, 1969); Slanchev Bryag 1971 (Swensson, 1972); Dortmund 1974 (Colquhoun, Folkard, Knauth, & Rutenfranz); Dortmund 1977 (Rutenfranz & Colquhoun, 1978).

As a result of these symposia, the Scientific Committee of Shiftwork of the International Association of Occupational Health decreed at its session in Dubrovnik 1978 that the main themes to be pursued in current research should be:

- -the implications of circadian rhythm research for shift work problems;
- -methodological problems in conducting both experimental and field studies of shift work;
- -individual differences in adaptability to shift work;
- -socio-psychological problems created by shift work;
- -development of criteria for optimal shift systems and their evaluation;
- -development of non-monetary techniques of compensating for the effects of working unsocial hours.

The general theoretical background for these topics is given in Figure 1. In terms of the stress-strain concept of modern occupational medicine, shift work problems can be described as:

1) The Objective Stress of Shift Work. This means the exposure of everybody working in shifts to the phase shifting of working and sleeping hours in relation to the normal phases of the circadian rhythms of physiological or performance functions; a special aspect of this problem is the time course of the adaptive processes in physiological functions after a shift in working hours, i.e., their re-entrainment.
2) The Subjective Strain Caused by This Stress. This strain may express itself in complaints, lowering of well-being and possible adverse health effects. At this moment, many governments are mainly interested in the health effects of shift work. This can be seen from the discussions about shift work as a possible cause of disease, especially gastrointestinal disease, although there is very little evidence of this. Nevertheless, shift work does produce many non-clinical complaints because of disturbed sleep, changes in eating habits and disruptions of family and social life. But the importance of these disorders for a particular person depends on
3) Intervening Variables, such as:
   - -housing standards (especially sleeping conditions);
   - -the family situation (age of children, acceptance of shift work by the family as a whole);
   - -personality;

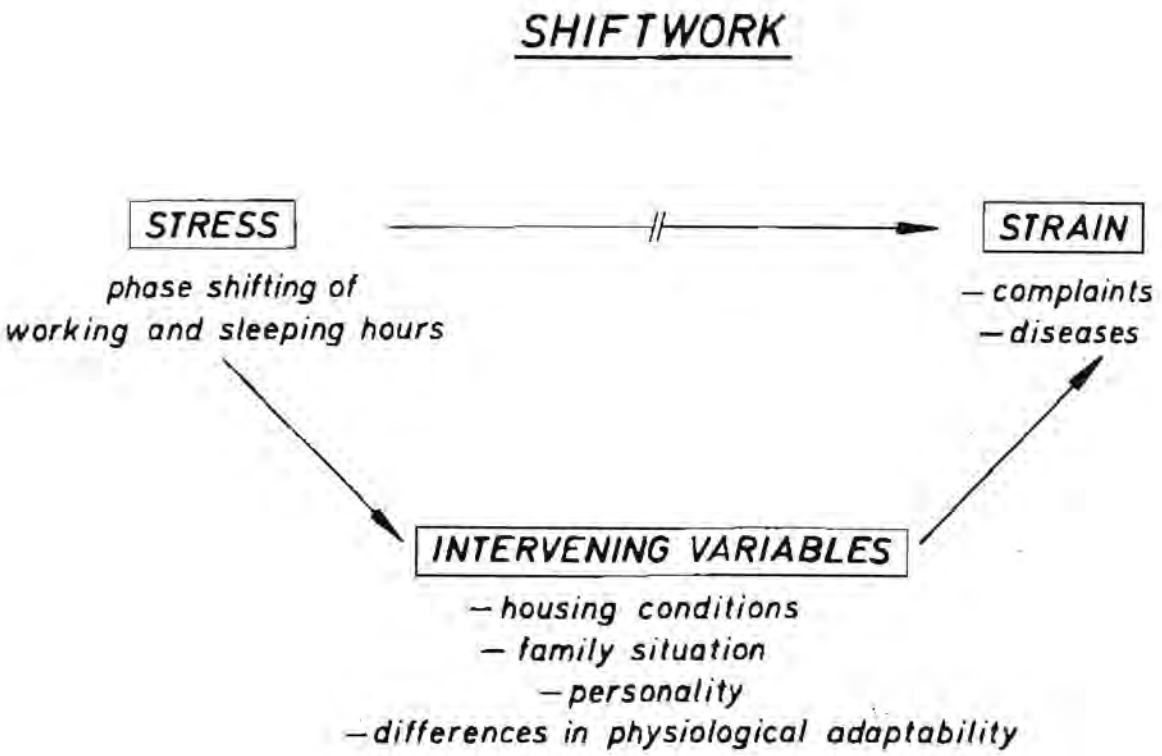


Figure 1. Model of relations between stress, intervening variables and strain in connection with shiftwork (Rutenfranz, 1976).

-differences in physiological adaptability.

These intervening factors determine if a particular person is able to cope with shift work, or if the disturbances of well-being will be augmented to such a degree that actual diseases will occur (Rutenfranz, 1976).

To cope with these problems, it is necessary to develop research-based principles for selection of shift workers, compensation for shift work, and construction of shift work schedules.

Therefore, I shall try to represent the actual position of research, including questions still open in relation to the following problems:
1) Re-entrainment of physiological functions during experimental shift work and in real life situations;
2) Effects of shift work on well-being and diseases;
3) Personal and situational differences in shift workers;
4) Chronohygiene of shift work.

Re-Entrainment Problems During Shift Work

If stress in shift work results from the discrepancy between the time-structure of behaviour (work, sleep) and the circadian rhythm of physiological functions geared to the normal daily routine, this stress can only exist as long as the circadian rhythm remains unadapted to the changed living conditions.

From numerous re-entrainment experiments with phase-shifting of the synchronizers, we know that the re-entrainment of most physiological functions takes place within a period of 3-14 days (Aschoff, Hoffmann, Pohl, & Wever, 1975). As far as shift work is concerned, the possibility of such re-entrainment has been disputed for a long time, since certain of the synchronizers essential to man, namely, time-consciousness and social contact, cannot be altered in real life. However, it is undisputed that shift work initiates adaptation processes of the circadian rhythm. The number of studies dealing with this question is surprisingly small at the moment, and it is useful to differentiate between those conducted in the field and those carried out in the laboratory, i.e., experimental shift work studies.

Results of Field Studies

As an example of field studies, we would like to take the findings on the oral temperature rhythms of a total of 133 experienced shift workers, which, depending on the shift system, were measured over 1-7 consecutive days of night shift (Knauth, Emde, Rutenfranz, & Smith, in prep.). The investigation lasted for 387 days altogether.

Figure 2 shows that the circadian rhythm of body temperature on the day of the first night shift remained practically unaltered in all groups and that up until the day of the 7th night shift, no indications of an inversion could be seen. However, it was striking that 'masking-effects'(Aschoff, 1978) could be recognized in both sleep and work, from the day of the second night shift onwards. Thus during the working period, there is a possible relative rise of the body temperature level, which clearly depends upon the energy expenditure

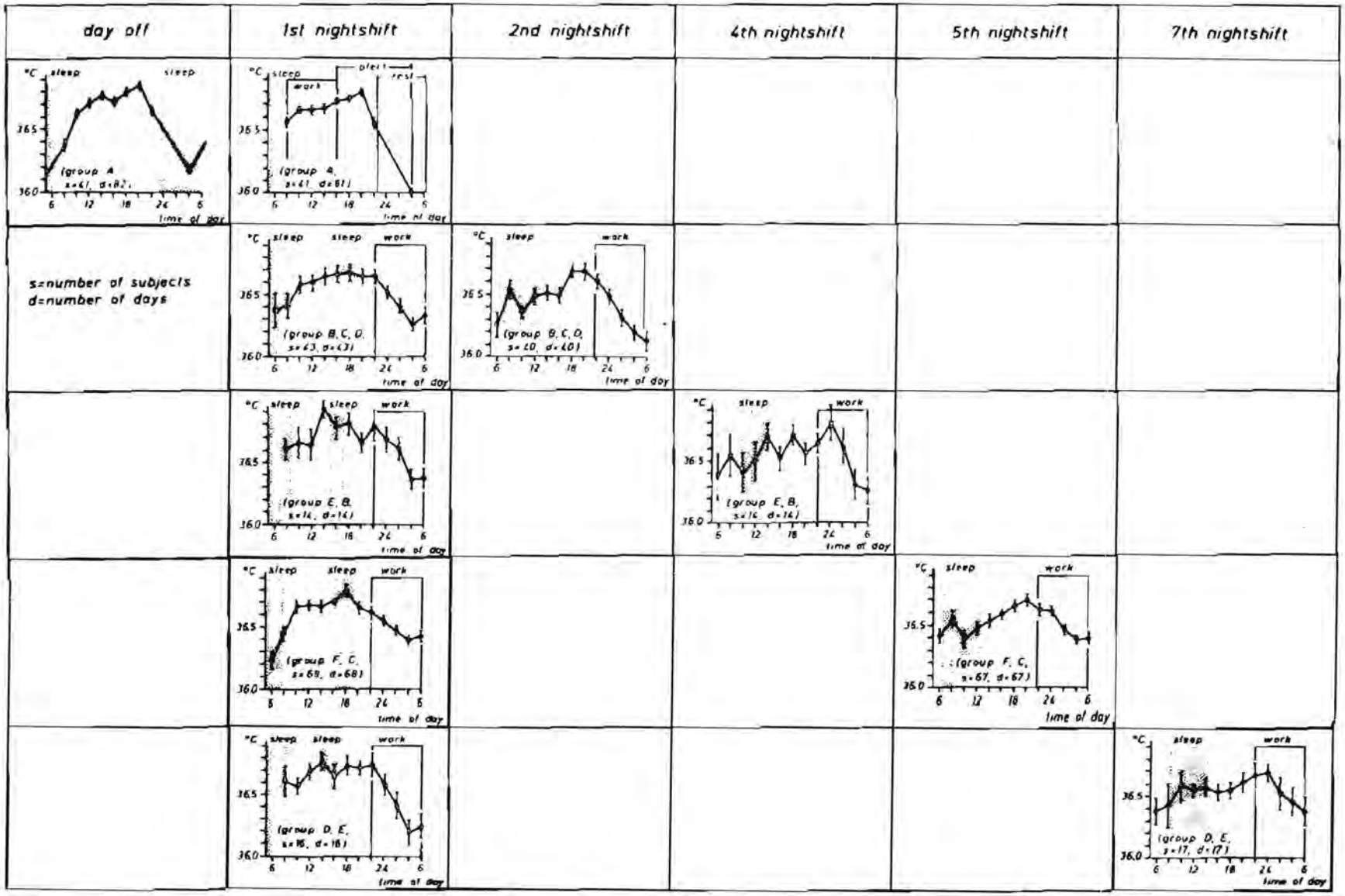


Figure 2. Circadian rhythms of oral temperature in 6 groups of shift workers studied in the field (Knauth et al., in preparation).

and the climatic conditions of the working place.

The upper part of Figure 3 shows the results from four other investigations of body temperature rhythms in field studies of shift work. It is evident at once that the picture is not homogeneous; however, only a few studies containing 24-hour recordings of body temperatures over several periods of night shifts have been carried out,and the number of subjects in these studies is very small (Åkerstedt, Patkai, & Dahlgren, 1977; Benedict & Snell, 1902; van Loon, 1963). Other experiments lack records about single days (Smith, 1979) or only cosinor values of the rhythms are given (Reinberg, Vieux, Laporte, Migraine, Ghata, Abulker, Dupont, & Nicolai, 1976).

From the data of field studies which so far have been considered, we may conclude that:

- one group of authors find no inversion up to the 7th night shift but only a flattening of the circadian rhythm (Benedict & Snell, 1902; Knauth et al., in press; van Loon, 1963; Smith, 1979). This group had at its disposal the largest number of subjects and, in most cases, complete records (often from two-hourly readings) over a period of several days;
- other authors report that oral temperature shows a tendency towards an 'adjustment (increase)' (Akerstedt et al., 1977) or an 'unusually fast adjustment' of the circadian rhythm of rectal temperature over a week of night work (Reinberg, Chaumont, & Laporte, 1975). Unfortunately, the data from this group are incomplete, as measurements for parts of the 24-hour period are missing, so that it is difficult to establish a clear picture of the re-entrainment.

Investigations resulting from field studies with more than 7 consecutive night shifts have not been published in Europe, since the laws of most of the countries do not allow such longer sequences of night shifts.

Experimental Shift Work Studies

For the reason given above, repeated attempts have been made in experimental shift work studies, to follow the circadian cycle of physiological functions over a sequence of night shifts longer than 7 days. In these studies, initiated more than 15 years ago by the late Michael Blake and his colleagues, an attempt is made to simulate shift work in the laboratory using, in the majority of cases, 'naive' test subjects. This is done either with work at taxonomically-built test-batteries or with work at actual industrial tasks carried out in the laboratory. The subjects normally live in the Institute in an "open-door" situation and sleep in controlled conditions; the latter allows sleep to be either limited or disturbed by controlled noise, if required.

Results of such experiments are shown in the lower part of Figure 3 and in Figure 4. The experiment by Colquhoun, Blake and Edwards (1968) shows, for example that on the 12th night shift day, a transference of the minimum body temperature rhythm was not evident even at this stage. In experiments by Knauth and Rutenfranz (1976) or by Knauth et al. (1978), which in some cases were continued for 21 consecutive night shift days, the same tendencies were found. Here an incipient migration of the body temperature was observed

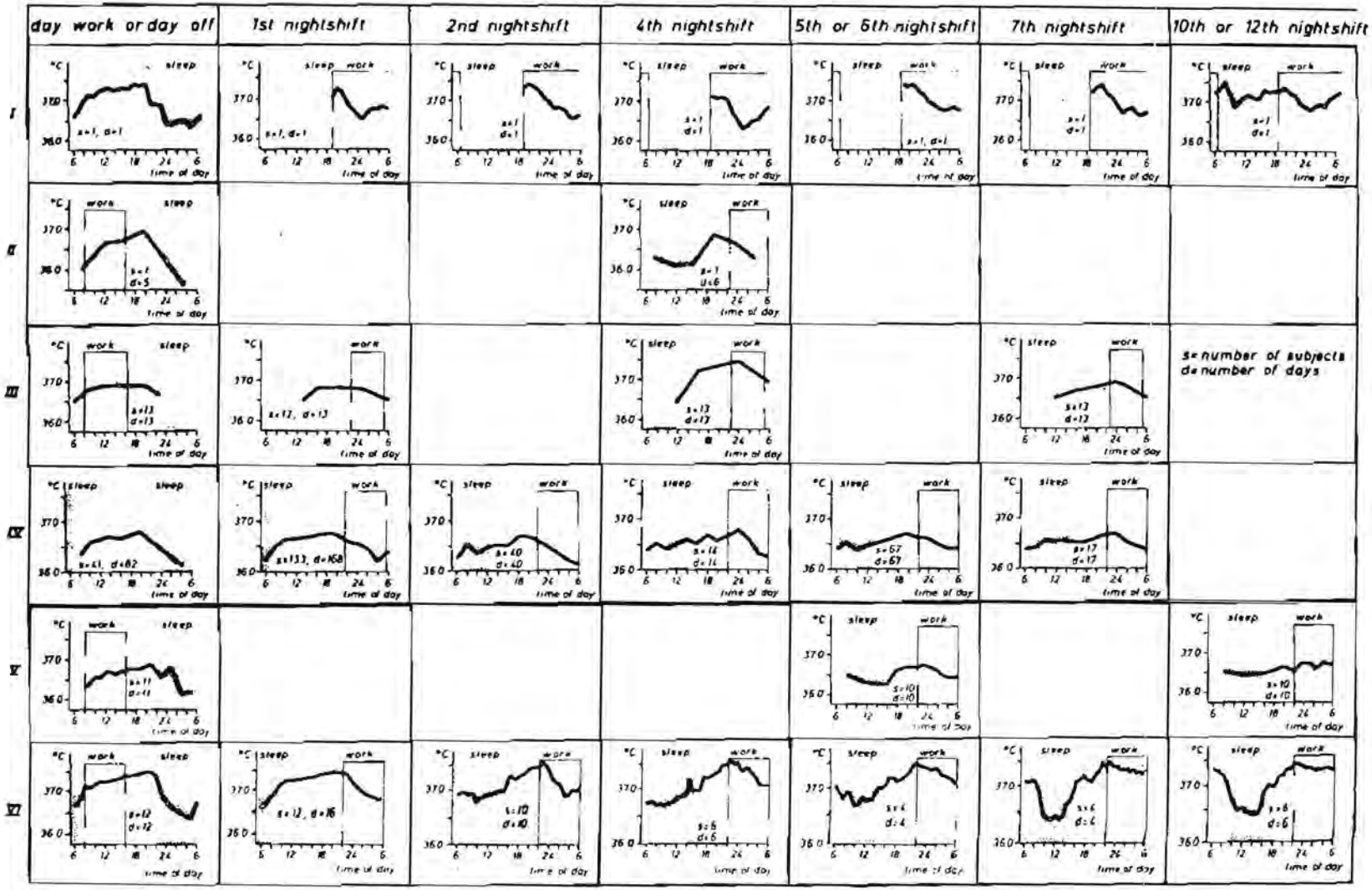


Figure 3. Circadian rhythms of body temperature in several field and experimental shift work studies by various authors (Knauth et al., in prep.).

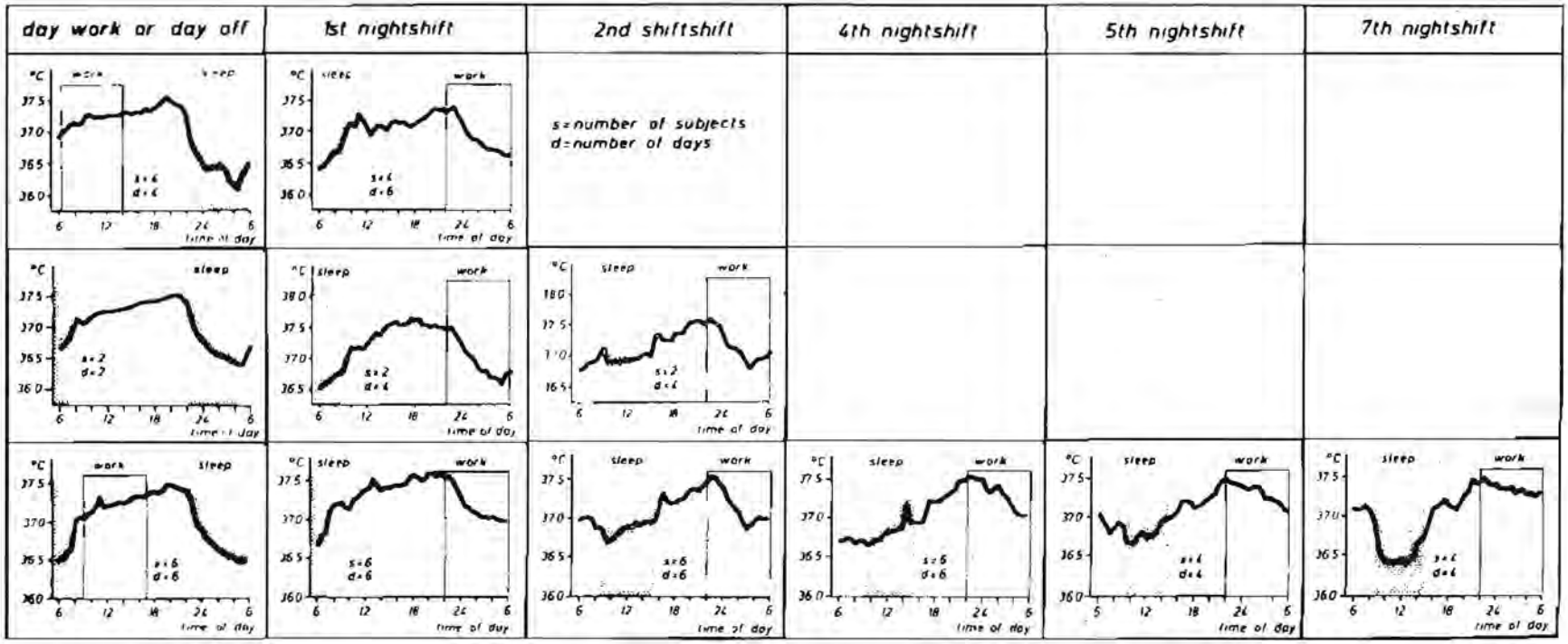


Figure 4. Circadian rhythms of rectal temperature during three experimental shift work studies (Knauth & Rutenfranz, 1976; Knauth et al., 1978).

from the 2nd night shift onward; this progressed during the following days, but was still not totally complete even on the 21st night shift day.

If one follows the changing position of the minimum of body temperature in relation to the middle of the sleeping period over the very long re-trainment period studied in certain of these experiments (Knauth & Rutenfranz, 1976; Knauth et al., 1978) it becomes apparent that the phase-alteration of this value to the expected value under the conditions of experimental shift work takes from about 7-14 days (Figure 5).

In this connection the question of the duration of the "re-re-entrainment" physiological functions in the reverse transition from night shift to day shift is of interest. Our results (Knauth et al., 1978) show that the duration of this second re-entrainment under the experimental conditions was related to the length of the night shift period. In experiments with 21 night shifts, re-entrainment had not, in fact, been completed even after 4 days (Figure 6).

Comparing the results from shift work under field conditions and from experiments under laboratory conditions, it emerges clearly that re-entrainment is more quickly, but only partly achieved with experimental shift work. We assume the reason for this to be that within the relatively closed group of persons participating in these laboratory experiments, a more or less unconscious displacement of the social synchronizers occurs, while in actual shift work, the phase position of the synchronizers within their normal time structure remains more stable because of family and social pressures. It should be noted also that the subjects in the studies of experimental shift work were always of a younger age group than the shift workers in the field studies.

Long-Term Adaptation to Shift Work

Finally, the question is as yet unsolved whether experienced shift workers develop special adaptation mechanisms to shift work, if for a long period they only work night shifts (i.e., if they are "permanent" night workers). From studies of night nurses who had been working 8 ('part-timer') or 16 ('full-timer') night shifts in every 28 days over many years, Folkard, Monk, and Lobban, (1979) came to the conclusion "that full-timers do show long-term adjustmen relative to part-timers, and that this is manifest in an enhancement of short-term adjustment, rather than a general flattening of the rhythms. It would appear to be even more apparent on the second night shift in a run of night work than on the first. However, the nature of this short-term adjustment would seem to vary with the variable considered, taking the form of a reduction in slope for temperature, but an increase in mean level for alertness and well-being, over the first night shift. In contrast, the changes from the first to the second night shift were in level for temperature, but in slope for alertness and well-being."

Desynchronization of Physiological Functions in Shift Work

From fundamental studies on re-entrainment of physiological functions (Aschoff et al., 1975; Wever, 1979), as well as from experiments on transatlantic flights (Klein, Wegmann, & Hunt, 1972), one can conclude that during the re-entrainment after a phase-shifting of working and sleeping times a

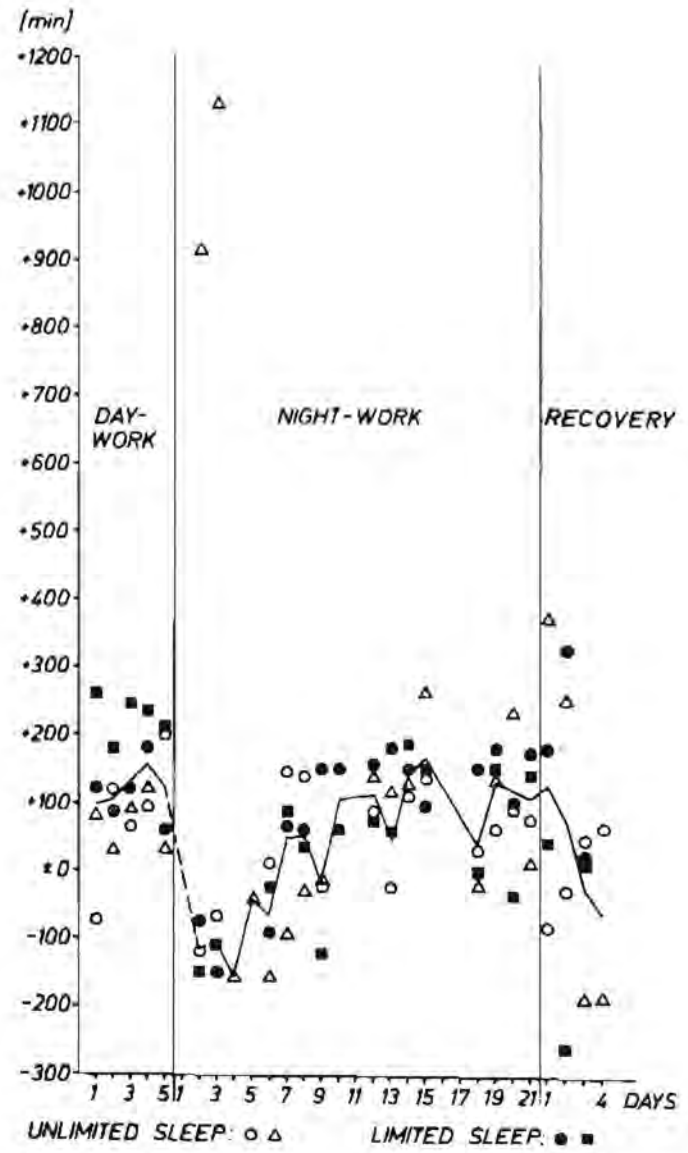


Figure 5. Mean time from mid-sleep to minimum body temperature (Knauth & Rutenfranz, 1976).

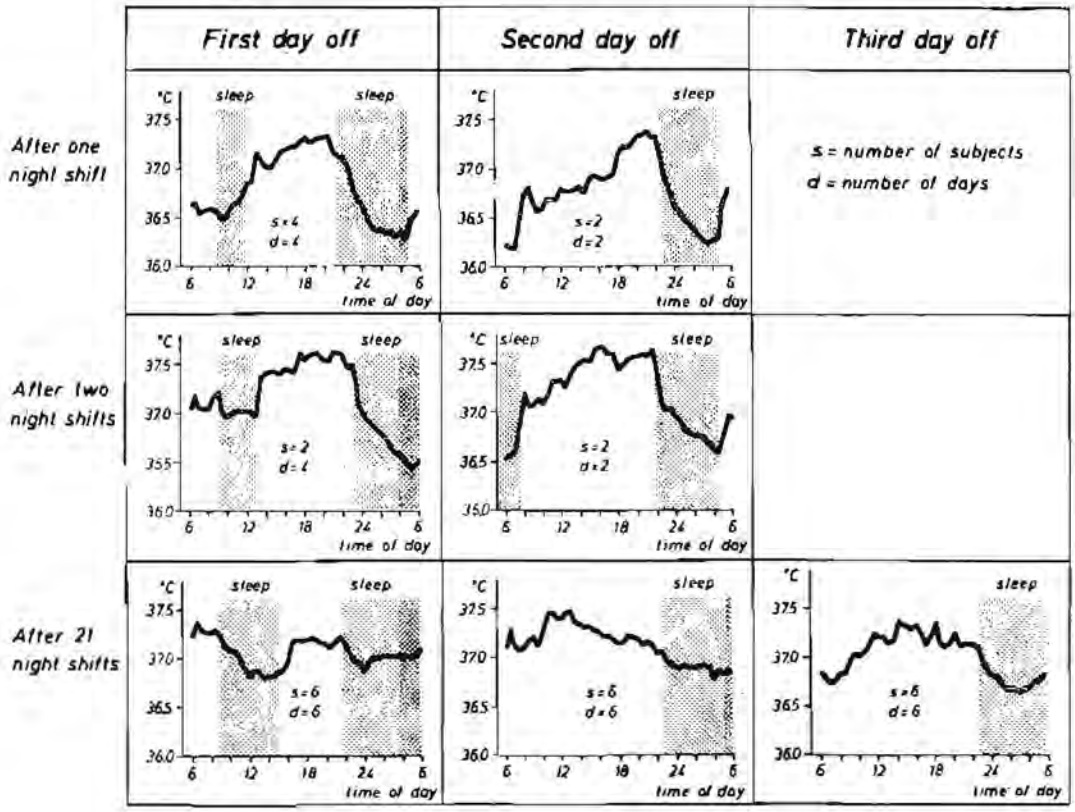


Figure 6. Circadian rhythms of rectal temperature after 1, 2, or 21 experimental night shifts (Knauth et al., 1978).

desynchronization can take place in the circadian rhythms of various physiological functions. Unforturately, as far as shift work is concerned, there are only a few investigations into this important question, and these are still in an early stage (Åkerstedt et al., 1977; Patkai, Åkerstedt, & Pettersson, 1977; Reinberg et al., 1975; Rutenfranz, Klimmer, & Knauth, 1975). So far, the results have produced no uniform picture, so that the question must remain open, whether the subjective complaints reported by shift workers are possibly increased by desynchronization of circadian rhythms.

Changes in the Sleep-Waking Cycle in Shift Work

A further objective problem of stress in shiftwork is produced by the disruption of the normal circadian rhythm of sleeping and waking (Kleitman, 1963) by the enforced behaviour. In the first place, this results in a shortening of the sleep period during day time sleep; if in addition (because of living conditions) noise-induced disturbances of sleep occur, this shortening is accompanied by alterations in sleep quality (Williams, 1973). Data concerning this phenomenon, obtained from tests during experimental shift work were reported in 1972 by Knauth and Rutenfranz (Figure 7). The long term adaptation to such behaviourally- and environmentally-conditioned disturbances of the sleep-waking rhythm is being studied anew at present by various groups (Ehrenstein & Müller-Limmroth, 1975; Foret & Benoit, 1978; Lortie, Foret, Teiger, & Laville, 1979; Patkai et al., 1975).

Open Questions

As a result of the recent experiments described in the presentations, our knowledge about problems of re-entrainment in shift work has been widened considerably; nevertheless, discrepancies remain. For further clarification, the following experiments are urgently required;

- -Experiments with continuous night shift under field conditions over more than 7 consecutive days, in order to check the stability of the social and cognitive synchronizers;
- -Experiments with continuous night shift under conditions of experimental shift work with experienced shift workers for more than 7 days, in order to check problems of long-term adaptation;
- -Experiments with continuous night shift under field and/or experimental conditions for more than 7 days in which the circadian rhythm of several physiological functions are recorded, in order to study the problem of desynchronization in shift work;
- -Investigations into the sleeping behaviour pattern in night shift periods of longer duration with experienced shift workers in field, as well as laboratory studies, including stress through noise, in order to check the importance of qualitative or quantitative sleep reduction in relation to the intensity of sleep disturbances complained of by the workers.

Effects of Shift Work on Well-Being and Disease

According to modern biology, life exists in coming to terms with the environment (Uexküll & Kriszat, 1956). Man is generally in a position to adapt himself not only to natural but also to artificial environments. Occupational medicine proceeds from the fact that there is a spectrum of possible adaptations between the two extremes of complete physical, psychical and social

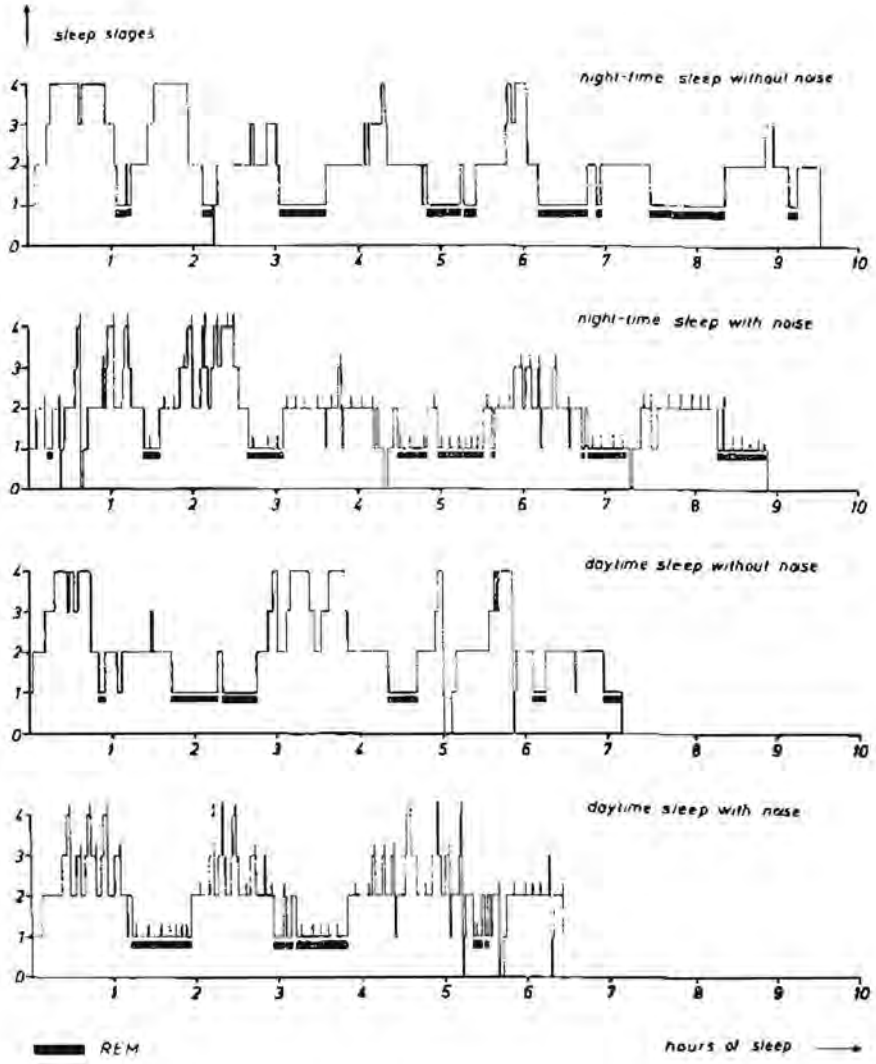


Figure 7. EEG sleep stages of one subject recorded in connection with an experimental shift work study (Knauth & Rutenfranz, 1972a).

well-being on the one hand, and death on the other (Karvonen, 1979).

It is possible to think of several degrees of adaptation between the two extremes. Should well-being, for instance, not be achieved in certain spheres of life (physical, psychical or social)--the term discomfort is used in epidemiology in order to describe this--a lowering of well-being, which is not illness, becomes likely. Conditions which are outside the normal limits of adaptation capacity, and which, therefore, do not meet the criteria of long-term endurability, will, eventually, lead to illness. In this context we describe innate characteristics, acquired patterns of behaviour, or pregiven conditions of daily life, all of which might decrease the physical capacity of adaptation of a person, as risk factors. This means that the presence of one or more of such factors does not at first cause any particular illness, but generally makes the eventual occurrence of an illness statistically more probable. In this sense, shift work may be regarded as a risk factor (Rutenfranz, 1967).

Health-Relevant Types of Shift Work

One may generally assume that shift work, or work at constantly unusual times, is disagreeable to the majority of human beings. Shift work has this in common with all other forms of work which differ from our average expectations of working conditions. Despite this, however, it cannot be denied that even shift work is expressly sought after by a small number of persons, because they believe that only with this kind of organization of their work can they realize certain expectations or enjoy certain hobbies. The best known examples are the farmers shift working in the chemical industry in Germany, and the fishermen shift working in the paper industry in Norway. According to Harrington's (1978) findings, it generally may be assumed that 20-30% of all workers decline shift work, approximately 10% see certain advantages in it, and the rest simply tolerate it.

Apart from this, it may be assumed that any working at changing times of day disturbs the order of our social life, and partly the order of our biological functions as well; this does not, however, mean that in every case it entails danger to health. If we consider the various forms of shift work listed in Figure 8, where the classification according to kinds of organization is similar to that in Rutenfranz, Knauth, and Colquhoun (1976), and if we bear in mind the problems of biological rhythms, we may set up the hypothesis that all forms of shift work, including night work, deserve special attention from the point of view of occupational medicine. Irregular forms of shift work, "continuous" shift work, and "permanent" night shift work should be examined particularly closely, because of their special psycho-social problems; no noticeable influence on health, however, may be expected from forms of shift work which exclude night shifts.

In considering the health effects of shift work, one tends to forget that shift work, as a special time-oriented organization of work, is superimposed upon the most varied activities. Thus, when discussing the possibilities of harmful effects from this work-organization, it is necessary to distinguish these from the stresses and possibilities of harm caused by the kind of work in itself, in the sense of the so-called 'confounding factors' as used by epidemiology (MacMahon & Pugh, 1970). On the other hand, stresses which otherwise lie within the range of harmlessness (Hacker & Macher, 1977) as, for in-

I. Systems without night work
Two-team ("double-days")
a. nonoverlapping (e.g., 0600—1400, 1400—2200)
b. overlapping (e.g., 0600—1400, 1330—2130)

II. Systems with night work
Two-team (up to 12-h shifts) ("days and nights")
Three-team (8-h shifts)
One-team (night work only) ("permanent night shift"): is often combined with I to provide complete coverage of the 24-h period

III. Systems with night work and including weekend work ("continuous shift work")
Regular
a. three-team (12-h shifts)
b. four-team (8-h shifts)
Irregular (varying number of teams and cycle lengths)

Figure 8. Types of shift system (Rutenfranz et al., 1977).

stance, work in climatic conditions below certain temperature figures, work with health-endangering substances within the limits of MAK, work with noise, etc., may possibly lead to health-endangering situations in night work conditions.

In all disturbances of health caused by shift work, it is however, advisable to distinguish between lowering of well-being and disease proper.

Lowering of Well-Being

Sleep Behaviour Patterns in Shift Work. Numerous investigations (e.g., Menzel, 1962) have shown that average sleeping time amounts to 7.5 hours before a morning shift, 8.5 hours after an afternoon shift and approximately 4-6 hours on the day after a night shift (Figure 9). The need for sleep, independent of the form of shift work, varies considerably with the individual human being and is also related to age. The amount needed is, however, definitely longer than any sleeping time which can be achieved with night work, as we have demonstrated with engine drivers (Rutenfranz, Knauth, Hildebrandt, & Rohmert, 1974) (Figure 10).

This shortening of sleeping time is brought about on the one hand by the transference of sleep to a time of day which is unfavorable for it in respect to circadian rhythms, and on the other hand through disturbances of sleep during the day time caused by noise (Figure 11); children and traffic are usually mentioned as most important sources of this disturbing noise (Knauth & Rutenfranz, 1972a,b).

On the basis of these facts, one would expect the frequency of sleep disturbance to be determined by the type of shift work. In Figure 12, we have plotted the reported frequency of sleep disturbance according to type of shift work among 5766 persons, on the basis of various investigations of our own or studies published by others (Aanonsen, 1964; Anderson, 1958, 1970; Barhad & Pafnote, 1970; Graf et al., 1958; Häkkinen, 1969; Hettinger et al., Knauth & Rutenfranz, 1972b; Kolmodin-Hedman & Swensson, 1975; Loskant, 1970; Mann & Hoffmann, 1960; Monnier,1963; Nachreiner & Rutenfranz, 1975; Rutenfranz et al., 1974; Wyatt & Marriott, 1953).

The table shows that sleep disturbances were reported by:
- approximately 15-20% of day workers;
- approximately 5% of the shift workers, not doing night shift;
- approximately 10-80% of shift workers doing night shift;
- approximately 60% of workers doing continuous night shift;
- approximately 90% of former shift workers at the time of their night shift activity; in switching over to day shifts, the sleep disturbances decreased to less than 20%.

From Figure 12, we may conclude that shift work which excludes night shift and straight day work do not lead to sleep disturbance to any significant degree; but that shift work which includes night shift and continuous night work bring about special sleep problems for the shift worker. At the same time, there is an indication that the irregular systems of shift work prevalent in the service sector (radar controllers,engine drivers) very often lead to sleep disturbances, whereas living conditions in the area around a big chemical fac-

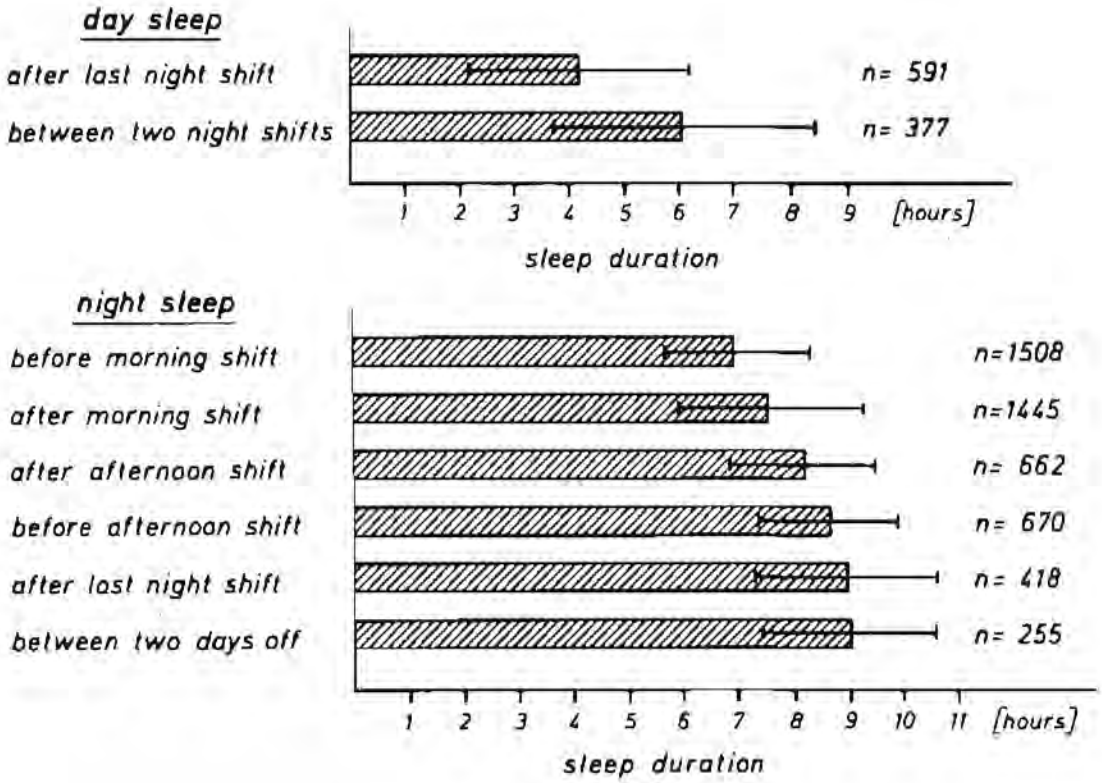


Figure 9. Sleep duration by shift type from diary records of 5926 days (Knauth, unpublished data).

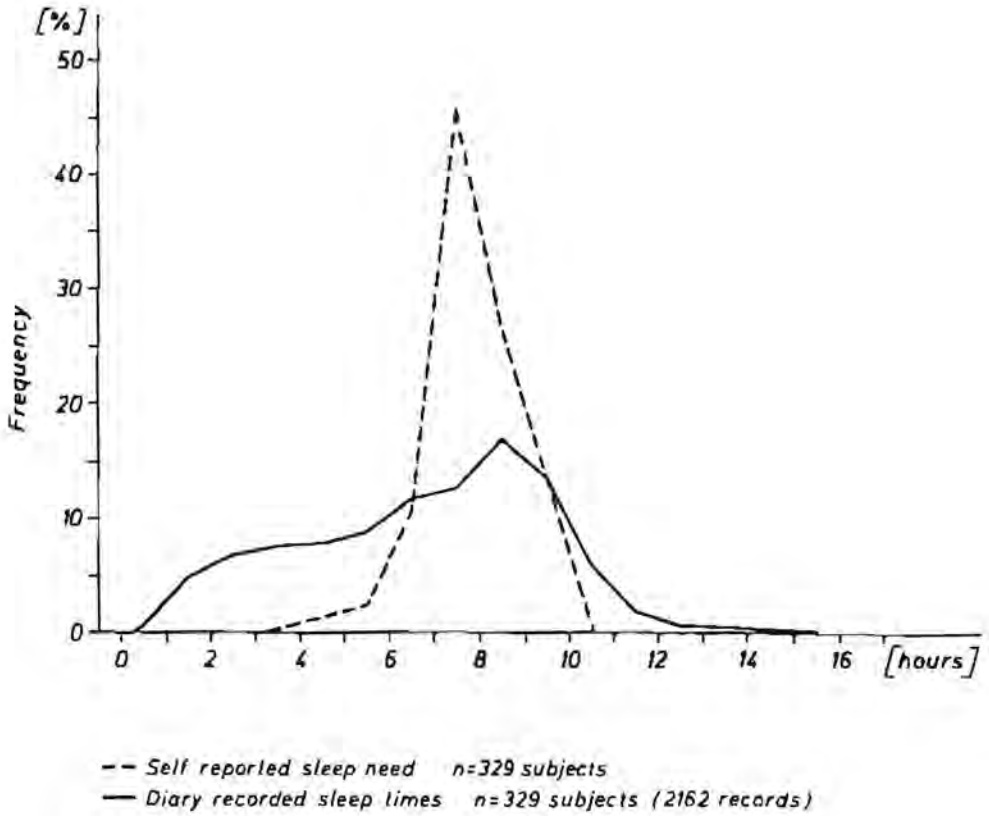


Figure 10. Frequency distributions of "sleep need" and of diary records of actual sleep duration between two consecutive shifts: Engine drivers (Rutenfranz et al., 1974).

Figure 11. Relative frequency with which different causes of sleep interruptions were mentioned by 808 shift workers who complained about frequent noise disturbances during sleep (Knauth & Rutenfranz, 1972b; Rutenfranz et al., 1974; Knauth et al., 1975).

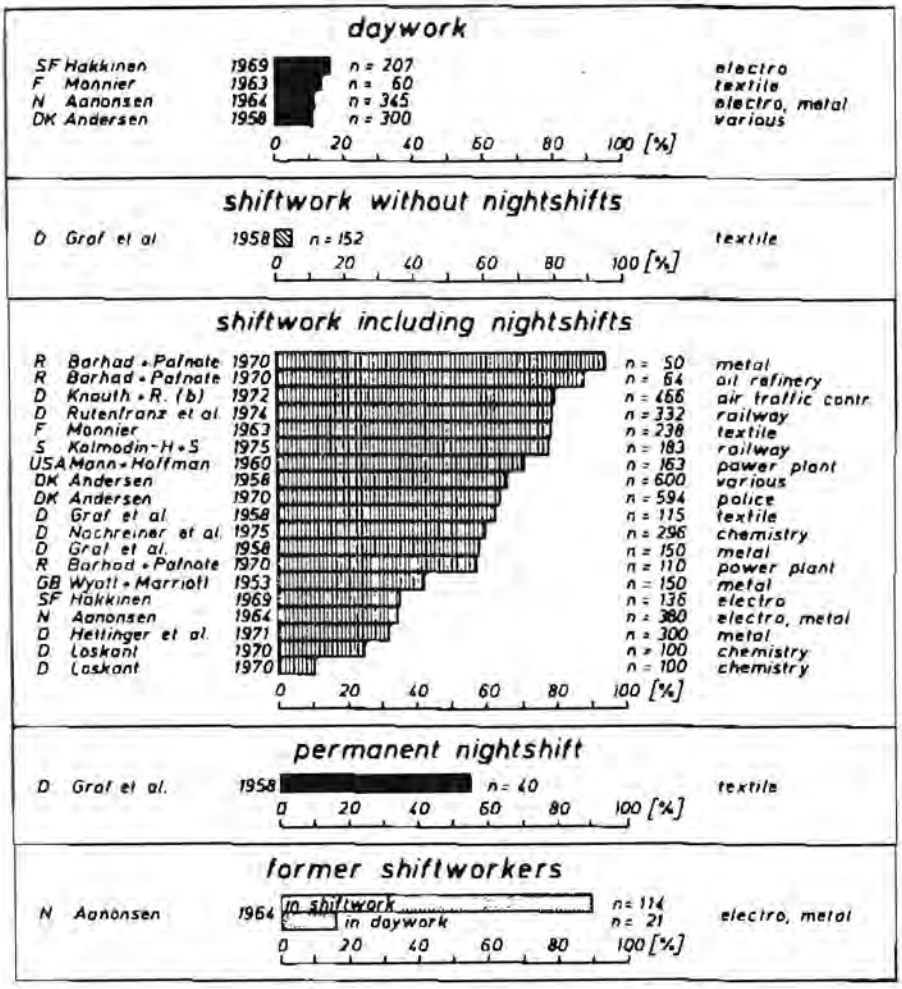


Figure 12. Frequency of complaints about sleep disturbances related to type of shift system.

tory with an advantageous shift work system apparently lead to favourable sleep conditions. The influence of other work conditions such as heat, noise, etc., cannot be clarified because of the variety of the types of industry.

These sleep disturbances with night shift workers are the dominant symptom of lowered well-being; compensation for which will have to be rethought anew.

Disturbances of Eating Habits. The time changes of work, sequence of meals and sleep very probably are the causes of disturbances in appetite during night work. On the basis of our own investigations and those of others, dealing altogether with 906 persons, we show the findings for various forms of shift work in Figure 13 (Graf, Pirtkien, Rutenfranz, & Ulich, 1958; Häkkinen, 1969; Wyatt & Marriott, 1953).

Figure 13 shows that disturbances of appetite occurred:
-in less than 5% of the day workers;
-similarly in less than 5% of shift workers not doing night work;
-in approximately 35-75% of shift workers doing night shift;
-in approximately 50% of workers doing continuous night shift.

The number of investigations concerning this problem is not very large. Nevertheless, Figure 13 shows that shift workers doing night shift or doing continuous night shift clearly suffer more from disturbances of eating habits than day workers or shift workers not doing night shifts.

Debry and Bleyer (1972) were able to show that these disturbances of appetite did not lead to a lessening of calorie intake; the disturbances of appetite have more to do with the dislike of having to eat at unusual times or with food that is often cold or which has to be taken outside the accustomed social environment.

Gastrointestinal Complaints. Irregularities in food intake can, as experience shows, lead to digestive disorders and gastrointestinal complaints; however, the reasons for this complex of symptoms are surely manifold. Nevertheless, complaints concerning the gastrointestinal system are often named as a predominant symptom in shift workers. On the basis of our own investigations and those published by other authors dealing altogether with 8060 persons, we have assembled in Figure 14 the findings for various forms of shift work (Aanonsen, 1964; Andersen, 1960; Bjerner, Holm, & Swensson, 1948; Graf et al., 1958; Häkkinen, 1969; Kolmodin-Hedman & Swensson, 1975; Loskant, 1970).

Figure 14 indicates that gastrointestinal complaints have been observed:
-in 10-25% of day workers;
-in approximately 17% of shift workers not doing night shift;
-in approximately 5-35% of shift workers doing night shift;
-in approximately 50% of workers doing continous night shift;
-in approximately 30-50% of former shift workers who have ceased work for reasons of health.

The striking factor in these findings is the wide overlap of the answers, which does not permit a clear differentiation between the various groups. This is especially noticeable in the day workers and in the group of shift workers

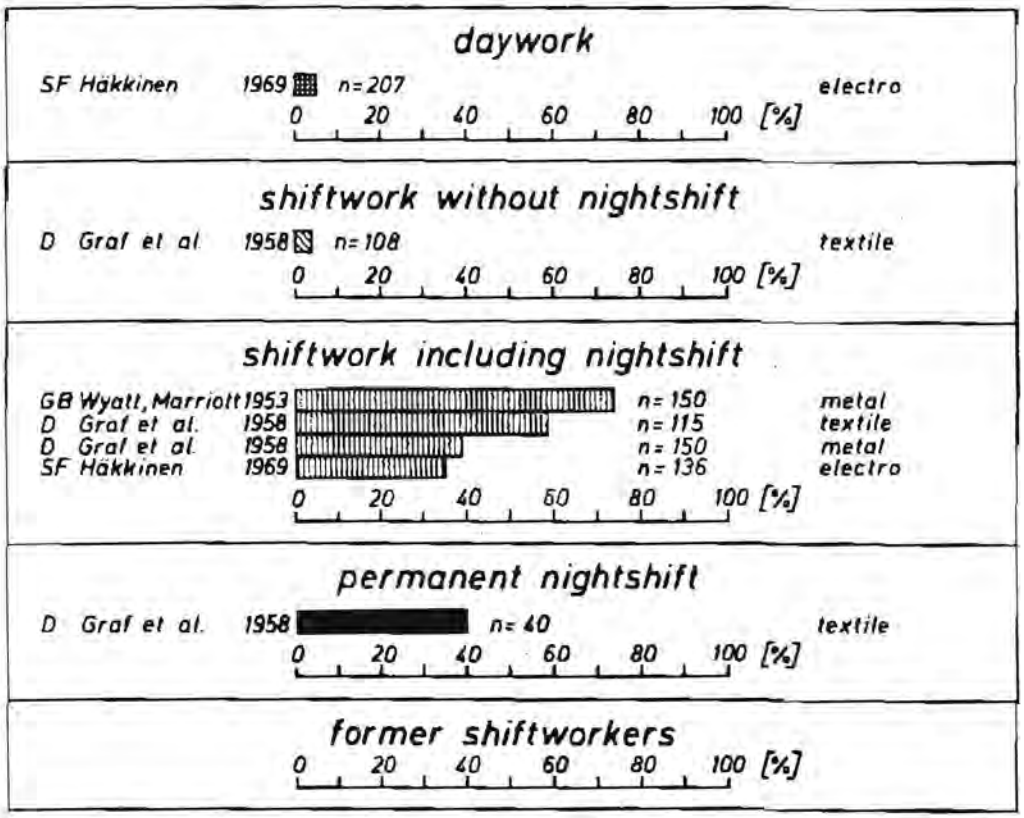
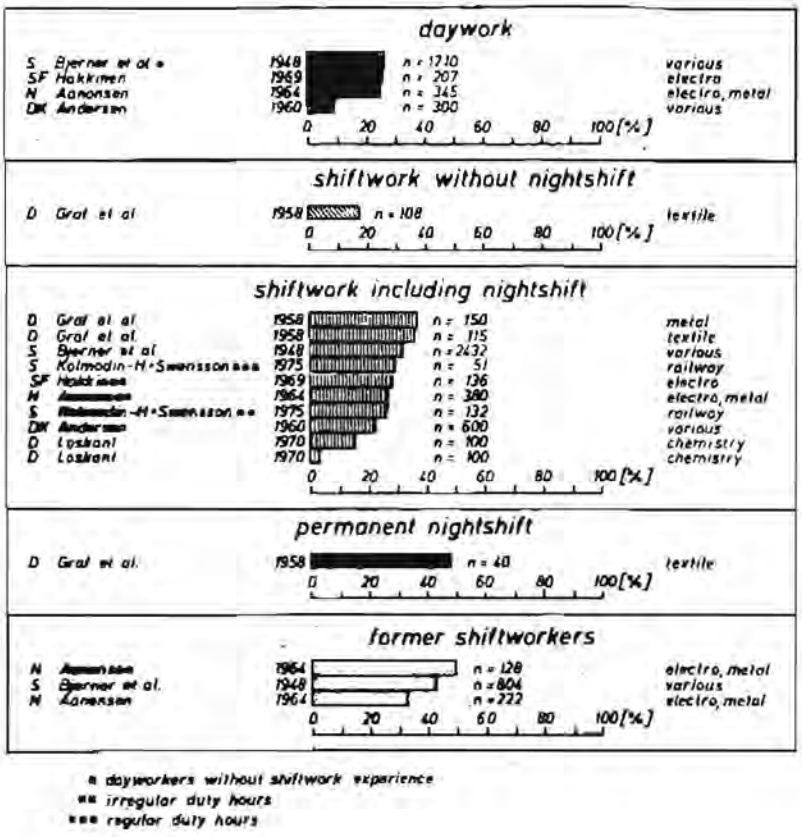


Figure 13. Frequency of complaints about disturbances of eating habits related to type of shift system.



* dayworkers without shiftwork experience
** irregular duty hours
*** regular duty hours

Figure 14. Frequency of complaints about gastrointestinal disturbances related to type of shift system.

doing night shift. It is conspicuous that (especially with the studies from Scandinavia) even day workers show a strikingly high percentage of gastrointestinal complaints. If one compares in groups investigated by the same authors, the groups of shift workers doing night shift with the corresponding groups of day workers (Aanonsen, 1964; Bjerner et al., 1948; Häkkinen, 1969), there are only insignificant differences. Contrary to this, the former shift workers [even taking the findings of the same investigations (Aanonsen, 1964; Bjerner et al., 1948)] show the greatest frequency of complaints; similar figures were found for a small group of shift workers doing continuous night work. Finally, gastrointestinal complaints were strikingly rare wherever experienced occupational physicians had been doing special medical examinations for years for beginners and follow-up tests with the shift workers (Loskant, 1970).

Dangers to Health

The adaptation disturbances in shift work, as detailed above, show that not all forms of shift work are similarly problematic, but, rather, that it is mainly those forms of shift work which include night shift that contain special risks. In these cases, shift work may become a risk factor as far as health is concerned if the unavoidable adaptation disturbances resultant on changes in the biological rhythms are augmented by other personal or situational factors at home or at the working place (Rutenfranz, 1976). Such transgressions of the adaptability limits of the human organism should show up in an excessive mortality rate or in an increased frequency of disease.

Studies of Mortality. Studies of mortality with shift workers are, so far, very rare. In an unusually careful study, Taylor and Pocock (1972) compared mortality rates in shift workers and day workers in 10 factories over a 13-year period; with 1578 deaths occurring in 8603 persons, they found no difference in rates between shift workers and day workers. Shift workers, however, who had given up shift work prematurely showed a higher mortality rate (standard mortality ratio: 118.9 against 101.5). A certain excessive mortality due to neoplasmas was found among shift workers and due to pulmonary complaints among the day workers. Further studies seem necessary here.

Gastrointestinal Diseases. On account of the high frequency of disturbed appetite and gastric complaints, special risk to the gastrointestinal system among shift workers appears probable and plausible, should other aggravating factors accrue.

Duesberg and Weiss reported, in the basis of health insurance company statistics in 1939, that workers who, under the conditions prevailing in the German armament industry, were employed in shift work doing heavy physical work, succumbed to gastric ulcers eight times as often as non-shift workers. Duesberg and Weiss (1939) mention in their publication: "Workers who, with only a short lunch break, often doing continuously heavy physical work, partially in shifts or in over-time, include among them approximately 8 times as many persons suffering from an ulcer as members of professions which permit a regular daily life and a sufficient lunch break with physically less exacting work."

In the discussion of this result it is often overlooked that the relative frequency of falling ill in the studies of Duesberg and Weiss (1939) was ex-

tremely low compared with that in other investigations. In evaluating material provided by health insurance companies, they found an ulcer frequency of approximately 0.3% among day workers; among shift workers doing heavy physical work while leading irregular lives, the frequency was approximately 2.4%. Reckoned altogether, this amounts to an eight-fold increase, but in investigations made after the second world war, there were significantly increased frequencies even among day workers, which indicates that there was an underlying upward trend.

This time trend may partially account for the completely different results found by Aanonsen in Norway in 1964. He established that shift workers and non-shift workers did not differ in any significant way from day workers as far as gastric ulcers were concerned, but that among day workers, the highest frequency of such diseases was to be found within the group of former shift workers.

Figure 15 shows the findings for ulcer incidence, compiled from investigations by various authors, in a total of 32550 persons doing various kinds of shift work (Aanonsen, 1964; Andersen, 1958, 1960; Bjerner et al., 1948; Bruusgaard, 1949; Duesberg & Weiss, 1939; Ensing, 1969; Kolmodin-Hedman & Swensson, 1975; Rietschel, 1978; Thiis-Evensen, 1958). According to this figure, gastric ulcers were found among:

-approximately 0.3-7% of day workers;
-approximately 5% of shift workers not doing night shift;
-approximately 2.5-15% of shift workers doing night shift;
-approximately 10-30% of those shift workers who had given up shift work, probably for health reasons.

These data make it evident that there is a wide overlap in the incidence of ulcer among shift workers and non-shift workers. It can generally be said that the material provided by health insurance companies shows exceptionally low percentages of ulcers, while investigations in plants produce significatly higher percentages in shift as well as in day workers, which cannot be explained merely by the different sizes of the populations studied. If one compares the different groups within the populations studied by individual researchers, Andersen (1960) found a slightly higher morbidity among shift workers doing night shifts than among day workers and former shift workers; however, Bruusgaard (1949) observed an identical frequency in day workers and shift workers doing night shift, but a small hyper-morbidity among former shift workers. In an exceptionally careful study, Aanonsen (1964) found the lowest frequency of ulcers in shift workers doing night shift, a slightly greater frequency in day workers, and a significantly higher incidence in former shift workers. These findings are confirmed by the data of Thiis-Evensen (1958).

Other Diseases. As far as other illnesses are concerned, a significant hyper-morbidity caused by shift work would seem unlikely. So far, investigations of cardiovascular diseases, neurological disturbances and psychiatric illnesses have been made, and, as a new assembly of the facts by Harrington (1978) shows, no effects of shift work can be demonstrated in these aspects of health.

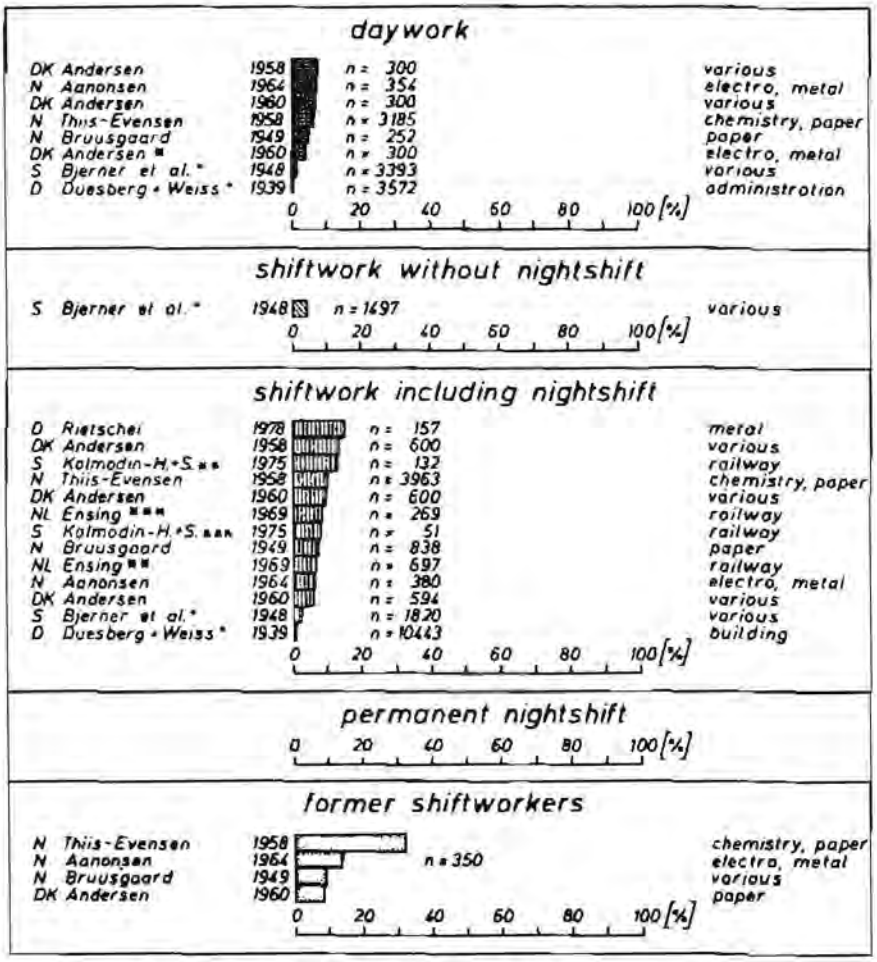


Figure 15. Frequency of gastric and duodenal ulcers related to type of shift system.

Open Questions

The question of whether health is damaged by shift work has not, as yet, been satisfactorily answered. The discussions have concentrated so far on gastrointestinal diseases; the possibility that shift work has a co-responsibility for other illnesses is considered by only a few authors (for instance Carpentier & Cazamian, 1977). The investigations published so far reveal the following deficiencies:

- -the diagnosis of diseases is based on very different kinds of facts (questionnaires on subjective health, medical history,x-ray, endoscopy);
- -so far, only cross-sectional studies have been made, very often without control groups.

As regards the latter, since it can be deduced from the investigation that test-groups of shift workers represent self-selected groups, it is clearly very difficult to answer the question by cross-sectional studies. As in epidemiology, retrospective--or better--prospective cohort studies, as well as case-control studies, are necessary.

One of the first studies using one of these techniques in shift work (Angersbach, Knauth, Loskant, Karvonen, Undeutsch, & Rutenfranz, 1980) supports the assertion that health data of shift workers can be evaluated only in relation to time, since it was found that the process of self-selection had not come to an end even after 10 years. The group of workers who for reasons of health had changed from shift work to day work, proved to be of special importance. The true reasons for the withdrawal of shift workers from shift work can only be found by a follow-up of the losses through prospective cohort studies of all workers. Such extremely work-intensive studies are especially necessary today.

Effects on Family and Social Life

Shift work affects, not only the workers themselves, but also their families. Time budget studies in families of shift workers (Knauth, Romahn, Kuhlmann, Klimmer, & Rutenfranz, 1975) have made it clear that the wives of shift workers have to try to keep the family together by altering meal times to fit in with the shift system (Figure 16).

From the investigations of Barhad and Pafnote (1970), Mott, Mann, McLoughlin, and Warwick (1965), Nachreiner and Rutenfranz (1975), and Wedderburn (1967), it can be concluded that shift workers consider the disturbances of their social life to be more serious than the physiological or organizational disturbances. Our studies (Figure 17) show that complaints are voiced relatively more often about disturbances in the wider social sphere than in the immediate family circle (Nachreiner & Rutenfranz, 1975). The importance of psychosocial disturbances as a cause of disease among shift workers has not been dealt with sufficiently.

Effects on Industrial Performance Rhythms

It has been shown many times that there are circadian rhythms in human performance (Colquhoun, 1971; Kleitman,1963; Rutenfranz & Colquhoun, 1979).

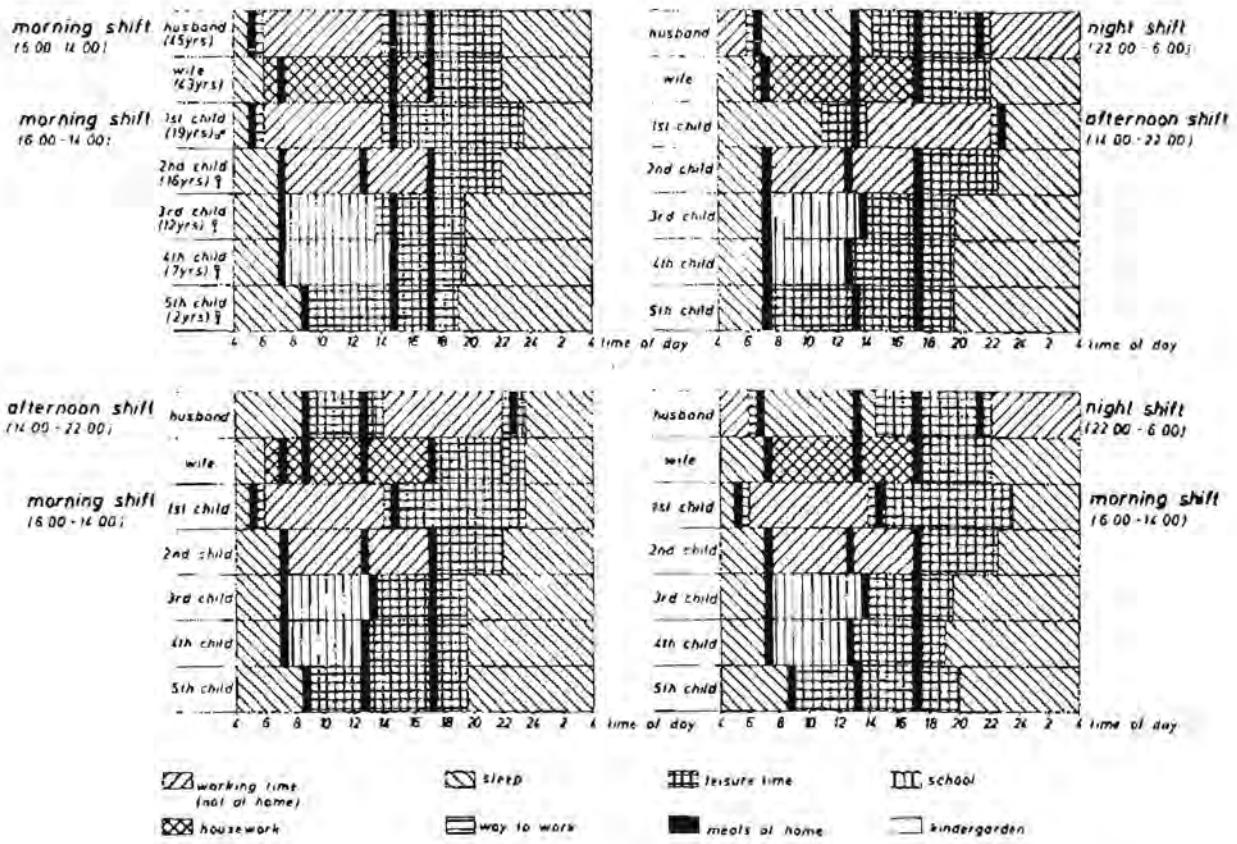


Figure 16. Activities of different members of a shift worker family related to time of day (Knauth et al., 1975).

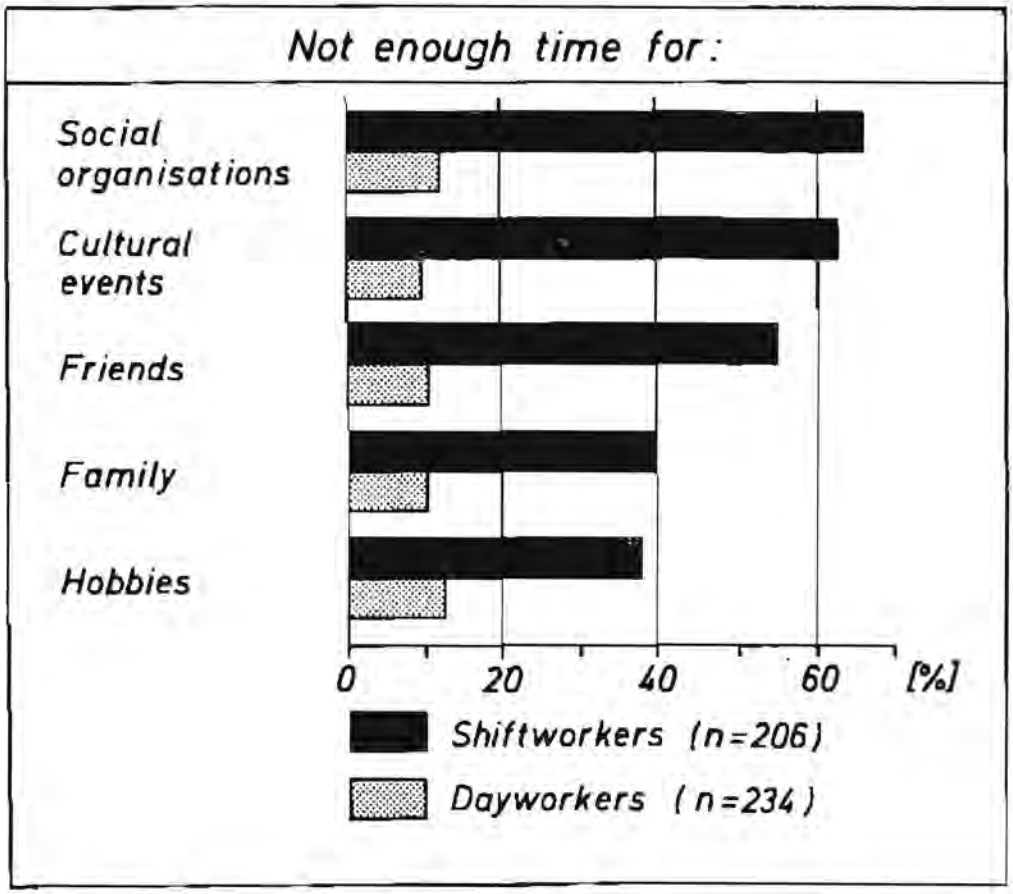


Figure 17. Frequency of reports of "not enough time" for different social activities of day workers and shift workers (Nachreiner & Rutenfranz, 1975).

This means that the same kind of work is carried out at different hours of day at different psychical and physical 'costs', so that "experienced industrial workers unconsciously adopt habits of work which tend to the production of a maximum output with a minimum of effort" (Vernon, 1921). Despite this, very few industrial performance rhythms have been described so far (Bjerner, Holm, & Swensson, 1955; Goldmark & Hopkins, 1920; Graf, 1943; Link, 1933). This is due to the fact that "workers attempt to mask such variations in productivity out of fear of changes in their piecework wages" (Graf, 1943).

Until now, therefore, we do not have a definitive answer to the question whether, during the period of re-entrainment in change-over to a night shift, regular changes in the "basic processes of performance rhythms"--similar to those in physiological processes--occur independently of other factors in the job situation which can affect observed output.

The difficulty of investigating this question lies in the fact that industrial performance rhythms can be masked by the mechanisms referred to, as well as by motivational factors. Understanding of these mechanisms, and of the extent of the physical and psychical cost is, however, very necessary in order to assess the strains to which a shift worker doing night shift is subjected.

Personal and Situational Differences Among Shift Workers

In spite of equal stresses, it is quite apparent that workers react to shift work in very different ways; this fact can only be explained by individual and situational differences. If such differences can be identified and are of importance for adaptation to shift work, it should be possible to use them as criteria for selection.

Health Differences

Because it is an established fact that persons with certain diseases suffer under shift work more than others, the following groups of persons (see Collier, 1943) should be excluded from shift work if possible (Rutenfranz, Colquhoun, Knauth, & Ghata, 1977):

- -People with a history of digestive tract disorders. Shift work produces special psychophysiological problems and also involves unusual meal times; both of which may affect gastric functions (Andersen, 1958; Collier, 1943; Dervellee & Lazarini, 1958; Menzel, 1962; Thiis-Evensen, 1958).
- -Diabetics and thyrotoxicosics. Regular food intake and correct therapeutic timing can be difficult to maintain under shift work conditions (Cook, 1954);
- -Epileptics. Reduction of sleep increases the incidence of fits (Cook, 1954).

The validity of these criteria for selection can be proved only by prospective cohort studies; standard medical examinations before starting work have (according to Taylor, 1968) only limited predictive value for sickness-absence. Loskant and Knauth (1976) have therefore proposed that shift workers should be subjected to another health examination no later than one year after starting shift work, in order to assess their degree of adaptation to it.

Personality Differences

Individual differences in adaptation to shift work have, over the past few years, repeatedly been linked with differences in personality structure. Most of the studies in which this link is alleged take the time needed for the re-entrainment of physiological functions--usually body temperature--as a measure of the capacity to adapt to shift work. Thus, Blake (1971) found "small but significant differences in certain aspects of the mean body temperature rhythms of introverts and extraverts." Later Colquhoun and Folkard (1978) were able to show that "neurotic extraverts exhibited the greatest degree of adjustment" as far as the trend of body temperature during night shift was concerned. Oestberg (1973), on the basis of preferences for, and habits of, activity, made the distinction between "morningness" and "eveningness", and stated that "the morning type of subject had the most pronounced difficulty in adapting to night work." Patkai (1971) found "a significant relationship between morningness and introversion and eveningness and extraversion" so that it is probable that both factors have a common basis. The observations of Folkard (1975) about rhythms of subjective alertness relating to extraversion or introversion must be interpreted in the same sense. Nachreiner (1975) used the personality variables identified in these studies in order to classify attitudes towards shift work among groups of shift workers. He found that "if a shift worker is rather introverted and tends to be emotionally unstable, the probability that he feels uncomfortable with shift work and would like to get out of it is fairly high."

The facts presented here are all based on cross-sectional studies and have not been used, so far, to make any predictions about the capacity to adapt to night work. Folkard, Monk, and Lobban (1979) have recently developed a predictive test of adjustment to shift work which is based on the hypotheses referred to above and Nachreiner (1975) has formulated a test of attitude to shift work using these hypotheses. Validation of these tests, however, will only be possible by projective cohort studies. Such studies still have to be carried out.

Physiological Differences in Adaptability of Circadian Rhythms

Various parameters of circadian rhythms have been discussed as possible physiological yardsticks for the prediction of adaptability to shift work. Breithaupt, Hildebrandt, Döhre, Josch, Sieber, and Werner (1978) used the circadian phase position and concluded that in evening types (as defined by Oestberg, 1973), the normal maximum and minimum body temperature appear later than in morning types. Evening types also show fewer sleeping problems and better adjustment to shift work than morning types.

Reinberg et al. (1976, 1978) used the circadian rhythm amplitude as a measure of individual capacity to adjust to shift work. They found that a smaller amplitude of body temperature on normal days increased the probability of a quicker adaptation of this circadian rhythm to shift work.

Neither of these measures of the capacity to adapt have been validated so far in prospective studies.

Situational Differences

Living conditions are of special importance for adaptability to shift work. As we (Knauth & Rutenfranz, 1972b; Knauth et al., 1975; Rutenfranz et al., 1974) have shown, approximately 60-80% of shift workers complain of sleep disturbance by noise on the day after the night shift, the most frequent sources of noise mentioned being traffic and children. Both these kinds of noise have been shown to disrupt sleep (Griefahn et al., 1976; Knauth & Rutenfranz, 1972a, 1975; Williams, 1973). It is therefore hardly surprising that people with unfavourable living conditions, especially those with badly insulated bedrooms, near roads carrying a lot of traffic, and with small children in the family, should complain more often about lowering of well-being and about health than people in more favourable living conditions. The value of living conditions as a predictor of good or bad adaptability to night work so far has only been investigated by Angersbach in a retrospective cohort study; prospective cohort studies are also needed here.

A situational factor which has hardly been investigated so far is the family's acceptance of shift work. If night work is not accepted by the members of the family, it cannot be expected that the worker himself can adapt to night work conditions without at least some effect on his well-being.

Chronohygiene of Shift Work

The technological, economic and social reasons for which shift work exists means that it will not be possible to eliminate it. But one can ameliorate the discomforts of shift work by selecting suitable personnel and one can also influence the organization of shift schedules. Over the last few years, more than 500 different shift systems have come to our notice; it is a priori improbable that all of them are equally good. One cannot, therefore, leave the construction of shift schedules to the plants alone. In order to assist them in their task, we (Rutenfranz et al., 1977) have put forth the following points:

> It is impossible to construct one single shift schedule which is optimal for all shift workers and for all working and living conditions. But, based on present knowledge, some criteria can be set for schedule construction.

The following statements are based on results obtained mostly from experimental studies of shift work:

1. Single night shifts are better than consecutive night shifts (a) because a single night shift does not significantly disturb circadian rhythms and (b) because more than seven consecutive night shifts are required for re-entrainment of the rhythms (Colquhoun et al., 1968, 1969; Knauth & Ilmarinen, 1975; Patkai et al., 1975). It could be argued that a sequence of consecutive night shifts longer than seven days would therefore be acceptable. However, for psychosocial reasons, most workers need either to change their shift or to have some rest days after no more than one week, so re-entrainment is not normally possible in practice.
2. At least 24 hours of free time should be allowed after each night shift. Sleep disturbances and reduction of sleeping time are the

most common complaints of shift workers, particularly of night workers. The resultant accumulation of sleep deficit over several days may be a risk factor. Thus, for preventing the harmful effects of sleep deprivation, a substantial recovery period is necessary after each night shift (Graf, 1955; Knauth & Rutenfranz, 1972b; Knauth et al., 1975; Rutenfranz, 1973). A similar problem can arise with the morning shift when the starting time is so early that the worker gets an insufficient amount of sleep the night before; in this case, a 24 hour break after each such shift should be allowed. (Alternatively, of course, it may be possible to delay the starting time of the shift by reorganization of the system.)

3. The length of the shift should be related to the type of work, particularly to the energy expenditure required by it. If the work is light, the length of the shift may (with caution) be extended to 12 hours, but it normally should not exceed 8 hours (or even 6 hours for certain types of work, e.g., work involving particularly heavy physical energy expenditure or a considerable mental load).
4. The cycle of a shift system should not be too long (4 weeks, for example, is better than 40 weeks). It is also better to have a regular system of rotation than an irregular one. Short cycles and regular systems make it easier for the worker and his family to plan their social life.
5. In case of continuous shift work, it is important to arrange as many free weekends as possible for the worker in order that he can participate at these times in the normal social life of his friends who do not do shift work.

Knauth et al. (1979) have recently proposed a systematic methodology for evaluating shift systems in relation to these criteria.

A final problem is the question of 'compensation for working unsocial hours'. Until now, night work has been almost universally rewarded only with money. Thierry et al. (1975) were the first to point out that this mechanism of compensation is no longer adequate for industrialized countries of Europe, since the shift workers there have begun to realize that sleep, and social contacts, cannot be bought with money. It must be seen as one of the tasks of psychosocial research to develop and to test alternative compensation mechanisms. Since social synchronizers are of particular importance for adjustment to shift work, mechanisms of compensation for the discomfort of shift work, based on psychosocial arguments, without any doubt, must be of special value not only in their own right, but also from the physiological point of view.

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