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The impact of shift work on the risk and severity of injuries for hospital employees: an analysis using Oregon workers' compensation data

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Background	While past research on health care workers has found that shift work can lead to negative physiological and psychological consequences, few studies have assessed the extent to which it increases the risk of specific work-related injuries, nor quantified and compared associated types, severity and costs.
Aims	This study aimed to derive and compare the rates, typologies, costs and disability time of injuries for various hospital worker occupations by day, evening and night shift.
Methods	This study used Oregon workers' compensation claim data from 1990 to 1997 to examine the differences in hospital employee claims (n = 7717) by shift and occupation. Oregon hospital employee claim data, hospital employment data from Oregon's Labor Market Information System and shift proportion estimates derived from the Current Population Survey (CPS) were used to calculate injury rate estimates.
Results	The injury rate for day shift per 10 000 employees was estimated to be 176 (95% CI 172–180), as compared with injury rate estimates of 324 (95% CI 311–337) for evening shift and 279 (95% CI 257–302), night shift workers. The average number of days taken off for injury disability was longer for injured night shift workers (46) than for day (38) or evening (39) shift workers.
Conclusion	Evening and night shift hospital employees were found to be at greater risk of sustaining an occupational injury than day shift workers, with those on the night shift reporting injuries of the greatest severity as measured by disability leave. Staffing levels and task differences between shifts may also affect injury risk.
Key words	Health care workers; occupational injury; shift work; workers' compensation; work schedules.
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Introduction

It has been found that shift work can disrupt human circadian rhythms which are normally acclimated to daytime wakefulness and nighttime rest [1,2]. At the physiological level, medical investigations have demonstrated that circadian desynchronization can lead to changes in hormonal levels, increase the risk of cardiovascular disease, produce sleep-cycle disturbances and result in significant fatigue [3–12]. In turn, these outcomes (in particular fatigue) may result in decreased levels of cognitive functioning, inferior job performance,

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increased feelings of stress and a greater number of work-related accidents [13–18]. Studies that have demonstrated such effects have included performance tests in laboratory settings and research on such occupations as offshore workers, security guards, textile workers, teleprinter operators and navy personnel [19–24].

Health care workers are particularly convenient to study as health care provision requires 24 h staffing and 36% of health care workers engage in shift work with a high variety of work tasks [25]. Shift work has been associated with decreased cognitive functioning in resident physicians, errors in task performance, complications following surgery by sleep-deprived residents, job dissatisfaction and turnover of emergency medical personnel [26–32]. Similarly, research on nurses has shown that shift work is correlated with high levels of stress, problems in concentration, increases in psychosomatic complaints and inferior quality of job performance [33–36]. Yet, while many of the shift work studies have attributed error and accidents simply to fatigue, the potential confounders of staffing and task differences between shifts that may affect these outcomes are frequently ignored.

Although previous investigations have demonstrated that fatigue can increase the likelihood of medical conditions or accidents, little work has been conducted to assess the risk to health care workers performing shift work [37]. One exception was a study of Massachusetts nurses that found that those on rotating shifts were almost twice as likely to report errors or accidents related to fatigue [38]. However, because the study focused exclusively on nurses, combined occupational injuries with on-the-job procedural errors, and did not elucidate on the type of injuries or nature of severity experienced by the nurses in the sample, the results do not generalize to the larger population of hospital workers and detailed information on the injuries sustained is unknown. Thus, there still remains an important need for continued research on the nature of occupational risks faced by health care employees from shift work schedules.

Workers' compensation data are considered to be particularly useful in assessing health conditions arising out of the course of employment by occupational health researchers [39–45]. This study aims to extend upon past findings by using workers' compensation data of all workers in general medical and surgical hospitals from the state of Oregon for the period of 1990–1997 to assess whether shift work affects health care workers' risk of workplace accidents and injuries.

Materials and methods

This study used workers' compensation claim data that were provided by the Oregon Department of Consumer and Business Information and Management Division for the period 1990–1997. Records were kept for all claims that were disabling or potentially disabling (i.e. those that involved either potential or actual lost work time), although the records were available for some claims that did not actually result in disability. For this study, only accepted claims from the hospital industry (SIC 806) were analyzed. Occupations were identified using the US Department of Labor's Standard Occupational Codes (SOC).

The data set included information on claimant occupation and industry, claimant demographics (e.g. age, gender), claimant work schedules, nature of reported injury, body part affected, compensated days of lost work by claimant and claimant cost. Claims costs were tracked through 1999 and the cost data reflect accumulated claim costs through this time. By the end of the observation period, 96% of all accepted claims used in this study were closed and for these claims the cost data were complete.

The workers' compensation data from Oregon recorded information on the hour that a claimant began work. In order to investigate work injuries by shift of work, we defined day, evening and night shifts as follows: individuals who reported starting work between 4 a.m. and 11 a.m. were classified as day shift workers; individuals who reported starting work between 12 p.m. and 7 p.m. were classified as evening shift workers; and individuals who reported starting work between 8 p.m. and 3 a.m. were classified as night shift workers.

Because the Oregon workers' compensation data contain no information on employment levels, yearly employment levels for the hospital industry were obtained from Oregon Employment Department's Labor Market Information System (LMIS) for the years 1990–1997. To estimate employment levels for different categories of hospital employees, these data were combined with proportion estimates using survey data from the United States Bureau of Census' Current Population Surveys (CPS). Researchers commonly rely on the CPS for the purpose of attaining denominators to estimate rates among study populations from geographic areas [46–51]. Estimates of the proportion of hospital industry employees belonging to different age, gender and occupation groups were calculated using a random sample of 539 Oregon hospital employees that were derived from the monthly outgoing rotation group (CPS-MORG) files for the years 1990–1997. For individuals in CPS-MORG, additional questions pertaining to an individual's employment were asked.

For all hospital employees, as well as each age, gender and occupation subgroup, the proportion of hospital employees that worked day, evening or night shift were estimated using a random sample of hospital employees derived from the May 1991 and May 1997 CPS surveys, which asked supplemental questions about an

individual's work schedule. Only individuals in these CPS work schedule supplements (WSS) who reported working in the hospital industry (SIC 806) were included in the analysis. Since only 38 of the 4395 hospital employees in this random sample reported residing in Oregon, in order to increase the precision of our estimates, we used the entire sample of hospital employees when estimating the proportion of employees in each shift. Such estimates are valid when the characteristics of Oregon hospital employees and hospital employees in other states do not differ.

Details of the method used to calculate injury rates are available as Supplementary data at *Occupational Medicine* Online.

To investigate whether total claim costs and lost workdays depended on age, gender, shift, occupation, weekly wage, year of injury, nature of injury and cause of injury, a multivariate linear regression model was estimated. Since a substantial fraction of claims involved either zero total costs and/or zero lost workdays, the standard errors of the regression estimates were adjusted for possible heteroscedasticity. To further investigate the impact of these explanatory variables on aspects of the total claim costs and lost workdays, distributions other than the mean, quantile regressions were estimated for the 25th, 50th (median) and 75th percentiles [53]. All statistical analysis was performed using Stata version 8.2 software (Stata Corporation, College Station, TX).

Results

Between 1990 and 1997, there were 7717 compensable workers' compensation claims filed by hospital employees in the state of Oregon, averaging ~965 claims annually. Seventy-nine per cent of all claims were filed by female employees. There was little variation by age or sex between day, evening and night shifts.

Table 1 presents a complete breakdown of injury claims by age, gender occupation, nature of injury and cause of injury both for all shifts of work and by shift or work. There was little variation in average working hours by shift, with day shift claimants averaging 8.4 h (SD = 1.4), evening shift claimants averaging 8.3 h (SD = 1.3) and night shift claimants averaging 8.3 h (SD = 0.9).

Because of the cross-sectional design of this study, injury rates by shift were estimated. The injury rate of day shift hospital employees per 10 000 employees was estimated to be 176 [95% confidence interval (CI) = 172–180]. Injury rate estimates for evening shift and night shift workers were 324 (95% CI = 311–337) and 279 (95% CI = 257–302), respectively. In many cases, large differences were found in the rates within occupations. For example, the injury rate for registered nurses working the day shift was estimated to be 145 (95% CI = 135–154) per 10 000, while the estimated injury rate for registered nurses working the evening and night shifts was 210 (95% CI = 195–225) and 257 (95% CI = 231–282), respectively. Table 2 provides detailed estimates of the injury rates and their associated confidence intervals for gender, age and hospital occupational groups, both overall and by shift.

For all hospital employees, lost workdays per claim averaged 38.9 days (SD = 81.3). Day shift employees filing claims lost an average of 38.0 (SD = 80.0) days of work, evening shift employees lost an average of 38.6 (SD = 81.2) days of work and night shift employees lost an average of 46.1 (SD = 89.5) days of work, which was about a week longer than the overall average for all workers. It should be noted that the large standard deviations in indemnity time are typical of large workers' compensation samples, as the severity of injuries sustained tend to vary greatly between individuals and type of accidents that were reported. Average amounts of lost work days in which an employee received Temporary Total Disability (TTD) benefits are presented in Table 3 for occupation group, nature of injury and event causing injury for all shifts and by each shift separately.

The costs associated with the types and sources of injuries were also analyzed both in aggregate and by shift. For all hospital employee claims, the average total amount per claim amounted to $6213 (SD = $13 382). An analysis of claim cost differences by shift shows that those working night shift had the highest claim costs, averaging $6715 (SD = $12 856), with day shift workers averaging $6187 (SD = $12 470) and evening shift employee claim costs averaging $6103 (SD = $15 338). Dislocations were found to be the most expensive injury type, averaging $16 692 (SD = $20 914) per claim, while bruises were the least expensive injury type, averaging $4673 (SD = $11 165) per claim. Of all causes of injuries, those stemming from repetitive motion resulted in the highest average claim amount of $7254, while those in which injury causation was attributed to being struck by an object had the lowest average claim cost of $4638 (SD = $9555). A complete breakdown of average total claim costs by shift for occupation, nature of injury and event causing injury is presented in Table 3.

Results from a linear regression analysis for TTD days of lost work that controlled for shift, gender, age, event causing injury, nature of injury, occupation, year of injury and weekly wage of claimant showed that shift had a significant impact on TTD days. In particular, claimants working the night shift on average had significantly more TTD days of lost work than claimants working either the day shift or the evening shift. Linear regression results for total claim costs, however, showed that shift was not a significant determinant of total claim costs. Quantile regression estimates for the 25th percentile, median and 75th percentile of TTD days of lost work and total claim costs produced similar results. The linear and quantile

Table 1. Demographic, occupation and injury characteristics of hospital industry claimants by shift

	All (n = 7717)		Shift					
	Claims	%	Day (n = 4789)		Evening (n = 2194)		Night (n = 734)	
			Claims	%	Claims	%	Claims	%
Age of claimant (years)								
≤25	657	8.5	332	6.9	274	12.5	51	7.0
26–35	1973	25.6	1165	24.3	608	27.7	200	27.3
36–45	2661	34.5	1718	35.9	690	31.5	253	34.5
46–55	1705	22.1	1103	23.0	443	20.2	159	21.7
56–65	671	8.7	435	9.1	170	7.8	66	9.0
>65	50	0.7	36	0.8	9	0.4	5	0.7
Sex of claimant								
Male	1595	20.7	960	20.1	511	23.3	124	16.9
Female	6122	79.3	3829	80.0	1683	76.7	610	83.1
Occupation of claimant								
Manager	38	0.5	33	0.7	3	0.1	2	0.3
Physician	8	0.1	7	0.2	1	0.1	0	0.0
Registered nurse	1772	23.0	904	18.9	593	27.0	275	37.5
Therapists, n.e.c.	92	1.2	63	1.3	25	1.1	4	0.5
Clinical lab. technologists and technicians	110	1.4	77	1.6	23	1.1	10	1.4
Radiological technicians	111	1.4	86	1.8	17	0.8	8	1.1
Licensed practical nurses	278	3.6	144	3.0	92	4.2	42	5.7
Health technologists and technicians, n.e.c.	246	3.2	166	3.5	67	3.1	13	1.8
Secretaries	109	1.4	82	1.7	21	1.0	6	0.8
Receptionists	82	1.1	61	1.3	10	0.5	11	1.5
Health aids except nursing	313	4.1	236	4.9	57	2.6	20	2.7
Nursing aids and orderlies	1953	25.31	1082	22.59	669	30.49	202	27.52
Maids and housemen	641	8.3	374	7.8	234	10.7	33	4.5
Janitors and cleaners	198	2.6	98	2.1	99	4.1	10	1.4
Other occupations	1766	22.9	1376	28.7	292	13.3	98	13.4
Nature of injury								
Dislocation	204	2.6	145	3.0	40	1.8	19	2.6
Fracture	281	3.6	177	3.7	78	3.6	26	3.5
Sprain	5405	70.04	3240	67.66	1614	73.56	551	75.07
Bruise	402	5.2	253	5.3	118	5.4	31	4.2
Carpal tunnel	271	3.51	207	4.32	49	2.23	15	2.04
Stress	24	0.3	13	0.3	7	0.3	4	0.5
Hearing loss	3	0.0	2	0.0	1	0.1	0	0.0
Multiple trauma	122	1.6	81	1.7	30	1.4	11	1.5
Cuts and lacerations	112	1.5	80	1.7	23	1.1	9	1.23
Rheumatism	165	2.1	121	2.5	36	1.6	8	1.1
Unknown	62	0.8	43	0.9	17	0.8	2	0.3
Other	666	8.6	427	8.9	181	8.3	58	7.9
Event causing injury								
Over-exertion	3975	51.5	2375	49.6	1190	54.2	410	55.7
Struck or rubbed	461	6.0	291	6.1	127	5.8	43	5.9
Fall or jump	1008	13.1	640	13.4	260	11.9	108	14.7
Repetitive motion	320	4.2	257	5.4	50	2.3	13	1.8
Violence	413	5.4	196	4.1	180	8.2	37	5.0
Other	1540	20.0	1030	21.5	387	17.6	123	16.8

regression results for of TTD days of lost work and total claim costs are presented in Tables 4 and 5, respectively, available as Supplementary data at *Occupational Medicine* Online.

Discussion

The results of the analyses demonstrated that Oregon hospital employees working the evening and night shift had substantially greater risks of injury than employees working the day shift. While the changes in the occupational composition of workers may explain some of the difference, we continued to find large differences in injury rates within occupation. While these results are consistent with past research demonstrating higher risks of accidents occurring among health care workers during

Table 2. Estimated risk of injury rates per 10 000 employees per year

	All		Shift					
	Rate	95% CI	Day		Evening		Night	
			Rate	95% CI	Rate	95% CI	Rate	95% CI
Age of claimant (years)								
≤25	203	198–208	169	162–177	260	248–272	224	197–252
26–35	220	212–228	169	160–179	378	355–401	436	393–480
36–45	199	191–207	167	157–177	338	312–363	233	198–269
46–55	226	218–234	194	184–203	348	324–372	274	238–311
56–65	206	201–211	188	181–196	283	265–301	197	173–222
>65								
Sex of claimant								
Male	178	172–185	146	137–154	302.06	283–321	189	158–220
Female	221	213–229	186	176–196	330.67	308–354	309	271–347
Occupation of claimant								
Manager	41	40–41	37	37–38	83	77–89	169	159–180
Physicians	4	4–4	4	4–4	22	21–23	0	0–0
Registered nurses	175	168–181	145	135–154	210	194–225	257	231–282
Therapists, n.e.c.	246	244–248	196	192–201	1571	1523–1619	106	76–137
Clinical lab. techs	87	85–88	77	75–79	102	97–108	213	199–226
Radiological technicians	105	103–106	111	108–114	73	66–81	159	141–177
Licensed practical nurses	330	326–335	345	336–355	328	315–341	292	272–311
Health techs, n.e.c.	247	244–251	208	203–213	448	429–466	272	238–306
Secretaries	72	70–73	63	61–64	129	122–136	113	101–125
Receptionists	432	430–435	443	437–449	225	210–241	1461	1419–1502
Health aids except nursing	620	614–626	664	652–676	453	424–481	841	770–912
Nursing aids and orderlies	1133	1113–1154	1046	1012–1080	1485	1425–1546	847	760–933
Maids and housemen	398	391–405	321	309–332	634	605–663	449	378–519
Janitors and cleaners	469	465–473	413	399–428	641	619.16–663.01	222	178–267
Other occupations	134	129–139	126	119–132	190	170–209	144	114–173

later shifts, our analysis was unable to discern how much of the increase was purely fatigue-related, as some previous case controlled studies of employee error have attempted to measure. Potentially, some of the increase in injury rates found between shifts was due to differences in staffing levels. For example, fewer nurses may have been available to deal with violent patients in the evening shift, hence leading to greater injury from violence during that shift. Likewise, fewer receptionists working at night may have experienced greater workload over time, thereby leading to the increased rate in repetitive motion injuries. It is also possible that variations in tasks between shifts led to differences in injuries, such as nurses having to perform higher amounts of secretarial-type work at night as the secretarial staff normally present during the day was reduced at night. Nevertheless, the fact that both evening and night shift hospital workers show dramatically higher rates of injuries mandates both further analysis and intervention development.

The severity of injuries associated with night shifts as measured by compensated lost work days was substantially higher than those associated with day and evening shifts. However, the multivariate linear and regression analysis indicated no significant shift differences in the overall cost of injury claims. These different results for the impact of shift are not due to night shift claimants having lower TTD payments than day or evening shift claimants but, instead, are attributable to other lower claim costs (medical, permanent partial disability and vocational training) for night shift than day or evening shift claimants.

Another finding of this study was that the average hours worked per day was almost equivalent for day, night and evening shift hospital workers. Thus, the length of shift did not appear to be a confounding factor in the proclivity to experience injury among the claimant population. It should be noted, however, that some previous research has indicated that employees working more hours per week (i.e. overtime) may be at a higher risk of experiencing negative health outcomes and fatigue [54–57]. Therefore, it is possible that some of the variance in injury rates observed by shift was due to differences in number of hours worked by employees on particular shifts. Hence, a detailed analysis of the interaction of shift work and hours worked is an area worthy of future research.

Aside from the confounding fatigue, task and staffing effects, this study has several limitations that should be noted. First, using the entire national CPS–WSS sample of hospital employees instead of relying only on those residing in Oregon to estimate the proportion of different

Table 3. Average days of total temporary disability (TTD) and average total costs

	Days indemnity (TTD)				Total costs ($)			
	All	Shift			All	Shift		
		Day	Evening	Night		Day	Evening	Night
Occupation of claimant								
Manager	24.0	26.4	5.3	12.0	4958	5191	1344	6530
Physicians	19.5	15.1	50.0	–	9656	10 607	2997	–
Registered nurses	32.8	32.2	30.7	39.3	6615	6833	5984	7256
Therapists, n.e.c.	31.1	36.1	21.2	14.3	5569	6706	3199	2480
Clinical lab. technologists and technicians	45.7	37.6	85.8	15.7	8145	7405	13 183	2259
Radiological technicians	21.3	21.8	17.9	23.5	4613	4700	3551	5942
Licensed practical nurses	41.7	47.1	32.5	43.2	6764	7280	6183	6270
Health technologists and technicians, n.e.c.	45.2	37.7	66.9	29.2	6631	5447	10 035	4200
Secretaries	37.5	25.9	64.6	100.2	6260	5288	9933	6696
Receptionists	42.7	38.8	97.8	14.1	7514	7538	14 255	1254
Health aids except nursing	47.3	46.6	43.3	66.7	6710	6430	6415	10 842
Nursing aids and orderlies	43.4	42.8	40.7	55.3	5861	5849	5864	5920
Maids and housemen	41.1	43.7	37.8	33.7	5555	5672	5475	4795
Janitors and cleaners	45.9	45.7	46.5	43.2	6142	6309	5955	6191
Other occupations	37.3	35.8	37.7	57.0	6175	6088	5794	8525
Nature of injury								
Dislocation	82.9	77.2	103.7	81.9	16 692	15 735	18 794	19 571
Fracture	33.2	29.5	34.6	54.4	6147	5658	6530	8332
Sprain	37.1	36.8	35.6	43.5	5744	5743	5615	6124
Bruise	32.8	33.7	29.5	37.8	4673	4847	3881	6273
Carpal tunnel	48.7	41.6	55.6	122.9	7803	7449	7733	12 933
Stress	59.0	76.8	54.7	8.5	5935	8758	3200	1544
Hearing loss	0.0	0.0	0.0	–	1056	1477	215	0
Multiple trauma	81.0	79.7	78.6	97.1	12 656	13 279	10 366	14 308
Cuts and lacerations	13.4	16.1	5.1	11.1	2669	3388	501	1820
Rheumatism	50.6	41.7	79.6	53.1	7231	5959	11 696	6384
Unknown	44.7	42.6	55.1	3.0	5894	6075	6080	413
Other	35.1	31.9	41.2	38.9	6347	5910	7504	5960
Event causing injury								
Over-exertion	41.8	41.7	39.1	50.5	6405	6385	6288	6857
Struck or rubbed	28.9	27.8	31.1	30.3	4638	4585	4582	5157
Fall or jump	37.6	36.1	34.2	54.7	6572	6579	5638	8780
Repetitive motion	41.7	39.0	62.4	17.6	7254	7070	8820	4874
Violence	47.3	47.1	50.3	33.4	6785	6842	7271	4115
Other	32.6	31.7	33.8	36.2	5585	5594	5448	5948

categories of hospital employee's working day, night and evening shifts may lead to biased estimates of these proportions. This in turn could lead to biased estimates of the injury rate estimates when broken down by shift. To explore this possibility, we tested whether the age, gender and shift distributions of Oregon hospital employees differed from those in other states and found no statistically significant differences based on χ^2 tests. However, given the limited sample of Oregon hospital employees in the CPS–WSS sample, we could not more fully examine any potential differences between hospital employees in Oregon and other states. Thus, the injury rate estimates broken down by shift presented in Table 2 should be viewed in light of this caveat.

Second, because workers' compensation data contains information only on reported injuries, it is likely that some minor injuries that occurred from the performance of occupational duties were not reported. However, as there is no reason to believe that the distribution of under-reporting would be different for these groups, we do not believe that our relative risk estimates would be materially different if all injuries were reported. Third, mixed evidence has been found that cognitive functioning and potential injury may increase when employees engage in shift work on successive evenings and scheduling is erratic [54–57]. The workers' compensation data, however, did not contain information on the consecutive days that claimants worked prior to the day of the accident, and thus this potential moderator could not be investigated. Moreover, the differing aetiologies of injuries also made causality difficult to define. For example, repetitive motion disorders such as carpal tunnel syndrome typically result from cumulative trauma over time, whereas sprains are more indicative of acute

traumatic events such as a slip and fall that may be more directly related to fatigue. Future research using workers' compensation data containing such information could thus be an area of future investigation. Last, because claimant identifiers were intentionally stripped from the data set to ensure individual confidentiality, it was not possible to identify if some of the claimants filed more than one claim, which may to some extent have affected duration and rate estimates. Thus, while this study has clearly demonstrated the value of using workers' compensation data to analyze shift work injury, this limitation also highlights the value of continued study using samples of individual hospital workers so such factors can better be measured and controlled.

Overall, this study found that evening and night shift hospital workers have significantly higher risk of workplace injury than employees working the day shift, with evening and night shift employees experiencing longer periods of TTD duration. However, the total claim costs do not vary significantly by shift once other factors affecting total claim costs are controlled, which may indicate that injury severity may not be substantially different between shifts, in spite of the longer absences of the evening and night shift workers. Our findings for significantly higher injury rates for evening and night shift workers are consistent with past findings and point to explanations that include fatigue, and differences in staffing and task by shift. These results illustrate the importance for future investigations to analyze the relative and potentially interactive impact of each of these various factors.

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