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### **Shift work trends and risk of work injury among Canadian workers**

by [Wong IS](#), [McLeod CB](#), [Demers PA](#)

**Affiliation:** University of British Columbia, School of Environmental Health, 3rd Floor - 2206 East Mall, Vancouver, BC, V6T 1Z3, Canada. [imeldaw@interchange.ubc.ca](mailto:imeldaw@interchange.ubc.ca)

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## Shift work trends and risk of work injury among Canadian workers

by Imelda S Wong, PhD Candidate,<sup>1</sup> Christopher B McLeod, PhD,<sup>2</sup> Paul A Demers, PhD,<sup>3</sup>

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**Objective** The aim of this study was to examine the risk of work injury across shift work types in a representative sample of Canadian workers.

**Methods** We used the Survey of Labour and Income Dynamics to investigate trends in work injury by shift type between 1996–2006. Work injury was defined by receipt of workers' compensation. Logistic regression was used to estimate the risk between shift type and worker injury after adjusting for potential confounders.

**Results** The rate of work injury decreased overall between 1996–2006, but did not decline for night shift workers. Night shift work was associated with work injury for women [odds ratio (OR) 2.04, 95% confidence interval (95% CI) 1.13–3.69] and men (OR 1.91, 95% CI 1.21–3.03), while rotating shift work was associated with work injury for women (OR 2.29, 95% CI 1.37–3.82). The excess risk of work injury attributed to shift work was 14.4% for women and 8.2% for men based on population attributable fraction estimates.

**Conclusions** Rotating and night shift workers appear to have a higher risk of work injury, particularly among women. Regulatory agencies and employers need to identify and mitigate factors that give rise to increased work injury among these types of shift workers.

**Key terms** gender difference; injury compensation; occupational accident; occupational health; night work; rotating shift; Survey of Labour and Income Dynamics; women's health; work–life imbalance.

Work outside of regular daytime hours, such as the case with shift work, has been associated with a wide range of negative health outcomes. This can be attributed to the alteration of normal sleep–wake cycles with light–dark cycles, which has been linked to the disruption of circadian rhythms. This change in normal biological processes may lead to an increased risk of chronic diseases such as cardiovascular disease and cancer (1–5). Changes and maladaptation to regular sleeping routines can also lead to sleepiness and fatigue, which may also increase the risk of accidents and injuries (6–10).

The risk of work injury associated with shift work may be difficult to estimate due to confounding by workplace characteristics. While most studies assume the risk of worker injury remains constant across shifts, it may actually vary significantly due to differences in the workplace environment even within the same occupation. For example, the shift length, type of tasks,

and number of staff and level of supervision may differ between day and night shifts, thereby making it difficult to compare risks (11).

Gender differences may also affect the association between shift work and injury. Women are generally the primary family caregivers (12) and on average, spend nine hours more per week on daily household and child-care duties than men (13). The challenge of balancing paid work and familial commitment can contribute to increased stress that has been linked to adverse health outcomes among women (14). As more women enter the workforce and work longer hours, the impact of these health outcomes associated with shift work may be on the rise (13, 15).

The objectives of this study were to examine the trends in shift work and worker injury in Canada and to compare the risk of injury by shift type. Our hypothesis was that night or rotating shift workers would have a

<sup>1</sup> University of British Columbia, School of Environmental Health, Vancouver, Canada

<sup>2</sup> University of British Columbia, Centre for Health Services and Policy Research, Vancouver, Canada

<sup>3</sup> Occupational Cancer Research Centre, Toronto, Canada

Correspondence to: Imelda Wong, University of British Columbia, School of Environmental Health, 3<sup>rd</sup> Floor – 2206 East Mall, Vancouver, BC, V6T 1Z3, Canada. [E-mail: imeldaw@interchange.ubc.ca].

higher risk of workplace injury than those on regular daytime-only schedules. In addition, the association between shift work and work injury would be stronger for women than men given the potential for shift work to be a greater stressor on the work–life balance among women.

## Methods

We used the Survey of Labour and Income Dynamics (SLID), an annual household income survey conducted by Statistics Canada. It includes all Canadian residents, except for those in the Yukon and Northwest Territories, Nunavut, and those living in institutions or Indian reserves. The survey follows a panel of participants over six years, with a new panel introduced every three years creating a cross-sectional overlap of two panels in any given year. Each panel is comprised of 15 000 households with approximately 30 000 individuals (16).

Participants are surveyed in January about their labor market activity and demographics for the past calendar year. Approximately 80% of all participants provide permission to use their current federal tax return for information on all income sources. Those who do not give permission are surveyed a second time for the income variables (17).

Our analysis was restricted to those within working age (16–65 years) and whose major activity in the past year was working at a job or business or being self-employed. This excluded students, retirees, and unemployed workers.

Work injury was defined as self-report of receipt of workers' compensation benefits in the past year. Respondents were asked to select one of the eight SLID shift type categories which best described their current job. We collapsed these categories into four shift work types: (i) regular daytime schedule, (ii) regular night (includes evening and "graveyard" shift or work generally starting around midnight), (iii) rotating, and (iv) other (includes split shift, on-call, irregular schedule, and other). All missing or non-applicable responses were excluded from the analysis.

We formulated three categories of variables (demographic, socioeconomic, and occupational) which may confound the relationship between shift work and work injury. Demographic characteristics included: gender, age, marital status, and province of residence. Due to the hypothesized work–life imbalance differences between men and women, gender was also considered as an effect modifier. Socioeconomic characteristics included: education and equivalized household income, as defined by total household income adjusted for the number of people in the household. These variables may

independently affect the risk of work injury, but may also enable workers to opt out of or avoid shift work (eg, working in a daytime management job). Occupational characteristics included: work stability, usual weekly hours worked, and occupational physical demands. These variables provide information about workplace conditions and the risk for injury. Precarious employment has been linked to an increased risk of work injury (18). Accordingly, we included a variable that specified if a job was permanent, temporary, seasonal, or casual as an indicator of work stability.

Usual weekly hours worked was derived from the total usual hours worked during the past year. This variable was included to account for potential differences in exposure times between day and night shifts. The amount of time spent working has been found to affect worker fatigue and may contribute to the risk of work injury (19).

We also included occupational physical demands, a variable derived from occupational codes following guidelines defined by the province of Quebec's Occupational Health and Safety Research Institute (Institute de Recherche Robert-Sauvé en Santé et en Sécurité du Travail) (20). This variable has been used in previous studies and has shown to be strongly associated with work injury (21, 22). The three categories of occupational physical demands are: (i) manual – occupations requiring: handling of heavy/average loads on a regular basis; handling lighter loads in static postures; or requiring continuous repetitive work; (ii) mixed – occupations requiring: handling of light loads but not in continuous static postures; or handling heavy/ average loads on an occasional basis; and (iii) non-manual – occupations that rarely require any physical activity.

## Analysis

We completed two analyses to answer our research questions. First, we determined the trends in shift work and worker injury, as measured by workers' compensation claims, by using the SLID cross-sectional data from 1996–2006. We then developed a multivariable risk model using 2006 cross-sectional data for all workers, and stratified for men and women.

Descriptive statistics were used to examine the distribution of shift work and work injury across the other variables. We used logistic regression to estimate the association between shift work and the likelihood of worker injury in the unadjusted model and also adjusting for age, gender, marital status, education level, equivalized income, work stability, usual weekly hours worked, and occupational physical demands.

Sampling weights were used to create a representative sample of Canadian workers. Standard errors and confidence intervals were adjusted for the multi-stage survey

design by calculating a variance based on estimates from 1000 sets of replicate bootstrapped weights supplied by Statistics Canada (17). We used Akaike's Information Criterion (AIC) to assess model fit and identify covariates with the most explanatory power (23).

In addition to the calculation of the risk of injury, we also examined the adjusted population attributable fraction (AF<sub>p</sub>). This is defined as the proportion of the outcome (worker injury) that can be attributed to a specific exposure (shift work) (24). The AF<sub>p</sub> was calculated using 2006 SLID cross-sectional data and expanded on our risk estimates by using the following equation:

$$AF_p = P_c \times [(OR-1)/OR]$$

where P<sub>c</sub> is the proportion of workers in shift work and the fully adjusted odds ratio (OR) is the risk of injury in shift work in comparison to regular daytime work. The AF<sub>p</sub> was then applied to the total worker population to provide an estimate of the number of work injuries that could be prevented if effective measures were implemented to reduce the risk of shift work on work injury.

## Results

### Trends in shift work

From 1996–2006 the Canadian labor force increased by 21.7% from 12.4 to 15.1 million workers, with almost half of this growth in non-regular daytime shift work. The growth in the overall labor force increased among women at a greater rate than men during this time period (65.5% versus 41.6%). The number of women in rotating and night shift work increased by 94.5%,

while for men the increase was 50.0%, leading to a convergence of women and men in these shift types by 2006. The industries with the most number of men in night and rotating shift work were: manufacturing (N=435 000), trade (N=251 000), and accommodations and food services (N=190 000). For women, the industries with the most night and rotating shift workers were: healthcare and social assistance (N=317 000), trade (N=316 000), and accommodations and food services (N=214 000) (25).

### Trends in worker injury

From 1996–2006, the number of reported worker injuries decreased from 415 000 to 356 300 resulting in a decline of 27.9% from 4.2 to 3.0 injuries per 100 workers. When stratifying by gender, the rate of decrease was steeper among men (figure 1). Moreover, the injury rate among night shift workers remained stable during this period, with women having a lower rate of work injury (4.8 per 100 women and 6.9 per 100 men).

### Risk of worker injury

The proportion of injuries among daytime workers (2.9%) was less than those working nights (5.9%), and rotating (3.9%) or other (3.1%) shifts (table 1). A distinct difference was also found for occupational physical demands: the majority of daytime workers were employed in non-manual labor (51%), whereas non-daytime workers were primarily in mixed and manual labor (night 85%, rotating 78%, other 64%). This suggests that occupation may be a key contributor to worker injury.

In the unadjusted logistic regression model (not shown), the OR of injury among night shift workers was 2.65 [95% confidence interval (95% CI) 1.92–3.66] and

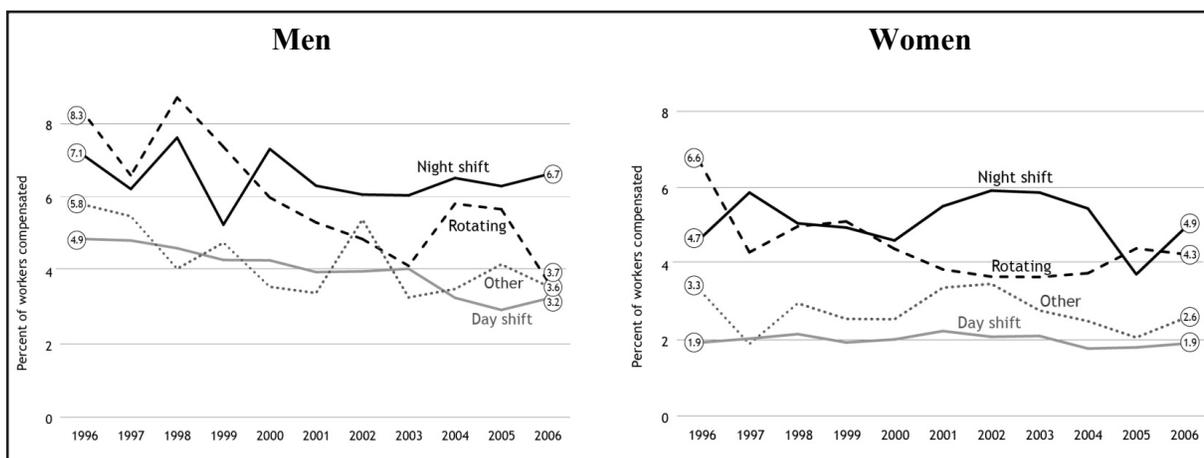


Figure 1. Trend in workers' injury compensation rate by shift type and gender

**Table 1.** Demographic, occupational and compensation characteristics by shift type (2006). [CA\$=Canadian dollar.]

	Regular day (N=15 903)		Regular night (N=1 377)		Rotating (N=2 774)		Other (N=2 757)	
	Weighted frequency	%	Weighted frequency	%	Weighted frequency	%	Weighted frequency	%
Received workers' compensation	221 270	3	45 079	6	48 596	4	41 337	3
Gender								
Male	4 431 377	53	433 968	57	713 227	58	714 487	53
Female	3 981 659	47	332 681	43	525 342	42	636 856	47
Age (years)								
15–24	646 240	7	123 886	16	165 928	13	215 777	16
25–34	2 011 776	24	194 533	25	332 055	27	326 571	24
35–44	2 356 750	28	200 421	26	340 487	28	331 451	25
45–54	2 389 161	28	167 205	22	276 459	22	292 306	22
55–65	1 009 109	12	80 603	11	123 640	10	185 239	14
Marital status								
Married	5 440 007	65	419 579	55	726 544	59	760 722	56
Single	2 065 787	25	260 651	34	380 919	31	443 027	33
Other	906 283	11	86 419	11	131 105	11	147 594	11
Education								
Less than high school	3 007 107	37	384 380	52	552 715	46	533 691	41
More than high school	5 165 509	63	357 193	48	648 774	54	761 511	59
Equivilized income (CA\$)								
<\$20 000	737 263	9	128 041	17	128 116	10	198 354	15
\$20 000–40 000	3 624 032	43	421 503	55	567 548	46	639 326	47
\$40 000–60 000	2 616 946	31	164 842	22	388 553	31	322 504	24
\$60 000–80 000	883 000	11	29 370	4	101 436	8	106 538	8
>\$80 000	551 796	7	22 893	3	52 916	4	84 621	6
Occupational physical demands								
Manual	2 357 625	29	427 773	57	569 841	47	399 151	30
Mixed	1 571 271	19	214 637	28	383 013	31	444 865	34
Non-manual	4 153 907	51	114 037	15	271 358	22	483 857	36
Work stability								
Permanent	7 734 181	92	714 457	94	1 152 457	96	1 051 900	80
Seasonal	180 519	2	12 277	2	17 779	1	78 044	6
Temporary	383 332	5	27 205	4	3 330	0.3	107 251	8
Casual	74 138	1	8 891	1	24 300	2	82 215	6
Usual hours worked per week								
1–25 hours	763 038	9	125 105	16	150 867	12	348 944	26
26–35 hours	925 446	11	112 694	15	156 554	13	183 910	14
36–40 hours	2 464 550	29	130 598	17	213 333	17	168 322	13
41–60 hours	3 865 370	46	359 461	47	617 578	50	434 962	32
>60 hours	394 634	5	38 791	5	100 236	8	215 205	16

**Table 2.** Odds ratio (OR) of receiving workers' compensation payments for the principal independent variables for the fully adjusted model and stratified by gender. Model also includes indicator variables for regions. [95% CI= 95% confidence interval; CA\$=Canadian dollar.]

	Fully adjusted model		Stratified by gender			
	OR	95% CI	Men		Women	
			OR	95% CI	OR	95% CI
Shift type						
Regular day	reference		reference		reference	
Regular night	1.915 <sup>a</sup>	1.342–2.733	1.913 <sup>b</sup>	1.209–3.028	2.043 <sup>c</sup>	1.131–3.690
Rotating	1.484 <sup>b</sup>	1.118–1.971	1.145	0.802–1.634	2.290 <sup>b</sup>	1.373–3.819
Other	1.302	0.919–1.846	1.238	0.798–1.919	1.437	0.810–2.545
Gender						
Male	reference					
Female	0.937	0.746–1.176	.	..	.	..
Marital status						
Married	reference		reference		reference	
Single	1.032	0.752–1.418	0.856	0.561–1.307	1.410	0.857–2.320
Other	1.360 <sup>c</sup>	1.021–1.813	1.644 <sup>b</sup>	1.138–2.375	1.164	0.736–1.840
Equivalized income (CA\$)						
<\$20 000	1.632	0.704–3.783	1.855	0.207–16.665	1.460	0.148–14.438
\$20 000–40 000	1.659	0.779–3.533	1.908	0.223–16.037	1.437	0.149–13.892
\$40 000–60 000	1.726	0.810–3.677	2.118	0.250–17.950	1.325	0.134–12.844
\$60 000–80 000	1.124	0.454–2.778	1.281	0.137–12.273	0.958	0.087–10.562
>\$80 000	reference		reference		reference	
Age group						
15–24	1.124	0.728–1.736	1.400	0.801–2.447	0.784	0.364–1.688
25–34	0.916	0.641–1.310	0.933	0.563–1.544	0.916	0.547–1.535
35–44	reference		reference		reference	
45–54	1.236	0.943–1.621	1.186	0.853–1.648	1.346	0.855–2.118
55–65	1.085	0.776–1.518	1.441	0.947–2.104	0.582	0.318–1.063
Level of education						
Less than high school	1.358 <sup>b</sup>	1.094–1.689	1.419 <sup>c</sup>	1.073–1.874	1.245	0.874–1.773
More than high school	reference		reference		reference	
Work stability						
Permanent	reference		reference		reference	
Seasonal	1.477	0.803–2.716	1.748	0.843–3.623	0.970	0.327–2.879
Temporary	0.557	0.256–1.212	0.600	0.197–1.828	0.516	0.129–2.060
Casual	0.790	0.239–2.613	1.064	0.122–9.266	0.631	0.197–2.022
Occupational physical demands						
Non-manual	reference		reference		reference	
Mixed	2.224 <sup>a</sup>	1.639–3.018	2.723 <sup>a</sup>	1.667–4.448	1.635 <sup>c</sup>	1.030–2.596
Manual	2.650 <sup>a</sup>	1.905–3.688	2.855 <sup>a</sup>	1.686–4.834	2.556 <sup>a</sup>	1.617–4.041
Usual hours worked per week						
1–25	reference		reference		reference	
26–35	0.762	1.639–3.018	0.622	0.279–1.386	0.868	0.473–1.594
36–40	1.163	0.746–1.813	0.910	0.426–1.947	1.344	0.758–2.383
41–60	1.546 <sup>c</sup>	1.015–2.355	1.554	0.774–3.119	1.416	0.809–2.477
> 60 hours	1.021	0.633–1.645	1.141	0.541–2.406	0.498	0.181–1.369
Observations	26 845		14 328		12 517	

<sup>a</sup> P<0.001.<sup>b</sup> P<0.01.<sup>c</sup> P<0.05.**Table 3.** Population attributable fraction (AF<sub>p</sub>) or proportion of workers in shift work type × [(OR-1)/OR] based on odds ratio (OR) and worker population estimates from the 2006 Survey of Labour and Income Dynamics (SLID).

Shift type	Men			Women		
	Portion of workers in shift type	OR <sup>a</sup>	AF <sub>p</sub> (%)	Portion of workers in shift type	OR	AF <sub>p</sub> (%)
Night	0.081	1.913	3.87	0.073	2.043	3.73
Rotating	0.113	1.145	1.43	0.100	2.290	5.63
Other	0.149	1.238	2.86	0.167	1.437	5.08
Total	0.343		8.16	0.340		14.44

<sup>a</sup> OR from table 2, fully adjusted, stratified models.

1.73 (95% CI 1.32–2.26) among rotating shift workers in comparison to regular daytime workers.

In the fully adjusted model (table 2), the risk of injury remained higher among night shift workers (OR 1.92, 95% CI 1.34–2.73) and rotating shift workers (OR 1.48, 95% CI 1.12–1.97). Statistically significant OR were found for those with less than high school education (OR 1.36, 95% CI 1.09–1.69), mixed (OR 2.22, 95% CI 1.63–3.03) and manual (OR 2.65, 95% CI 1.90–3.69) labor, and workers who work between 41–60 hours per week (OR 1.54, 95% CI 1.02–2.36).

In the stratified analysis, the risk among night shift workers remained significant for men (OR 1.91, 95% CI 1.21–3.03) whereas the risk among rotating shift workers was attenuated and no longer significant (OR 1.24, 95% CI 0.80–1.92) (table 2). For women, the risk was slightly more robust among regular night (OR 2.04, 95% CI 1.13–3.69) and rotating shift work (OR 2.29, 95% CI 1.37–3.82).

The overall excess risk of injury attributed to non-regular daytime schedules was 11.3% (not shown). This excess risk was generally higher among women than men (14.4% versus 8.2% respectively) (table 3).

## Discussion

The purpose of this study was to examine the trends in shift work in Canada and determine the risk of injury by shift type. Results of the trend analysis in work schedule showed that there was greater growth in non-regular compared to regular daytime schedules. In addition, this growth is more pronounced among women, leading to almost a convergence with the number of men in non-regular daytime shifts. A report on the Canadian workforce also found that more women, particularly those with children, were entering the workforce with an increase of weekly work hours between 1997–2008 (15). The findings of our trend analysis were similar to those in a report for Human Resources Development Canada which found a 17% increase in the number of people working outside standard “9 to 5” working hours from 1991–1995. This study also found that women in rotating shift work reported the most difficulties in managing work–home conflict (26).

Although the rate of worker injury has declined between 1996–2006, there was little change among night shift workers. This result, in conjunction with our finding that there is steady growth of workers in this category, suggests that the burden of injury associated with night shift work may be increasing. Both men and women working night shift schedules have almost twice the risk of injury than those in regular daytime schedules. However, the difference in the strength of

the association supports our hypothesis that gender is an effect modifier with the risk more pronounced among women in non-regular daytime work.

Results of the logistic regression model and population attributable fraction show that working at night may contribute to a higher relative risk of injury among women than men. In particular, frequent rotation between day and night shifts may have a detrimental effect on work–life imbalance for women, perhaps causing a less stable environment for regular childcare duties. This may lead to fatigue and increased chance of injury at work. It is worth noting that in our study, among women, there is a lower proportion of occupational injuries attributed to regular night shift work than for rotating and other non-regular dayshift types. This may be because their predictable schedules allow for adjustment to regular sleep/work routine and planning childcare requirements.

A few studies have explored the difference in sleep patterns among male and female shift workers. In a study examining crane operators working the same rotating shifts in a steel plant, women reported a shorter length of sleep, felt drowsier during their shifts, and were more likely to experience symptoms of chronic fatigue (27). Rotenberg (28) examined length of sleep among night shift workers during non-working days and found that women with children had shorter sleep lengths than men (16.8–33.3 hours versus 21.3–35.6 hours). It has been shown that this chronic sleep disruption, particularly during recovery days from shift work, has a harmful and lasting influence on alertness levels and overall job performance (29). This may explain the increased risk among women in our study findings.

In 2006, there were a total of 2.7 million lost-time injury compensation claims awarded in Canada (25). Results of our population attributable fraction calculations suggest that approximately 107 000 claims among men and 200 000 claims among women could be attributed to the higher risk of injury associated with shift work. The average reported injury compensation awarded to non-regular daytime workers in 2006 was CA\$165 (25), which totals over CA\$50.5 million in lost-time claims due to risk of injury associated with shift work. This suggests that there may be room for policy implications and prevention measures to reduce the risk among non-regular daytime workers, especially women. For example, the length of night shifts may need to be shorter than day shifts, and shift workers may need longer breaks or periods of rest to prevent fatigue while at work.

Our analyses examined men and women across various industries. However, the majority of men working rotating and night shift work are situated in manufacturing whereas women in rotating and night shift work are primarily in the healthcare sector. Although we

accounted for occupational physical demands, the work environment and job tasks could be very different for men and women. Future analysis should explore the interaction between gender and industry. The findings of this analysis are consistent with previous studies of other occupations. De Castro (30) found that nurses who work non-daytime shifts had a higher risk of reporting work-related injuries (OR 1.54, 95% CI 1.07–2.24) than those on day shifts. Dembe (31) also found increased hazard ratios among non-daytime workers. In comparison to regular daytime shifts, evening shifts had a 43% elevated risk, followed by rotating (36%) and night shifts (30%). The small differences between our findings and Dembe's could be due to differences in the outcome measure as we used self-report of receipt of workers' compensation while Dembe used self-report of work-related injury.

In a similar study that used compensation claims to measure the risk and severity of injuries among workers, Horwitz (8) found that evening and night healthcare workers had an increased risk of injury (risk ratios 1.84 and 1.58 respectively) in comparison to daytime workers. Linear regression analysis also showed that shift type had a significant effect on the workdays lost due to injury, with night shift workers taking more days off per claim in comparison to daytime workers. In a cohort study that used national cross-sectional surveys linked to death registries, Åkerstedt (7) reported that non-daytime workers were also at a higher risk of fatal accidents (risk ratio 1.63, 95% CI 1.09–2.45). However, this study attributed the increased risk primarily due to difficulties in sleeping and found no effect from overtime or physically strenuous work.

Our study had some limitations. One concern was the use of self-reported "receipt of workers' compensation" as a surrogate measure for worker injury. Less than 50% of workplace injuries are reported (32), and not all are awarded compensation. As such, our measure does not capture all work-related injuries. In addition, regular night and rotating shift workers are generally new workers and may be less inclined to file a compensation claim or take time off work leading to an underestimation of the true risk among these types of workers. In addition, the shift work measure in the SLID precluded examining other aspects of shift work, such as speed of rotation or length of shift, which may be key determinants of the association between shift work and work injury.

The award of compensation claims is also a reflection of the compensation system itself. Using this measure includes the effects of different rules and regulations of each provincial compensation board and employer. This may bias results for one geographic region or industry. While a stratified analysis could be completed at the geographic and industry level to account for this variability, these analyses are precluded in the current

study due to sample size limitation of the SLID. The study was a cross-sectional design which did not allow us to account for work history or prior accidents that may influence the risk of an individual worker. For example, workers who have had prior repetitive motion injuries such as carpal tunnel syndrome may have a cumulative risk.

This study has a number of strengths. It is a large representative sample of the Canadian labor force with 99.1% response rate to our primary question: receipt of injury compensation by shift type (33). Our study extends previous research by accounting for a larger number of potential confounders and stratifying by gender. We can also have confidence in the income measures used in the study, as these data were largely taken from tax records.

Results of this study found that rotating and night shift workers have a higher risk of work injury, with women being a particularly vulnerable group. This suggests that further work is necessary to gain a better understanding of the factors that may contribute to the association between worker injury and shift type. Nevertheless these results also indicate that additional occupational health and safety policies and programs are needed to reduce risk of work injury among night and rotating shift workers, especially among women.

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