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Shiftwork, job type, and the work environment as joint predictors of health-related outcomes

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Abstract

This article examines the potential confounding of observed relations between shiftwork and health outcomes by differences in the jobs typically carried out by shiftworkers and dayworkers. Objective factors (daywork vs. day/night shiftwork, and job type) and work perceptions (job demand, discretion, social support and physical stressors) were analyzed as joint predictors of psychosomatic complaints (headaches, musculo-skeletal, gastric and sleep problems), affective distress, and work-related injuries in data from oil industry personnel (N=1462). Logistic regression showed that, after control for individual differences (including age and negative affectivity), shiftwork and job type, evaluated simultaneously, each predicted specific health outcomes. Work perceptions also contributed significantly to each outcome, partially mediating relations between job type and health.

Shiftwork, job type, and the work environment as joint predictors of health-related outcomes

Numerous studies have investigated the effects of shiftwork on employee health and performance; studies of mortality rates (Taylor & Pocock, 1972), cardiovascular disease (Kawachi et al. 1995; Tenkanen, Sjöblom, Kalimo, Alikoski, & Härmä, 1997), psychosomatic complaints and other health problems (e.g. Vaernes et al. 1988; Tucker, Smith, Macdonald, & Folkard, 1998), sleep patterns (Parkes, 1994; Rosa, 1991), affective responses (Frese & Semmer, 1986; Kandolin, 1993), cognitive performance (e.g. Meijman, van der Meer, & van Dormolen, 1993) and accident rates (Pokorny, Blom, & van Leeuwen, 1987) have all been reported. Whilst the methodology of such studies varies widely, a distinction can be made between research approaches based on data from single occupational groups and those which use data from a range of occupations.

Within single occupational samples, outcome measures have been directly compared across groups of shiftworkers and dayworkers, or across individuals working different rotation schedules (e.g. Kandolin, 1993; Peacock, Glube, Miller, & Clune, 1983; Tucker, Barton, & Folkard, 1996); underlying such comparisons is the assumption that job demands are similar across the groups working different shift systems. Other single-group studies are based on within-subjects designs, the same individuals being assessed on two or more occasions under different shiftwork conditions (e.g. Hennig, Kieferdorf, Moritz, & Weise, 1998; Totterdell, Spelten, Smith, Barton, & Folkard, 1995; Hornberger & Knauth, 1995; Rosa, 1991).

The alternative to using single occupational groups in shiftwork research is to use data from a range of occupations; such studies, especially those of an epidemiological nature, have the potential advantage of large sample sizes (e.g. Taylor & Pocock, 1972; Cherry, 1984; Tenkanen et al. 1997). However, shiftwork (particularly, round-the-clock

shiftwork) is more common in some occupations, such as process control and emergency services, than in others. Furthermore, occupational groups differ in job characteristics, and in mental and physical health (e.g. Marmot, Rose, Shipley, & Hamilton, 1978; Schechter, Green, Olsen, Kruse, & Cargo, 1997; Tuomi et al. 1991); consequently, if there is no control for occupational differences, the effects of job types on health outcomes are potentially confounded with the effects of shiftwork.

For instance, Taylor and Pocock (1972) compared mortality rates in shift workers and dayworkers carrying out manual work in ten different factories, but did not take into account possible differences in job characteristics between the shiftwork and daywork groups. Similarly, in a 15-year study of papermill employees, Knutsson, Akerstedt, Jonsson, and Orth-Gomer (1986) compared the incidence of ischaemic heart disease among shift workers with that among day workers, finding that a significant risk of disease occurred after 11 years of exposure to shiftwork. This analysis was controlled for age and smoking history, but not for psychosocial job differences between the shift workers (process-control operators), and the day workers (maintenance personnel). On a smaller scale, the problem is also illustrated by a comparison of health reports of process-control operators working rotating shifts with those of administrators working daytime schedules (Vaernes et al. 1988). Similarly, job demands and shift work were confounded in a study of health among night security guards as compared with a national sample (Alfredsson, Akerstedt, Mattsson, & Wilborg, 1991).

Several attempts have been made to overcome potential confounding between shiftwork and job type. One approach is to control for broad social class differences. Thus, Tenkanen et al. (1997) examined coronary heart disease in relation to shiftwork in a cohort of 1806 industrial employees, distinguishing between blue-collar and white-collar workers. Among day-workers, white-collar and blue-collar employees did not differ

signficantly in coronary heart disease risk, but blue-collar shiftworkers had significantly higher risk than white-collar day workers. In some studies, also, occupation has been used as a matching variable in case-control studies (e.g. Taylor, Pocock & Sergean, 1972), or matched sub-groups of dayworkers and shiftworkers from a larger sample have been compared (e.g. Taylor & Pocock, 1972).

An alternative approach to potential confounding between shiftwork and job type is to include measures of perceived job characteristics in the analysis of shiftwork effects. In this case, jobs are represented by subjective job dimensions rather than by objective categories. For instance, Frese and Semmer (1986) compared shiftworkers, former shiftworkers, and never-shiftworkers on measures of affective distress and general ill-health. They found significant differences between the three groups in measures of psychosomatic complaints and psychological strain. Stress at work, as represented by job perceptions, contributed additively rather than interactively to the outcomes examined; thus, shiftwork and perceived job stress acted independently as predictors of ill-health.

Cervinka (1993) also controlled for psychological stress at work in evaluating shiftwork effects; again, shiftwork and subjective stress measures were found to contribute independently to self-reported health status. Conversely, when job perceptions are the main factors of interest, shiftwork status may be used as a control variable (e.g. Melamed, Ben-Avi, Luz, & Green, 1995). However, none of these studies included information about shiftwork, objective job categories, and subjective job perceptions. Thus, as noted by Frese and Semmer (1986), and more recently by Akerstedt and Knutsson (1997), the combined effects of shiftwork and job characteristics on health outcomes, and particularly the possibility of confounding, have not been fully examined in the existing literature. The present study addresses these issues.

Shiftwork, job characteristics, and health

There are several mechanisms by which job characteristics (represented either as objective job types or in terms of subjective dimensions) may combine with exposure to shift work to influence health outcomes.

- Shiftwork and job characteristics may show *additive* effects on health, in accordance with the findings of Frese and Semmer (1986) and Cervinka (1993). However, it is also possible that the effects of shiftwork and job characteristics may be specific to particular types of health outcomes, i.e. shiftwork may be associated with some aspects of impaired health, while particular features of jobs relate to other health problems. This model would be consistent with the idea that the circadian adaptation required in shiftwork, and the physical and psychological demands of particular jobs, have specific and differential patterns of health impact.
- Objective job categories may act to *confound* observed relations between shiftwork and health outcomes, i.e. the apparent impact of shiftwork on health measures may be due to differences in the types of jobs that typically involve day/night shiftwork and those that are normally involve only daywork. If so, when shiftwork and job type are simultaneously entered as predictor variables, the significance of shiftwork as a predictor would be reduced or eliminated. Conversely, observed differences between job types may be partially due to differences in the extent to which they involve shiftwork.
- Consistent with current theoretical models of work stress (e.g. Israel, Baker, Goldenhur, Heaney, & Schurman, 1996), subjective perceptions of the work environment may *mediate* relations between shiftwork and health outcomes. For instance, on offshore installations, physical environment stressors (e.g. exposure to

cold) tend to be more severe during nightwork than during daywork and this difference may play a role in the link between shiftwork and health.

- The impact of work demands on health may be *moderated* by whether the job is carried out under shiftwork or daywork conditions, the effects of shiftwork on health depending on the nature of the job concerned. This possibility has rarely been examined although Cherry (1984) found no evidence of interactions between shiftwork (some *vs.* none) and occupational category (as assessed by sociodemographic group) in predicting nervous strain at work.

The present study

In the light of the possible mechanisms outlined above, the present study examines the combined effects of shiftwork, objective job categories, and work perceptions on health-related outcomes in data from personnel working on North Sea oil and gas installations. For the purposes of this study, the offshore setting had two advantages. First, the round-the-clock nature of offshore production and drilling processes is such that day/night rotating shiftwork is carried out by a relatively high proportion of personnel, applies in all occupational groups, and imposes particularly severe adaptational demands (Parkes, Clark, & Payne-Cook, 1997; Parkes, 1998). Second, all personnel work 12-hour shifts and live on board for the duration of the offshore tour (2-3 weeks) with no opportunity to leave the installation at the end of a shift.

In the present study, the main interest was in the independent and combined roles of daywork *vs*. shiftwork, objective job type, and the perceived work environment. Evidence suggests that job types are significantly associated with health outcomes among oil industry personnel (Fischer et al. 1998), and eight categories of jobs were identified in the present study. Subjective work dimensions were also assessed; the measures used

were perceived job demand, job discretion and social support, dimensions known to have significant health implications (Karasek & Theorell, 1990), particularly for shiftworkers (Schechter et al. 1997). Exposure to adverse physical conditions, an important aspect of the offshore work environment (e.g. Hellesoy, 1985), was also assessed. In addition, in accordance current approaches to work-related disorders (Buckle, 1997; Israel et al. 1996), individual differences in personality traits and in biomedical variables were included in the model.

Method

Data collection

Data were collected from personnel working on 17 North Sea oil and gas installations. Researchers visited each installation for periods of 3-4 days, with a subsequent visit to the 'back-to-back' crew (i.e. those on shore break at the time of the first visit). While offshore, the researchers outlined the research plan to personnel on board, responded to questions, distributed the survey materials, and collected the completed questionnaires.

A total of 1598 male personnel returned questionnaires; return rates varied across installations, with an average value of 82.6%. In the analyses reported here, only data from personnel with at least two months' experience of their current jobs, working either day/night rotating shifts or day shifts, were included in the analyses (N=1354). Listwise deletion of missing data further reduced the sample used in the analysis (N=1320: day-workers, n=680; shiftworkers, n=640). The average age of participants in the sample analyzed was 38.9 years (*SD* 8.9).

Measures

Neuroticism. A 12-item version of the neuroticism scale from the Eysenck Personality Questionnaire (Eysenck *et al.* 1985) was used to assess negative affectivity (alpha = .84).

Type A behavior. Three items from the Framingham Type A scale (Haynes, Levine, Scotch, Feinleib, & Kannel, 1978) were used to assess '*speed and impatience*' Type A traits, which have significant implications for the health and safety of offshore personnel (Parkes, 1993). The alpha value for this sub-scale was .66, closely comparable to values reported elsewhere for similar Type A sub-scales (e.g. Feather & Volkmer, 1991; Kaliterna, Vidaček, Radosevic-Vidaček, & Prizmač, 1993).

Body mass index (BMI). Height (feet/inches) and weight (lbs) were reported by survey participants. These data were converted to metric measures, and BMI values were calculated from the formula: BMI = weight in kgs / (height in ms)^2

Smoking habits. Participants were asked whether they were current smokers, and if so approximately how many cigarettes per day they smoked. These responses were coded 0 (*non-smoker*), 1 (*moderate smoker*, <20 per day), and 2 (*heavy smoker*, ≥ 20 per day).

Shift pattern. All personnel worked 12-hour shifts; day workers, coded 0, were distinguished from shift workers (ie. those working day/night rotating shifts), coded 1.

*Job type***.** Participants were asked to record their job titles, which were classified into eight job categories. The sample sizes in each of the job groups were: management (n=150), technical (n=92), maintenance (n=361), production (n=213), drilling (n=222), construction (n=110), administration (n=96), and catering (n=76).

Perceived work environment. In accordance with Karasek and Theorell's (1990) formulation, *job demand* was measured by five items assessing work demands, work pace and time pressures, work overload, and multiple tasks (alpha = .87), and *job discretion* by 10 items assessing control over work tasks, involvement in decision-making, varied work, and opportunities for learning (alpha= .73). For both these scales, items were worded as statements to which participants responded on a five-point 0 "do not agree at all" to 4 "agree strongly" scale. The s*ocial support* measure was taken from House (1981); the

five-item scale assessed the extent to which supervisors were perceived to be supportive and helpful to their subordinates (alpha=.84). Six items taken from Hellesoy (1985) measured the extent to which personnel considered themselves to be exposed to an adverse *physical environment* (e.g. noise, vibration, poor air quality, cramped workspace) in the course of their work (alpha=.80).

Psychosomatic complaints. An eight-item checklist developed for use with shift workers in process industries (Vaernes et al. 1988) was used to assess minor health complaints. Headaches and sleep problems were each assessed by a single item, while gastric and musculoskeletal problems were each assessed by three items. Participants indicated whether or not they had experienced each of the problems listed during the previous six weeks. Responses to the sleep and headache items were coded 1 (*yes*) or 0 (*no*).

Responses to the three items describing musculoskeletal problems were significantly intercorrelated; the most frequently endorsed of these complaints was back pain (29.9%), but reports of neck pain (23.0%) and shoulder pain (18.1%) were also not uncommon. Overall, 53.5% of the sample reported no musculoskeletal problems, 28.4% reported one, 11.7% reported two, and 6.4% reported all three problems. The three gastric problems (indigestion, heartburn and stomach pain) also tended to cluster together, although they were less frequently reported (indigestion, 21.6%; heartburn, 18.5%; stomach, 12.1%) than the musculoskeletal problems. Overall, 69.0% of the sample reported no gastric problems, 15.1% (one), 13.9% (two) and 2.0% (three). In the logistic regression analyses, for both musculoskeletal and gastric problems, individuals were coded 0 if they responded negatively to each of the component items, or 1 if they endorsed any of the three items.

Psychological distress. The General Health Questionnaire 12-item symptom checklist (GHQ-12) (Goldberg, 1978) was used to assess psychological distress, distinguishing

between '*cases*' (coded 1) and '*normals*' (coded 0). GHQ-12 items have a four-point response scale, scored 0-0-1-1 for case detection purposes. The recommended 2/3 cutting point (Banks et al. 1980) was used to identify potential 'cases'.

Work-related injuries. Respondents were also asked whether they had experienced an injury requiring medical treatment (i.e. treatment by the installation sickbay 'medic' and/or at onshore medical facilities) as a result of a work-related accident offshore during the previous year, positive and negative responses being coded 1 and 0, respectively.

Data analysis

Logistic regression was used to assess the extent to which the independent variables jointly predicted the health outcomes assessed. In these analyses, the three categorical predictor variables (smoking behavior, shiftwork, and job type) were dummy coded; "non-smokers", "daywork", and the "maintenance" job type were treated as the reference categories. The other predictor variables (age, BMI, neuroticism, and Type-A) were treated as continuous measures. The significance of predictor variables was tested by means of Wald's statistic, and relative risk (RR) values were calculated to indicate the excess risks associated with the significant factors.

Separate analyses were carried out for each outcome measure. Individual difference variables were entered simultaneously at the first step of the analysis. For the BMI measure, curvilinear effects were also tested, but the quadratic term was dropped from the model if not significant. To examine the separate and combined effects of shiftwork and job type, the second step of the analysis was carried out in two alternative orders; shiftwork was tested with and without control for job type, and job type was tested with and without control for shiftwork. At the final step, the perceived work environment variables were entered simultaneously, and the extent to which they mediated the effects of shiftwork and job type was examined. To test possible moderating effects, interactions

between job type and shiftwork, and between the work environment measures and shiftwork, were evaluated; in the latter case, individual interaction terms were only interpreted if the block of four interactions was significant overall.

Results

Means, standard deviations, and associations between predictor variables

Table 1 shows the means, standard deviations and intercorrelations of the continuous predictor variables (age, neuroticism, Type A behavior, BMI, and the four work environment measures). Also shown in Table 1 are the correlations with shift pattern, the dichotomous variable representing daywork *vs.* shiftwork. In general, with the exception of the positive correlations between neuroticism and Type A behavior, and between job discretion and social support, the correlation values were relatively small (mostly less than .20), although age was significantly correlated with each of the other continuous variables.

Shift pattern was unrelated to the two personality measures, but it was significantly related to age and BMI; dayworkers were more likely to be older and higher in BMI than those doing shiftwork. Shift pattern was also significantly related to job type, $\varkappa^2$=427.2, df=7, p<.001. The highest proportions of shiftworkers were among production operators (92.5%) and drill crews (82.4%), while catering and management personnel were least likely to be shiftworkers (14.5% and 16.0%, respectively). Also shown in Table 1 are correlation values indicating that shiftwork was perceived as lower in job discretion and higher in exposure to adverse physical environment, although it was unrelated to job demand and social support.

Smoking behavior, coded into three categories, was significantly related to job type, $\varkappa^2$ = 34.12, df = 14, p = .002, but not to shift pattern. Drilling personnel had the lowest

proportion of non-smokers (52.3%), whilst the highest proportions of non-smokers were among management and production personnel (72.7% and 72.3%, respectively). Job type significantly predicted job demand and discretion, and the physical environment measure, but not social support. Production, drilliing and construction jobs had relatively high scores on exposure to physical environment stressors, while management personnel reported the highest levels of job demand and discretion.

Health outcomes: prevalence and associations with predictor variables

The first column of Table 2 shows the prevalence of each health problem assessed. Nearly half the sample responded positively to the items concerned with sleep and musculo-skeletal problems. However, other items were endorsed less often; in particular, mental health problems, as reflected in the proportion of GHQ 'cases', were much less frequent (14.4%), as were work-related injuries (9.5%). Correlations between predictor and outcome variables are also shown in Table 2. Neuroticism was significantly related to each outcome except injuries, higher levels of neuroticism predicting greater likelihood of problems. Type A scores also positively predicted each outcome variable, except headaches. In addition, age was negatively related to headaches and injury. Shift pattern showed significant tetrachoric correlations with sleep and gastric problems, GHQ caseness, and injuries.

Measures of the perceived work environment were significantly related to each of the outcome measures but the correlations, although significant, were generally small. Chi-square tests showed that sleep, headache, and musculo-skeletal problems varied significantly across job types, although the detailed pattern of results was different for each measure. Reports of injuries also differed significantly across jobs, construction workers (and to a lesser extent, drillers) showing higher levels than other job groups.

Logistic regression analyses predicting health outcomes

Results of the logistic regression analyses predicting the psychosomatic complaints and other health-related outcomes are summarised in Table 3. For each of the measures, the overall models were found to be highly significant at each stage of the analysis. However, each outcome was predicted by a different combination of independent variables. The relative risk values associated with the significant factors in each of the final simultaneous models are shown in Table 4.

Individual differences To control for the effects of individual differences on health, the personality and biomedical variables were entered into the model at the first step. Neuroticism was a significant predictor of all outcomes except injuries, and Type A scores were significant for all outcomes except headaches; personnel high in neuroticism and/or high in Type A scores were consistently more likely to report health problems than their low-scoring counterparts. Other predictor variables showed more specific patterns of relationships. Thus, age was negatively associated with headaches and with injuries but was unrelated to the other outcomes. BMI showed no significant main effects in relation to the outcome variables examined (although it was marginally significant in relation to gastric problems); however, the curvilinear term predicting mental health was significant, individuals with below-average or above-average in BMI being more likely to be GHQ 'cases' than those of average BMI. As shown in Table 4, the highest relative risk (RR) values in the final logistic regression model were those associated with smoking 20+ cigarettes per day; in particular, for gastric problems, RR = 1.60.

Shiftwork and job type. Table 3 presents two sets of results for entry of shiftwork and job type variables into the logistic regression model; Step 2a shows the effect of shiftwork with and without control for job type, while Step 2b shows the effect of job type with and

without control for shiftwork. These analyses allowed possible confounding between job type and shiftwork in predicting health outcomes to be examined.

*Shiftwor*k, controlled for job type, significantly predicted two psychosomatic outcomes, gastric problems and sleep complaints. In each case, shift workers were more likely to report adverse outcomes than day-workers. However, for both gastric and sleep problems, when job type was omitted from the model, the Wald test values and the significance levels obtained were higher than when job type was taken into account. Furthermore, with no control for job type, shiftwork was also significant in relation to mental health and, to a marginal level of significance, to injuries. Thus, when job type was not controlled, the apparent risks of gastric and sleep problems attributable to shiftwork were partly due to job type differences. The RR values for shiftwork in the final model were 1.36 for gastric problems, and 1.81 for sleep complaints, representing significant excess risks of these complaints for day/night rotating shift workers as compared with day workers.

Job type significantly predicted headaches, musculoskeletal problems, and injuries; as shown in Table 3, these results were not affected by whether or not shiftwork was included in the model. As compared with the reference group (maintenance personnel), drillers were significantly more likely to report musculoskeletal problems, while catering personnel were significantly less likely to report these problems. Managers, construction workers and drillers were most at risk of headaches, while the overall impact of job type on injuries was entirely due to the high level among construction workers. In contrast to these findings, which were not changed by control for shiftwork, the results for sleep problems were significant only when shiftwork was omitted from the model; when shiftwork was entered simultaneously with job type, there was no significant association between job type and sleep problems. Thus, confounding had the effect of giving rise to

spurious results for the association between job type and sleep problems if shiftwork was not controlled.

Examination of the RR values from the final model, shown in Table 4, showed that management and construction personnel were both at nearly double the risk of headaches relative to the reference group (maintenance workers), the RR values being 1.88 and 1.84 respectively. Drillers showed RR values significantly greater than unity for both headaches and musculoskeletal problems, while for the injury outcome measure, construction workers showed almost a threefold increase in risk relative to the reference group.

Perceived work environment. At the final stage of the logistic regression, the four work environment measures were entered as a block. For each outcome measure, entry of this block produced a highly significant increment in the model chi-square but, as shown in Table 3, a different pattern of results was found for each outcome. In general, social support and physical environment stressors predicted health outcomes more strongly than the measures of job demand and discretion. Thus, social support was highly significant in relation to headaches, gastric problems, and mental health, perceived high support being a preventative factor for each of these complaints. In contrast, musculoskeletal problems and injuries were strongly and positively predicted by physical environment stressors; the physical environment was also implicated in sleep problems although this effect was less marked. Job demand was a highly significant predictor of accidental injury; the relationship was negative, low perceived demand being associated with higher risk of injury than high demand. These findings were reflected in the relative risk values shown in Table 4. Thus, exposure to adverse physical environment was associated with RR values significantly greater than unity for all outcome measures except GHQ caseness, musculoskeletal problems and injuries showing the highest values (1.31 and 1.46

respectively). Conversely, the preventative role of favourable social interactions was demonstrated by the significantly reduced risks of headaches, gastric problems, and GHQ caseness when social support was perceived to be high.

Mediating effects of work environment measures. Theoretically, it would be expected that the effects of objective work characteristics on health outcomes would be mediated by the subjective perceptions of the personnel concerned. In the present study, mediation effects were examined by determining whether the significance of job type and/or shiftwork in the second step of the analysis shown in Table 3 was reduced or eliminated when the perceived work environment measures were included in the model. Evidence of partial mediation of shiftwork/health relations by the work environment measures was found for gastric and sleep problems; in each case, the significance of the shiftwork factor was reduced in the full model, as compared with Step 2 of the analysis. There was a corresponding reduction in the RR values. For gastric problems RR for shiftwork fell from 1.46 (with job type controlled) to 1.36 (with perceived work environment measures also taken into account); for sleep problems the corresponding RR reduction was from 2.24 to 1.81. However, in each case, the effect of shiftwork remained significant in the full model, indicating that only a relatively small minor of the association between shiftwork and the two health outcomes concerned was accounted for by the work environment variables. A similar pattern of results was obtained when the association between job types and health outcomes was examined; as shown in Table 3, for headache, musculo-skeletal and injury outcomes, the significance of job type was reduced by inclusion of the perceived work measures in the full model, but this reduction was small relative to the direct effects of job type in the full model.

Tests of moderating effects. To test whether either job type or the measures of the perceived work environment acted as moderators of relations between shiftwork and

health, the *shiftwork x job type* interaction, together with the set of four product terms representing the *shiftwork x work environment* interactions, were entered simultaneously as a final step in the analysis for each of the outcome measures. There was no evidence of interaction effects, only one marginally significant ($p<.10$) interaction term being found.

Discussion

In focusing on the separate and combined roles of shift work, job type, and the work perceptions as predictors of a range of health-related outcomes, the present study sought to extend the findings of previous research into shiftwork and health. In summary, the main findings were: (i) that, when included in the model as simultaneous predictors, shiftwork and job type showed significant associations with different health problems; (ii) that confounding between shiftwork and job type tended to inflate these associations when shiftwork was considered without control for job type, or *vice versa*; (iii) that measures of the perceived work environment contributed additively to the predictive model, and partially mediated associations between the objective factors (shiftwork and job type) and health outcomes; and (iv) that there was no evidence that shiftwork effects were moderated by job type or by work perceptions. These findings, together with other points arising from the present work, including the role of individual difference variables, are discussed in the following sections.

Shiftwork and job type

The results of the present study suggest that day/night shiftwork (as compared with daywork) and job type are associated with different patterns of health-related outcomes. When each of these predictors was controlled for the other, outcomes that were predicted by shiftwork (gastric complaints and sleep problems) were not predicted by job type; conversely, those that were predicted by job type (musculo-skeletal complaints,

headaches, and work-related injury) were not predicted by shiftwork. Thus, the adaptational demands of shiftwork and those associated with particular types of jobs had differential patterns of impact on health.

One implication of this finding is that the use of single overall scores representing the summation of a number of different health complaints to assess the impact of current or previous shiftwork as compared with daywork (e.g. Frese & Semmer, 1986; Schmieder & Smith, 1996) may give misleading or weak findings. The present study also suggests that the findings from shiftwork studies may be distorted if the sample includes a variety of occupational groups, and the effects of job differences are not controlled.

Thus, in the present study, absence of control for job type in the evaluation of shiftwork effects gave rise to inflated significance levels for three outcome measures, gastric problems, sleep complaints, and psychological distress. Controlling for job type resulted in the observed impact of shiftwork on sleep and gastric problems being substantially reduced, while the effect on psychological distress ceased to be significant. Similarly, when job type was evaluated without control for shiftwork, a highly significant effect on sleep problems was observed, which was no longer significant when shiftwork was controlled. These results suggest a degree of confounding between shiftwork and job type in predicting psychosomatic and mental health outcomes which has been largely disregarded in past work (eg. Alfredsson et al. 1991; Jaffe, Smolensky, Wun, 1996; Knutsson et al. 1986).

In the present study, after control for job type differences, shiftwork directly predicted gastric problems and sleep disturbance, findings consistent with other evidence in the literature (e.g. Costa, 1997; Jaffe et al. 1996; Vener, Szabo, & Moore, 1989). These effects can be primarily attributed to the circadian adjustment necessitated by changes from day to night work, and *vice versa*. In the offshore environment, this problem is

particularly acute because jobs are covered by two 12-hour shifts, and the shift change typically occurs in the middle of the two-week work cycle, with no intervening rest days. The pattern of results for job type indicated that construction workers were most likely to report work-related injuries while drillers were most likely to report musculo-skeletal problems; headaches were common to both these groups. Both these job types involve heavy physical work, often in difficult environmental conditions (Hellesoy, 1985). Findings reported by Buckle (1997) and Houtman, Bongers, Smulders, and Kompier (1994) suggest that these work conditions could account, at least in part, for the results obtained. However, the relative risk of managers reporting headaches was also high and could not primarily be attributed to physical work stressors; in this case, long work hours, interpersonal demands, and the responsibilities of managing remote and potentially hazardous installations may provide a more realistic explanation.

Perceived work characteristics

The initial analyses indicated that two perceived work characteristics (job discretion and adverse physical environment) were significantly predicted by both shiftwork and job type. Consistent with other findings (Tenkanen et al. 1997), shiftworkers reported lower job discretion than dayworkers; in the present study, also, shiftworkers perceived greater exposure to adverse physical work conditions than day-workers. Job types differed significantly on three perceived work environment measures, the differences in exposure to adverse physical working conditions being particularly marked. Frese and Semmer (1986) reported that psychological and environmental stress at work contributed significantly to psychosomatic outcomes over and above shiftwork status, and in the present study similar additive effects of work environment variables were found. In particular, adverse physical environment made a significant contribution to each outcome measure except psychological distress; in agreement with other findings (e.g. Houtman et

al. 1994), its impact on musculo-skeletal disorders was especially marked but it was also a highly significant predictor of accidental injury. Similarly, the tendency for high workload and time pressure to be associated with musculo-skeletal disorders reflects the findings of Bongers, de-Winter, Kompier, and Hildebrandt (1993).

Mediating and moderating effects

One aim of the present study was to investigate the roles played by mediating and moderating effects in relation to the health outcomes assessed. As in other studies (Cervinka, 1993; Cherry, 1984; Frese & Semmer, 1986), there was no evidence of significant moderating effects involving shiftwork and either job type or the perceived work environment. However, the perceived work environment was found to partially mediate the impact of objective work factors (i.e. shiftwork and job type) on health; thus, the significance of these objective factors on health outcomes was reduced by inclusion of the work environment variables in the predictive model. None the less, these indirect effects were relatively small compared with the direct effects of shiftwork and job type.

As Evan and Lepore (1997) point out, identifying variables that fully explain the relation between environmental factors and human responses is rare; the present findings suggest that the dimensions of the perceived work environment assessed, although significant predictors of health outcomes, explain only part of the path by which shiftwork and job differences impact on health. It is likely that other factors including, for instance, detailed task characteristics such as those shown to be associated with mental and physical health by Shaw and Riskind (1983), and current concerns such as job insecurity (e.g. Dekker & Schaufeli, 1995; Roskies & Louis-Guerin, 1990), also play a role in this process.

Individual differences

In the present study, individual differences in personality and biomedical factors were included among the predictor variables primarily for control purposes. In particular, inclusion of a measure of generalised negative affectivity (NA) is important when the predictive model includes subjective ratings of work conditions and self-reported health outcomes (e.g. Brief, Burke, George, Robinson, & Webster, 1988). Previous research in which shiftwork and subjective work perceptions have been examined in relation to health ratings have tended to overlook the role of NA (e.g. Frese & Semmer, 1986; Cervinka, 1993). The present study included neuroticism as a NA measure, and demonstrated its highly significant impact on the psychosomatic outcome measures and, especially, on psychological distress. Contrary to the findings of Iverson and Erwin (1997), NA was not significant in relation to reported injuries. However, injury reports were predicted by Type A behavior, individuals higher in 'speed and impatience' being more likely to report work-related injuries, a finding similar to that noted by Sutherland and Cooper (1991). The role of Type A as a predictor of other outcome measures, although generally significant, was less marked than that of neuroticism.

The other individual difference variables, age, smoking habits, and BMI also gave rise to significant findings. In particular, age was found to predict, negatively, both headaches and injuries. Increased caution among the older personnel may be a contributory factor in relation to injuries. However, a more general explanation of these findings is that personnel who experience difficulty adapting to the demands of offshore shiftwork, are more likely to leave their jobs than those who do not experience such adaptational problems. Thus, self-selection produces an older 'survivor' group, better able to cope with environmental and work-related demands than those who quit. The finding of the present study are also of interest in that BMI predicted psychological distress in a curvilinear manner; concern has tended to focus on the problem of

overweight in the population as a whole (e.g. Wolf & Colditz, 1998) and among offshore employees in particular (e.g. Light & Gibson, 1986), but less attention has been paid to those who are underweight, although curvilinear relationships between BMI and health-related outcomes have been reported previously (Parkes, 1987).

Methodology

Whilst the present study had the advantage of a relatively large sample size and high response rate, the cross-sectional nature of the data set inevitably imposes familiar limitations on causal interpretation of the findings. Thus, more rigorous evaluation of the combined effects of shiftwork and job characteristics on health requires prospective research that takes into account the effects of selection into different jobs and shift patterns, and differential patterns of survival in the industry. These issues are particularly important in that offshore employment differs from work in onshore industry in ways that may have significant implications for selection and survival patterns. In particular, North Sea personnel live and work in confined and potentially hazardous conditions in isolated locations, and are separated from their families and communities through the two-week tour of duty. Also, medical requirements for offshore work are more rigorous than for comparable onshore employment.

A further limitation of the present study was its reliance on self-reported health outcomes; in future work, inclusion of objective health outcome information would enhance the value of the research. The present work was also limited in the range of health complaints examined; for instance, cardiovascular problems (potentially of particular relevance to a sample of employed men, half of whom were in the 40+ years age range) were not assessed.

None the less, the present study highlights the specific patterns of associations of shiftwork with gastric and sleep problems, on the one hand, and of job type with

headaches, musculo-skeletal problems and injuries, on the other; it also demonstrates that, over and above these objective predictors, work perceptions contribute to the outcomes assessed. In these respects, the present work cautions against research designs that compare the health and psychological well-being of shiftworkers and dayworkers without taking into account possible differences in job characteristics between the two groups. From an applied point of view, it is also relevant that in examining the role of objective work factors, the present study facilitates the identification of particular groups of employees on whom occupational physicians and other health professionals can most effectively focus specific health promotion interventions.

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Table 1
Means, standard deviations, and intercorrelations of predictor variables

	M	*SD*	2	3	4	5	6	7	8	9
1. Age (years)	38.87	8.87	-.13**	-.12**	.25*	-.15**	.11**	.22**	.12**	-.12**
2. Neuroticism	3.82	2.88	----	.36**	-.03	.05	.10**	-.20**	-.15**	.17**
3. Type-A	7.18	2.28		----	.02	-.02	.22**	-.08**	-.09**	.07*
4. BMI	25.63	2.77			----	-.06*	.02	.03	-.01	.04
5. Shift pattern	.49	--				----	-.08**	-.21**	-.04	.31**
6. Job demand	2.25	.89					----	.06*	-.10**	.00
7. Job discretion	2.43	.64						----	.34**	-.27**
8. Social support	1.65	.67							----	-.13**
9. Physical environment	2.16	.86								----

N=1320 ** p<.01 * p<.05

Table 2
Correlations of outcome variables with predictor variables

Health outcomes	Prevalence	*Correlations with predictor variables*								
		Age	Neuroticism	Type A	BMI	Shift pattern	Job demand	Job discretion	Social support	Physical environme
Sleep problems	45.3%	-.04	.26**	.14**	-.05	.19**	.08**	-.14**	-.11**	.15**
Headache Musculo-	37.9%	-.08**	.19**	.09**	-.01	.02	.07**	-.07*	-.11**	.11**
skeletal	46.5%	-.02	.17**	.13**	.00	.03	.08**	-.09**	-.08**	.17**
Gastric	31.0%	-.02	.19**	.13**	.04	.09**	.04	-.09**	-.12**	.16**
GHQ 'cases'	14.4%	.03	.36**	.19**	-.02	.06*	.08**	-.13**	-.14**	.08**
Work-related injury	9.5%	-.10**	.03	.08**	-.06*	.06*	-.08**	-.10**	-.04	.14**

N=1320 ** p<.01 * p<.05

Table 3
Hierarchical logistic regression analyses predicting health-related outcomes

	Predictor variables	*df*	*Psychosomatic complaints*				Psychological distress: GHQ 'cases'	Work-related injury
			Headache	Muscular	Gastric	Sleep		
Step 1	Age	1	3.83*	<1	<1	1.14	<1	6.13*
	Neuroticism	1	34.33***	23.43***	28.84***	60.68***	105.18***	<1
	Type-A	1	<1	8.07**	6.50**	5.62*	7.13**	6.46**
	BMI / (BMI quadratic)	1 / (1)	<1	<1	3.05†	1.90	<1 / (4.25*)	1.34
	Smoking behavior	2	4.54	7.42*	12.38**	<1	1.65	<1
Step 2a	Shiftwork	1	<1	<1	9.39**	43.64***	5.46*	3.05†
	Shiftwork (job type controlled)	1	<1	<1	6.33*	20.50***	2.94	1.41
Step 2b	Job type	7	18.67**	28.60***	8.95	30.78***	8.78	30.81***
	Job type (shiftwork controlled)	7	18.68**	28.17***	6.17	7.32	7.36	30.41***
Step 3	Job demand	1	2.03	2.97†	<1	2.09	<1	7.58**
	Job discretion	1	<1	2.40	<1	1.40	2.95†	2.71†
	Social support	1	8.11**	1.21	8.34**	3.00†	7.94**	<1
	Physical environment	1	3.79*	16.42***	9.61**	4.62*	<1	10.54**
Shiftwork in full model		1	<1	1.52	3.88*	16.72***	3.05†	<1
Job type in full model		1	17.14*	24.23**	4.07	6.30	8.04	18.15*

Overall model:						
Chi-square	91.90	116.05	107.88	166.7	207.51	76.61
df	18	18	18	18	19	18
Significance	p<.0001	p<.0001	p<.0001	p<.0001	p<.0001	p<.0001

*** p < .001 ** p < .01 * p < .05 † p < .10

Table 4
Relative risks of the predictor variables in relation to health outcomes

Predictor variables	*Psychosomatic complaints*				Psychological distress: GHQ 'cases'	Work-related injury
	Headache	Muscular	Gastric	Sleep		
Age	ns	ns	ns	ns	ns	ns
Neuroticism	1.13 (1.08 - 1.18)	1.09 (1.05 - 1.14)	1.11 (1.06 - 1.17)	1.17 (1.12 - 1.23)	1.39 (1.30 - 1.48)	ns
Type-A	ns	1.06 (1.01 - 1.18)	1.07 (1.01 - 1.14)	ns	1.10 (1.01 - 1.19)	1.15 (1.05 - 1.26)
BMI	ns	ns	ns	ns	ns	ns
BMI quadratic					1.17 (1.00 - 1.25)	
Smoking behavior†						
< 20 per day	ns	ns	ns	ns	ns	ns
20+ per day	ns	1.43 (1.08 - 1.91)	1.60 (1.19 - 2.15)	ns	ns	ns
	ns	ns	1.36 (1.00 - 1.84)	1.81 (1.36 - 2.42)	ns	ns
Shiftwork††						
Job type†††	ns	ns	ns	ns	ns	ns
Technical	ns	.50 (.28 - .89)	ns	ns	ns	ns
Catering	ns	ns	ns	ns	ns	ns
Production	1.88 (1.21 - 2.91)	ns	ns	ns	ns	ns
Management	ns	ns	ns	ns	ns	ns
Administration	1.84 (1.17 - 2.89)	ns	ns	ns	ns	2.91 (1.58 - 5.36)
Construction	1.64 (1.11 - 2.42)	1.68 (1.14 - 2.47)	ns	ns	ns	ns
Drilling						
Job demand	ns	ns	ns	ns	ns	.75 (.61 - .92)
Job discretion	ns	ns	ns	ns	ns	ns
Social support	.83 (.73 - .94)	ns	.82 (.72 - .94)	ns	.76 (.63 - .92)	ns
Physical environment	1.14 (1.00 - 1.31)	1.31 (1.15 - 1.50)	1.25 (1.09 - 1.44)	1.16 (1.01 - 1.33)	ns	1.46 (1.16 - 1.84)

Note. All relative risk values are taken from the final simultaneous model. The values shown in brackets are the 95% confidence limits..

† Reference category: Non-smokers †† Reference category: Day workers ††† Reference category: Maintenance workers