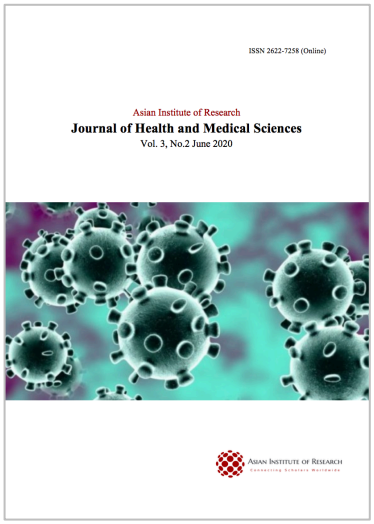

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Combinations of Workplace Stressors and Work-Related Injuries

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Abstract
Consideration of factors associated with increased accident likelihood has tended to concentrate on the influence of one specific factor (for example, noise) and other influences are either not considered or are controlled for. The aim here was to examine the influence of combinations of stressors on the prevalence of workplace accidents using self-report measures of exposure, health and work outcomes. Logistic regression analyses were carried out, with 'work-related/non-work-related accident' as the dependent variable. The main predictors were combinations of physical agents (noise, fumes, hazardous substances) and temporal stressors (night and shift work, long working hours). Additional predictors - the job demand-control-support model (Karasek 1979; Johnson and Hall 1988) and home-work interface (HWI) were also investigated. Other measured predictors (i.e., age, sex and social class based on occupation) were included in all analyses. There was some evidence for an increased likelihood of work-related accidents in those exposed to combinations of stressors - increased likelihood was largely due to independent effects of stressors, particularly noise. Certain stressors were also associated with a decreased risk of having a work-related accident (i.e. unpredictable work hours). Job-demand-control-support did not have a major impact on predicting work-/nonwork-related accident likelihood. Prevalence of accidents at work largely reflected social class based on occupation - 'skilled manual workers' or 'partly skilled workers' were most likely to have an accident.

Keywords: Occupational Medicine, Accidents, Noise, Working Hours, Combined Effects

1. Introduction

The purpose of this paper is to describe a preliminary investigation into the association of self-reported measures of occupational factors and the likelihood of suffering an accident at work. In this investigation, an accident at work is defined as an 'injury deemed severe enough by employee/employer to warrant a visit to the emergency unit at University Hospital Wales in Cardiff, which is subsequently categorised as a work-related injury during triage by a nurse'. The motivation for undertaking this research was to address the issue of the extent to which certain stressors are associated with work-related accidents and whether there is any evidence of the combined exposure to more than one stressor in the workplace being significantly more strongly associated with work-related accidents than exposure to single stressors.

There has been some suggestion for the role of occupational noise exposure in work-related accidents, although it is often felt that there is little real evidence of a relationship due to potential confounding

influences that may not have been considered (for a review: see Smith 1990). There is considerable information however that suggests a role of temporal stressors in increased accident risk. On a societal level, many of the major man-made disasters of the last 20-30 years have to some extent been attributed to tiredness or other outcomes of workplace temporal stressors such as night work, shift work or long working hours. Temporal stressors have been implicated in Chernobyl, Exxon Valdez, Three-Mile Island and Bhopal (Matthews et al. 2000). On the individual level, the role of tiredness in increased risk of error is well established and a circadian rhythm of accidents has been suggested (Folkard 1997). However, accurately modelling the cause of accidents is impaired by the inability to control for potential confounders. For example, accidents are more likely to occur at night in many jobs but the work done at night is often very different in a number of other ways - i.e. people often work alone and on different tasks compared to day workers (for a review see: Sparks et al. 1997). The workplace is a complicated environment and the general approach of studying, say, the effects of noise or night work on accident risk does not necessarily reflect the reality of the workplace. This survey intends to provide enough information so that simple questions concerning whether there is a significant increase in work accident likelihood associated with exposure to specific combinations of stressors can be addressed with more confidence.

2. Material and methods

2.1 Survey Content

The questionnaire was designed to ask about the physical, temporal and psychosocial stressors associated with the workplace. Physical and temporal stressors were measured by a series of items that asked whether the individual's job involved exposure to loud noise, disturbing background noise, exposure to fumes, having to handle hazardous substances, night work, shift work, unsociable working hours, unpredictable working hours or long working hours. Each of these items was measured on a four-point scale – 'often', 'sometimes', 'seldom' and 'never' – except long working hours which was measured by the question 'how many hours do you work per week?' which was subsequently categorised into quartiles and those in the top quartile (>48 hours per week, in line the council of the European Union working time directive number 93/104/EC) were considered as working long hours. Items were taken from the Bristol Health and Safety at Work Study (Smith et al. 2000).

Psychosocial work factors were assessed by using the job (iso-)strain model (Karasek 1979; Johnson and Hall 1988). This model can be assessed by 25 items which make up 3 scales, job demand (4 items), work social support (6 items) and decision latitude [Also termed 'job control', reflecting the amount of control one has over how they do their job.] (15 items). It is postulated that the relationship between these scales influences health, with a situation of low support, low decision latitude and high demand having the most negative outcome on health. Home/work interface (HWI) was measured using a scale adapted from the Whitehall II studies (Marmot et al. 1991). The questionnaire also included an item asking what the individual's current job was. From this, 'social class based on occupation' could be calculated - a reflection of both socioeconomic status and job type. Other demographic details were gathered from the hospital records.

2.2 Participants/Procedure

After being approved by the hospital's ethical committee, the questionnaire was distributed to 2,000 individuals randomly selected from the hospital records of the last 3 months with the assistance of hospital staff. 1,000 of these selected individuals had been categorised by staff at triage as having suffered work- related accidents and 1,000 had been categorised as having suffered nonwork- related accidents (i.e. RTA's, accidents at home, sports injuries).

2.3 Response Rate

The sample consisted of 367 (18.4%) participants. This was a poor response rate and subsequent investigation will need to greatly improve this. 162 of these reported work-related accidents and 205 non-work-related accidents. The mean age of the sample was 40.0 (Std. Dev = 11.7), ranging from 16 to 70 years old. The sample consisted

of 200 men and 115 women, due to incomplete hospital records, gender of 66 questionnaire returners was not available

3. Results

Physical stressors and temporal stressors were considered in terms of their combined effects on work-related accident likelihood.

3.1 Statistical Methods

Firstly, physical and temporal stressors were examined for an intuitive factor structure using principal components analysis in SPSS. These items grouped on to 3 factors, representing physical stressors, temporal stressors and hours of work respectively (Table 1). Physical stressors explained more of the variance (27.2%) than temporal stressors (24.0%) and hours of work (12.1%), 63.3% being accounted for in all.

Table 1: Factor analysis of the predictor variables

	Factor 1	Factor 2	Factor 3
Shift Work		.889	
Night Work		.885	
Unsociable hours of work		.856	
Unpredictable hours of work		.520	.500
Long work hours			.885
Noisy work environment	.742		
Exposed to breathing fumes	.729		
Handle dangerous substances	.611		
Left with ringing in ears	.678		
Disturbed by background noise	.773		
Unsuitable air temperature	.643		

The next set of analyses examined associations between the predictor variables and the outcomes. All analyses were carried out using SPSS binary logistic regression. The first analysis was designed to give an overview of the approximate influence of (a) physical workplace stressors, (b) temporal workplace stressors and (c) these stressors in combination. Scores on the factor 1 and factor 2 groupings were summed individually and split into quartiles. These quartiles were recoded into dichotomous variables, with quartiles 1-3 = low/medium exposure, and quartile 4 = high exposure. These 2 variables were then used to group participants into 1 of 4 categories:

1. Low exposure to both physical and temporal stressors
2. Low exposure to physical stressors, high exposure to temporal stressors
3. High exposure to physical stressors, low exposure to temporal stressors
4. High exposure to both physical and temporal stressors

A simple indicator contrast was used in the analysis, comparing the likelihood ratio of each level of the predictor to the effect associated with the first group. Subsequent analyses included an 8-level predictor variable outlining the various permutations of the job (iso-) strain model (i.e. combinations of high and low job demand, job control and social support).Home/work interface was also included as a 3-level predictor variable, (1) little or no problem, (2) moderate problems and (3) considerable problems integrating work and home life. Age, gender and social class based on occupation were all included as predictors in the logistic regression analyses. A simple indicator contrast was used for this predictor, comparing the likelihood ratio of each level of the predictor to the effect associated with the first group. Analysis of three models was

undertaken. Model 1 consisted of the key predictor alone (i.e. physical/temporal stressors). Model 2 included the demographic covariates (i.e. age, gender and social class based on occupation). Model 3 also included 'other job characteristics' (i.e. job (iso-) strain, HWI). After looking at the summed physical agents and temporal stressors, median splits of stressors were considered in pairs - 1 physical stressor and 1 temporal stressor in each analysis.

3.2 Descriptive Statistics

Descriptive statistics for age are shown in Table 2. Work-related accident cases were marginally older and had a greater age range.

Table 2: Age and accidents

	N	Mean	SD	Min	Max	Range
Work-related accident	169	39.6	12.5	16	70	54
Non-work-related accident	212	38.4	10.8	17	60	43

Descriptive statistics for gender are shown in table 3. More men had returned the questionnaire. More of the work-related accident sample were male than the non-work-related accident sample.

Table 3: Gender

	Work-related accident	Non-work-related accident
Male (N/%)	105 (69.1%)	95 (58.3%)
Female (N/%)	47 (30.9%)	68 (41.7%)

Descriptive statistics for social class based on occupation are shown in table 4. 'Skilled: manual', 'partly skilled' and 'unskilled' workers are better represented in the work-related accidents sample. 'Professional', 'managerial & technical' and 'skilled: non-manual' workers are better represented in the non-work- related accidents sample.

Table 4: Social Class Based On Occupation

	Work-related accident	Non-work-related accident
Professional (N/%)	3 (1.9%)	17 (8.3%)
Managerial & Technical (N/%)	32 (19.8%)	56 (27.3%)
Skilled non-manual (N/%)	19 (11.7%)	42 (20.5%)
Skilled manual (N/%)	57 (35.2%)	33 (16.1%)
Partly skilled (N/%)	35 (21.6%)	26 (12.7%)
Unskilled (N/%)	12 (7.4%)	5 (2.4%)
Missing data (N/%)	4 (2.5%)	26 (12.7%

The exposure to physical and temporal workplace stressors is shown in Table 5. Of the temporal stressors, the most frequent was shift work (29.7%). Of the physical stressors, a ‘noisy working environment’ was the most frequently reported condition (57.8%). Some information about the accidents is described below. Where the non-work injury was sustained is shown in Table 6. Although a considerable number of non-work- related accidents were poorly described in hospital records (33.7%), the single biggest recorded percentage was accidents in the home (27.0%). The type of injury sustained is shown in Table 7. The most frequent reason amongst the work-related injury sample was 'laceration/cut' (20.4%) and 'abrasion/bruise' (18.4%). The most frequent reasons amongst the non-work-related injury sample were 'abrasion/bruise' (19.0%) and 'sprain' (17.8%).

Table 5: Workplace exposure

	Low/Medium exposure	High exposure
Shift Work	265 (70.3%)	112 (29.7%)
Night Work	293 (78.3%)	81 (21.7%)
Unsociable hours of work	274 (67.5%)	109 (25.8%)
Unpredictable hours of work	296 (78.5%)	218 (57.8%)

Long work hours (> 48 hours per week)	313 (74.2%)	109 (25.8%)
Noisy work environment	159 (42.2%)	218 (57.8%)
Exposed to breathing fumes	240 (63.7%)	137 (36.3%)
Handle dangerous substances	274 (73.7%)	98 (26.3%)
Left with ringing in ears	329 (87.3%)	48 (12.7%)
Disturbed by background noise	268 (71.3%)	108 (28.7%)
Unsuitable air temperature	174 (46.0%)	204 (54.0%)

Table 6**:** Where the non-work injury was sustained

Road Traffic Accident	17 (10.4%)
Sport	13 (8%)
Home	44 (27.0%)
Public Place	34 (20.9%)
Other/poorly described	55 (33.7%)

Table 7: Type of injury

	Work-related	Non-work-related
Abrasion/Bruise	28 (18.4%)	31 (19.0%)
Laceration/cut	31 (20.4%)	11 (6.7%)
Sprain	13 (8.6%)	29 (17.8%
Soft tissue injury	16 (10.5%)	16 (9.8%)
Fracture	19 (12.5%)	16 (9.8%)
Burn/scald	10 (6.6%)	1 (0.6%)
Local infection	2 (1.3%)	3 (1.8%)
Foreign body	8 (5.3%)	1 (0.6%)
Other	24 (15.8%)	43 (26.4%)
Missing information	1 (0.7%)	12 (7.4%)

What the outcome of the visit to the emergency unit was is shown in table 8. More of the non-work-related accidents were of a severity/complexity to require admittance (11.0%) compared to the work-related accidents (4.0%), although generally minor injuries not requiring a stay as an inpatient are seen in this sample.

Table 8: Outcome of visit to emergency unit

	Work-related accident	Non-work-related accident
Sent home	142 (93.4%)	141 (86.5%)
Admitted to hospital	6 (4.0%)	18 (11.0%)
Did not wait	3 (2.0%)	4 (2.5%)
Unspecified	1 (0.7%)	0 (0%)

3.3 Summed Physical and Temporal Stressors

Table 9 shows the accident rates for the different stressor conditions. Univariate non-parametric analysis using Pearson chi-square showed significant differences between the categories of the summed physical and temporal stressors predictors against accident type (chi square =16.69 $p < 0.001$). Individuals reporting high exposure to physical and temporal stressors were more likely to have been admitted to the emergency unit with a work-related accident than a non-work-related accident. Looking at multivariate analysis using binary logistic regression, a test of the full model with all predictors against a constant-only model was statistically reliable (chi square

(17, N = 266) = 43.53, p<0.001). This indicated that the predictors as a set reliably distinguished between those who had suffered work-related accidents and those who had suffered non-work-related accidents. The variance accounted for however was relatively small, RL= .12. Predictive success was however quite impressive. The constant-only model correctly classified 51.9% of cases, model 1 60.2%, model 2 65.4% and model 3 67.3%. This was a 30.0% increase overall. There was no problem with outlying studentized residuals (<2). Investigation of collinearity diagnostics showed that there was no concerns regarding multicollinearity between the predictor variables. The combined stressors category was significant in all 3 models. The 'high physical stressors only' category was significant in model 1 only, but subsequently removed when additional predictors were added in models 2 and 3 (see Table 10).

Table 9: Chi-square analysis for accidents in different stressor conditions

	Non-work-related accidents	Work-related Accidents
Neither stressor	O=56; E=43.3; 27.2%	O=22; E=34.7; 13.3%
High temporal stressor	O=23; E=20.5; 20.5%	O=14; E=16.5; 8.5%
High physical stressor	O=70; E=69.4; 34.0%	O=55; E=55.6; 33.3%
Both stressors	O=57; E=72.7; 27.7%	O=74; E=58.3; 44.8%

Table 10: Odds Ratios (Exp (B)) and Confidence Intervals (CI) for the Physical/Temporal Stressors Predictors

	Model 1[a] Exp(B) (95% CI)	Model 2[b] Exp(B) (95% CI)	Model 3[c] Exp(B) (95% CI)
Neither Stressor			
High temporal stressor	1.256 (0.48, 3.27)	1.09 (0.39, 3.07)	1.40 (0.48, 4.04)
High Physical stressor	2.26 (1.10, 4.61)*	1.80 (0.84, 3.86)	2.02 (0.92, 4.44)
Both stressors	3.33 (1.62, 6.82)**	3.35 (1.08, 5.09)*	2.54 (1.11, 5.80)*

a. Physical and temporal stressors predictor only

b. Physical and temporal stressors predictor, age, gender and social class based on occupation

c. Physical and temporal stressors predictor, age, gender, social class based on occupation and job-strain

*p < 0.05 **p < 0.01

Of the other predictors included in models 2 and 3, contrast comparisons within social class based on occupation revealed that (a) skilled-manual and (b) partly-skilled workers were more likely to have suffered a work-related accident than a non-work-related accidents.

3.4 Other predictors

Initial investigation demonstrated that sex, social class based on occupation (Table 11) and job (iso-) strain showed significant associations with the work- related/non-work-related accidents. This is why they were included as predictors in models 2 and 3. Although age did not show a significant association, this was included in models 2 and 3 because it is a standard demographic measure. HWI did not demonstrate a significant association with the work-related/non-work-related variable and was excluded from the models. As noted in the previous section, workers classified as 'skilled-manual' and 'partly-skilled' were significantly more likely to have been admitted for a work- related accident. This remained significant in models 1 and 2 but, although the trend remained, it was non-significant in model 3. Low decision latitude and high social support from the job (iso-) strain model were associated with an increased likelihood of a work-related accident (or a decreased likelihood of non-work-related accident).

Table 11: Exp (B) and C.I. for Social Class Based On Occupation

	Model 1[a] Exp(B) (95% CI)	Model 2[b] Exp(B) (95% CI)	Model 3[c] Exp(B) (95% CI)
Professional			
Managerial/technical	1.02 90.57, 1.84)	1.12 (0.61, 2.07)	1.10 (0.58, 2.084)
Skilled manual	0.67 (0.34, 1.33)	0.86 (0.42, 1.78)	0.85 (0.40, 1.78)
Skilled non-manual	2.50 (1.41, 4.43)**	2.20 (1.22, 3.96)**	2.11 (1.15, 3.89)

Partly skilled	2.23 (1.18, 4.25)**	2.09 (1.09, 4.02)*	2.16 (1.10, 4.24)
Unskilled	2.60 (0.89, 7.58)	2.14 (0.71, 6.49)	2.36 (0.74, 7.49)

a. social class based on occupation only
b. social class based on occupation, physical and temporal stressors predictor, age, and gender
c. social class based on occupation, physical and temporal stressors predictor, age, gender and job-strain
*p<.05 **p<.01

3.5 Summary of Analyses of Item Pairs

The previous analyses summarised findings from looking at the *overall* exposures to physical and temporal stressors in the workplace and other predictors. Below is a summary of further analyses that considered exposure to specific stressors in combination. Where individuals had self-reported working in a noisy environment and also often worked either nights, shifts or unsociable hours of work then there was approximately a 3-fold increase in the likelihood of the individual having had an accident at work (Table 12), in comparison to having a non-work related accident. In each case of a significant 'combined effect' there was also a significant increase in work accident likelihood associated with the noise contrast in comparison to the 'neither stressor' reference category. There was no significant difference between the likelihood ratio associated with the high noise exposure category and that associated with the combined stressors group. This can be demonstrated by observing that the odds ratio of the signficant contrasts falls within the confidence intervals of each other.

Table 12**:** Exp (b) and CI for Noisy Work Environment and Unsociable hours of work

	Model 1[a] Exp(B) (95% CI)	Model 2[b] Exp(B) (95% CI)	Model 3[c] Exp(B) (95% CI)
Neither Stressor			
Unsociable hours	1.90 (0.82, 4.38)	1.52 (0.63, 3.68)	1.68 (0.67, 4.21)
High Noise	3.41 (1.83, 6.37)**	2.59 (1.29, 5.20)**	2.73 (1.34, 5.56)**
Both stressors	4.12 (2.07, 8.18)**	3.19 (1.50, 6.81)**	3.48 (1.58, 7.67)**

a. Physical and temporal stressors predictor only
b. Physical and temporal stressors predictor, age, gender and social class based on occupation
c. Physical and temporal stressors predictor, age, gender, social class based on occupation and job-strain
*p < 0.05 **p < 0.01

All other combinations - i.e. loud noise and temporal stressors, disturbance by background noise and temporal stressors, fumes exposure and temporal stressors, hazardous substances and temporal stressors and unsuitable temperature and temporal stressors, showed no significantly increased likelihood associated with the combined stressors group. The combination of 'unpredictable work hours' and physical stressors showed a decreased risk of work-related accident compared to physical stressors alone (Table 13). Indeed, unpredictable working hours were associated with a decreased risk of accidents at work. This can also be interpreted as an increased risk of non-work-related accident in workers reporting working unpredictable hours. Noisy work was associated with increased work-related accident risk, which supports previous findings.

Table 13: Exp (B) and C.I. for Noisy Work Environment and Unpredictable Hours of Work

	Model 1[a] Exp(B) (95% CI)	Model 2[b] Exp(B) (95% CI)	Model 3[c] Exp(B) (95% CI)
Neither Stressor			
Unpredictable hors	0.52 (0.20, 1.37)	0.22 (0.56, 0.89) *	0.21 (0.49, 0.88) *
High Noise	2.63 (1.64, 4.23) **	2.23 (1.19, 4.16) *	2.045 (1.07, 3.92) *
Both stressors	2.36 (1.22, 4.55) *	1.39 (0.60, 3.25)	1.49 (0.62, 3.58)

a. Physical and temporal stressors predictor only
b. Physical and temporal stressors predictor, age, gender and social class based on occupation
c. Physical and temporal stressors predictor, age, gender, social class based on occupation and job-strain
*p < 0.05 **p < 0.01

4. Discussion

The present study provides preliminary evidence that a combination of stressors can lead to increased risk of accidents at work. Exposure was based on self-report and objective measurement is necessary in future studies. There is also the problem of missing information. For example, no information was obtained about whether people considered their job to be dangerous or whether they worked with heavy machinery. The ubiquity of increased work- related accidents being associated with 'skilled non-manual' and 'partly skilled' work shows the important role that type of job has. However,this is clearly not the whole story – as shown by the significant effect associated with the combined stressors contrast in the summed physical and temporal stressors analysis that remains even after the addition of other predictors.

It may be that as well as an increased risk depending on one's occupation, increased exposure to stressors within that workplace further increases the risk. To give an example,a factory worker may work with heavy machinery that puts them at risk of injury. This machinery may be noisy, but if their job requires them to, say, work long, unsociable hours also then the likelihood of having an accident at work may be greatly increased due to the additional strain put on the individual. In addition,the complexities of the work place – i.e. the fact that 'skilled-manual' and 'partially- skilled' occupations will often be low status jobs, with lower pay, lower job satisfaction and a more negative psychosocial environment only further increases the strain and further leads to increased accident risk.

Further adjustments that need to be made to this study are as follows: a control group needs to be added (i.e. those who have had no accident at all) as attempts to get case-controls by sending out questionnaires for participants to forward on to colleagues in comparable job roles was unsuccessful. The questionnaire does not tap into the wide variety of information that may be beneficial to a discussion of accident likelihood (i.e. risk taking, health related behaviours - alcohol, drugs etc., other health symptoms and negative affectivity - a measure of dispositional response bias). A longer questionnaire has been distributed to 5 samples of 2,000 people drawn from Hospitals around Wales. This questionnaire includes more items to allow a more in-depth analysis of the data.

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