

Shift work and work related injuries among health care workers: A systematic review

AUTHORS

Isabella Zhao

RN, BN, BN (Hons)
PhD Candidate, The University of Queensland, School of Nursing and Midwifery, Brisbane, Australia.
i.zhao@uq.edu.au

Fiona Bogossian

RN, Midwife, DipAppSci, BAppSci, MPH, PhD, MACMI
Associate Professor, The University of Queensland, School of Nursing and Midwifery, Brisbane, Australia.
f.bogossian@nursing.uq.edu.au

Catherine Turner

RN, BA, Grad Dip Ed, MN, PhD
Professor, Head of School, The University of Queensland, School of Nursing and Midwifery, Brisbane, Australia.
catherine.turner@uq.edu.au

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KEY WORDS

Shift work, needlestick injury, musculoskeletal disorder, motor vehicle crash.

ABSTRACT

Objective

To review the published scientific literature for studies analysing the associations between shift work and work related injuries among health care workers.

Design

Systematic review.

Methods

The following selection criteria were used to systematically search the literature: primary research studies published in English; target populations were health care workers engaged in shiftwork; and outcome measures were work related injury/injuries. Data extraction and quality assessment were performed independently by the authors using a standardised procedure. Synthesis of data is presented in text and tabular format. Meta-analysis was not possible due to the heterogenic nature of the studies reviewed.

Results

This review retrieved 13 studies that met all inclusion criteria, none of which were conducted in Australia. The majority of study findings have shown that shift work is associated with a higher incidence or risk of sustaining work related injuries. However, most studies were cross sectional in design. The only case control study presented contrary results to the other studies. Furthermore, all study results could have been biased or confounded due to methodological limitations.

Conclusions

The relationship between shift work and work related injuries amongst health care workers could not be determined due to the relatively low level of evidence. High quality analytic studies should be conducted to provide better results explaining the causal relationship.

INTRODUCTION

Work-related injuries impact on the individual employee's health and impose costs on employers, other workers and the community and in turn affect a nation's productivity. The National Occupational Health and Safety Commission (NOHSC) reported that about 380 workers suffer from a work-related injury or disease for which they receive workers' compensation in Australia everyday (ASCC 2004). This results in an estimated cost of work-related injury and disease of \$82.8 billion for the 2000-01 financial year (NOHSC 2004). Over the past six years, about half of all new workers' compensation claims and almost half of compensable fatalities have occurred in four industries namely: manufacturing, construction, transport and storage and health and community services (ASCC 2007). In 2004-05, 10% of the Australian workforce worked in the health and community services sector. In the same year, the employees in this sector made 17,400 claims for compensation, accounting for 12% of all workers' compensation claims involving employee absence from work for one or more weeks (ASCC 2007).

The health sector of any country comprises a large group of people working on nonstandard work schedules. In Australia, the health and community services sector has the second highest proportion of shift workers of any industry, which is 32.3% (ABS 2004). The majority of nurses in Australia are working rotating shifts in order to provide twenty four hour health care. Previous research has demonstrated the adverse health effects from shift work (Chee et al 2004; Karlsson et al 2001; Sudo and Ohtsuka 2001; Geliebter et al 2000). The current global crisis in health care workforce shortages (Pan American Health Organization 2006), especially nurses, signifies the importance of recognising that occupational injury related to shift work may potentially contribute to health care workforce attrition. Nursing workforce shortages are acknowledged globally. In Australia, there was an estimated shortfall of between 10,000 to 12,000 nurses in 2006 and between 10,000 and 13,000 in 2010 (Productivity Commission 2006). Therefore, it

is imperative to investigate the association between shift work and work-related injuries among the health care workforce.

The aim of this paper is to systematically review the evidence in the published scientific literature that examines the association between shift work and work-related injuries among health care workers.

METHODS

For the purpose of this review, shift work and work related injuries were defined as follows: shift work is work performed primarily outside typical daytime hours and includes evening shifts, rotating shifts, irregular shifts, extended duty shifts (\geq eight hours), and flexitime (Green-McKenzie and Shofer 2006). A work-related injury is any injury, illness or disease where a person suffered either physically or mentally from a condition that arose out of, or in the course of, employment. Included are work-related injuries that occurred while commuting to or from work, outside of work but while on work duty, or during work breaks (ABS 2007).

Electronic databases were searched using EBSCO host as a search engine for CINAHL (1982-2008), Pre-CINAHL (2008), Health Source: Nursing/Academic Edition (1975-2008), and MEDLINE (1966-2008). The first round search was not limited to only health care workers, so the extent of literature related to shift work and injury could be explored.

Keywords:

'shift work' or 'night shift' or 'rotating shift' or 'long hours'

AND injur* or accident or disorder

NOT treatment

The combined results of the above searches produced 604 abstracts. Following screening of the titles and abstracts by the first two authors, and the exclusion of those papers which did not meet the study inclusion criteria a total of 28 full text articles reporting findings on health care workers were retrieved. The references of these retrieved articles were also examined. A 'snowballing' strategy of reference titles was used and related abstracts and/or full text articles were accessed.

Table 1: Studies of associations between shift work and work related injuries

Authors	Study design	Study population	Outcome measures	Exposure measures
Green Mckenzie et al (2007)	Cross sectional study	A data review of all accidental blood and body fluid was conducted from January 2001 to December 2002, at a large urban teaching hospital. 360 HCWs reported an accidental blood and body fluid exposure. The mean age of all 360 HCWs was 33 (21-75) years. (N= 360)	Accidental blood and body fluid exposures	Length of shift; HCW group (House staff, Nursing staff, Technician)
İlhan et al (2006)	Cross sectional study	449 of the 516 nurses from a Turkish hospital participated in the study. 41.4% were in the 25–29 years age group, 67.8% had worked as a nurse for <10 years, the working hours of 71.9% of the nurses were 8 hours or less per day. (N= 449, response rate 87%)	Incidence of sharp and needle stick injuries	Age; Total years in profession; Total years at current hospital; Daily working hours; Working in shifts; Unit employed (clinical/surgical); Where employed most in the last year (outpatients/ward/intensive care/other).
Smith et al (2006)	Cross-sectional study	Nurses were recruited from a large Japanese hospital. (N = 860)	Needlestick and sharps injuries (NSIs)	Sex; Age < 25 years; < 2 years work; Hours worked/ day; Hours worked/ week; mixed shifts; Very difficult work; Fatigued after work; Stressed from work; High time pressure; Much unplanned work; High mental pressure; Too much work; Too much overtime; Not enough staff.
Suzuki et al (2004)	Cross-sectional study	A survey using the 12-item General Health Questionnaire was conducted among 4407 nurses in 8 general hospitals in Japan.	Needlestick injuries	Mental health, sleep, demographic variables and shift work system.
Parks et al (2000)	Cross sectional study	A retrospective review of 745 reported exposures by medical students and residents was conducted in a large urban teaching institution—the University of Texas Health Science Center in Houston, between November 1993 and July 1998.	Accidental exposures to blood borne pathogens	Sites, gender, time of the day when the accidents happened.
Guastello et al (1999)	Cross sectional study	Participants were 1708 health care workers at the three hospitals located in Maryland, Minnesota, and Texas.	Exposure to blood borne pathogens and other accidents	Depression symptoms, shift work, job satisfaction, safety climate, environmental stressors, work pace, compliance with universal precautions and HIV related training.
Neuberger et al (1984)	Cross sectional study	Data on needlestick injuries of hospital employees were obtained from workers' compensation reports, from January 1, 1979, through May 31, 1981. (N = 286)	Incidence of needlestick injuries	Work schedule characteristics (status, number of jobs, hours/ day, hours/week, days/week, weekends/month, shift, breaks/ day, breaks)
Engkvist et al (2000)	Case control study	Female nurses (age (SD) 30.3 (8.9)) working in 8 general hospitals equipped with 400 beds or more in Japan. (N = 4,279)	Occupational accidents including drug-administration errors; incorrect operation of medical equipment; errors in patient identification; needle stick injuries.	Age; Spouse; Mental health; Subjective sleep evaluation; Difficulty in initiating sleep; Difficult in maintaining sleep; Early-morning awakening, difficulty in getting back to sleep; Shift work (night/split/irregular)
Lipscomb et al (2002)	Cross sectional study	A sample of 1163 nurses, randomly selected from the list of actively licensed nurses in two states of the United States. Data were collected via an anonymous survey mailed to the participants' homes from October 1999 through February 2000.	Reported musculoskeletal disorders	Department, occupation, activity, shift, and full or part time status.

Table 1: Studies of associations between shift work and work related injuries, continued...

Authors	Study design	Study population	Outcome measures	Exposure measures
Sveinsdóttir (2006)	Cross sectional study	A sample of 394 nurses drawn from the registry of the Icelandic Nurses' Association, representing 17% of the workforce of Icelandic nurses. (N= 394, response rate 65.7%)	Socio demographics; Quality of sleep; Symptom scales (gastrointestinal scale, sound perception scale, stress and exhaustion scale, common cold scale, musculoskeletal scale); Working environment; Illness experience; Job satisfaction.	Day shifts only; Rotating day/evening shifts; Rotating day/night/evening shifts.
Horwitz et al (2004)	Cross sectional study	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. Seventy-nine per cent of all claims were filed by female employees.	Demographic characteristics; Occupation of claimant; Nature of injury; Event causing injury	Day shift (starting work between 4a.m. and 11a.m.); Evening shift (starting work between 12 p.m. and 7 p.m.) Night shift (starting work between 8 p.m. and 3 a.m.)
Steele et al (1999)	Cross sectional study	All US allopathic EM-2-EM-4 residents were invited to participate in the study by completing a survey. 62% (957/1,554) of the eligible residents returned usable surveys. The median age of the respondents was 30 years, with an interquartile range of 30-33. Seventy-five percent of the respondents were male. (N= 957)	Motor Vehicle Collisions (MVCs)/ Near crashes	Tolerance of shiftwork, Ability to overcome drowsiness, No. of night shifts/ month, Resident age, Emergency medicine year, Gender, Morningness/eveningness preference, Shift length worked
DeMoss et al (2004)	Cross sectional study	188 permanent day and night-shift workers, with an average age of 40 years: 85% were female, and 55.6% were employed full-time. Two-thirds (66.0%) of workers were registered nurses (RNs), with a mean of 13.8 continuous years on the job. (N= 188, response rate 87%).	Sleep disorders; Difficulty performing routine orders.	Day shift; Night shift.

Other databases were also searched adding health care workers into the searching strategy, including the Cochrane library, Proquest, and PsycInfo. However, only Proquest and PsycInfo produced another 55 and 114 results respectively. After removing duplicates, six full text articles were retrieved for further examination.

Keywords:

'shift work' or 'night shift' or 'rotating shift' or 'long hours'

AND injur* or accident or disorder

AND 'health care worker*' or 'health personnel'

Overall, 34 full text articles were retrieved and assessed by the first two authors independently, using the following selection criteria for this study:

1. primary research studies published in English;
2. the target populations were health care workers engaged in shift work; and
3. outcome measures were work related injury/injuries.

Thirteen studies met all the inclusion criteria for this review. Assessment for the quality of the methodology of these studies was based on a standardised abstraction procedure (Centre for Reviews and Dissemination Report 2001). The results of selected studies are outlined in table 1 and table 2. The 21 excluded articles are shown in table 3 with the reasons for exclusion.

Table 2: Results of selected studies

Authors	Study design	Results
Green Mckenzie et al (2007)	Cross sectional study	Of the 360 HCWs who reported an accidental blood and body fluid exposure, 243 (68%) were women, 180 (50%) were married, 139 (40%) had 1 or more dependents, 158 (44%) were medical residents, 141 (39%) were nurses, and 61 (17%) were technicians; 3 of the technicians were phlebotomists. Medical residents were on duty for a significantly greater mean number of hours before accidental blood and body fluid exposures (7.9 (4.9) hours) than were nursing staff (6.3 (3.7) hours; $p = 0.02$) and technicians (4.8 (2.6) hours; $p < 0.0001$). Of blood and body fluid exposures incurred by medical residents, 30 (24%) occurred during the first 4 hours of duty, 42 (34%) during hours 4-8, 27 (22%) during hours 8-12, and 24 (20%) after 12 hours. Eight (6%) of the nurses and no technicians sustained an accidental blood and body fluid exposure after more than 12 hours of duty.
İlhan et al (2006)	Cross sectional study	During the professional life of nurses, the prevalence of sharp and needle stick injury in the past in nurses working more than 8 hours per day was higher than for those who worked 8 hours or fewer per day (86.5% and 77.1% respectively) ($p < 0.05$). In the last year, the group which worked more than 8 hours per day had an incidence of 77.1%, while the group working 8 hours or fewer per day had an incidence of 64.7% (RR 1.84; 95% CI 1.10 to 3.08). In the last year, the incidence of sharp or needle stick injury was 75.8% in those working in varying shifts and 50% in the group that did not work in varying shifts ($p < 0.05$). Working mixed shifts (rotating day and night, as opposed to day shifts alone) was associated with a 1.67 fold increased risk of sustaining any NSI (OR 1.67, 95% CI 1.01 to 2.85) and a 2.72 times greater risk of sustaining an NSI from a contaminated device (OR 2.72, 95% CI 1.71 to 4.44).
Smith et al (2006)	Cross sectional study	Night/split/irregular shift work was not significantly associated with needlestick injuries (OR: 1.18, 95% CI 0.91 to 1.52).
Suzuki et al (2004)	Cross sectional study	There was a slightly higher relative risk of working on rolling schedule (RR 1.3, 95% CI 0.8 to 2.1) compared to working on fixed schedule. Elevated relative risk was found in nurses who work more than 35 hours per week (RR 2.4, 95% CI 1.6 3.6) compared to nurses who work less hours per week.
Parks et al (2000)	Cross sectional study	The total number of medical residents and students working during the day ($n = 1102$) was greater than that of night ($n = 296$). As a result, the total number of exposures occurring during the day was much higher than at night (531 v 214). When the number of exposures was calculated relative to the number of medical students and residents at risk per clock hour, the mean rate of the exposures was significantly higher ($p < 0.04$) during the night time (60 incidents per hour per 1000 medical residents and students at risk) compared to during the day (40 incidents per hour per 1000 medical residents and students at risk). Overall, the relative risk for an exposure during the night (18:00–05:59) was 1.5 times higher than it was during the day (06:00–17:59).
Guastello et al (1999)	Cross sectional study	Two variables predisposed the worker to a greater accident risk: depression symptoms and shift work ($p < 0.01$). Four other variables predisposed the worker to lesser accident risk: job satisfaction, safety climate, environmental stressors, and work pace.
Neuberger et al (1984)	Cross sectional study	The overall annual incidence of needlestick injuries was 48.8/1000 employees. Of the reported incidents, almost 90% occurred among nursing personnel, housekeepers, and clinical laboratory personnel. The overall annual rate of needlestick injuries per 1000 employees was highest during the night shift (134.8). The rate is significantly higher than that of the day shift ($p < 0.05$) and that of the evening shift ($p < 0.01$). Overall, the evening shift had the lowest rate.
Engkvist et al (2000)	Case control study	No significant associations were observed between needlestick injuries over the past 12 months and with night/irregular shift work (OR 1.18, 95% CI 0.91 to 1.52).
Lipscomb et al (2002)	Cross sectional study	Shift work was associated with an increased risk of musculoskeletal disorders only when combined with weekend work. Working 'off shifts' (≥ 2 weekends/month and other than day shift work) elevated the odds ratio for musculoskeletal disorders of the neck (OR 1.43, 95% CI 0.94 to 2.18), a shoulder (OR 1.52, 95% CI 0.95 to 2.38), and the back (OR 2.08, 95% CI 1.35 to 2.96). Working 'long hours' (≥ 12 hours/day and ≥ 40 hours/week) elevated the odds ratio for musculoskeletal disorders of the neck (OR 2.30, 95% CI 1.03 to 5.11), a shoulder (OR 2.48, 95% CI 1.07 to 5.77), and the back (OR 2.67, 95% CI 1.26 to 5.66).
Sveinsdóttir (2006)	Cross sectional study	Nurses working rotating days/evenings shifts experienced more severe gastrointestinal and musculoskeletal symptoms when compared with others ($F(2,307) = 6.398$; $p \leq 0.002$; $F(2,305) = 3.599$; $p \leq 0.029$).
Horwitz et al (2004)	Cross sectional study	The injury rate for day shift per 10 000 employees was estimated to be 176 (95% CI 172 to 180), as compared with injury rate estimates of 324 (95% CI 311 to 337) for evening shift and 279 (95% CI 257 to 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.
Steele et al (1999)	Cross sectional study	Nearly three fourths of the MVCs and 80% of the near-crashes followed the night shift. Univariate analysis showed that MVCs and near-crashes were inversely related to residents' shiftwork tolerance ($p = 0.019$) and positively related to the number of night shifts worked per month ($p = 0.035$).
DeMoss et al (2004)	Cross sectional study	No significant differences were noted in the likelihood of work or non work-related injuries or motor vehicle crashes in the preceding year. (No analysis results to support the conclusion)

Table 3: Studies retrieved but not selected

First author	Reason for exclusion
Roman (2008)	News, not a primary research article.
Lee (2007)	Doctoral dissertation, not a published primary research article.
Dembe et al (2007)	The target population is not health care workers.
Huang et al (2007)	The outcome measure is perception of injury risk; the target population is not health care workers.
Peate (2007)	Not a primary research article, a summary article about how to cope with shift work.
Scott (2007)	Not a primary research article, a summary article about coping strategies for shift work.
Wilkins and Mackenzie (2007)	No discrete analysis on health care workers.
Driscoll et al (2007)	Not a primary research article.
Nugent et al(2007)	Not a primary research article.
Solomon et al (2007)	Majority of study population is men working in agriculture.
Dembe et al (2006)	There is no discrete data on occupational injuries experienced by health care workers.
Raediker et al (2006)	There is no discrete data on health complaints experienced by health care workers.
Siddharthan et al (2006)	Exposure variable is under-reporting of work related musculoskeletal disorders in the Veterans Administration, instead of occupational injuries.
Suzuki (2005)	The exposure variable is excessive daytime sleepiness instead of shift work.
Åkerstedt et al (2005)	No separate analysis on health care workers.
Folkard et al (2005)	A review paper, not a primary research.
Sorensen (1999)	Study population is not health care workers.
Wysong (1997)	Periodical, not a primary research article.
Tan (1991)	A review article, not a primary research article.
Gillmore (1990)	Doctoral dissertation, not a published primary research article.
Williamson et al (1988)	Not a primary research article.

RESULTS

This search revealed 13 studies that met all inclusion criteria. These studies can be categorised into three groups, namely studies examining the association between shift work and blood or body fluid exposure; the association between shift work and musculoskeletal disorders; and the association between shift work and motor vehicle crashes.

Studies examining the association between shift work and blood or body fluid exposure

Seven cross sectional studies were identified from the literature reporting the relationship between shift work and blood or body fluid exposure.

A retrospective cross sectional descriptive study aimed to determine the length of shift before blood and body fluid exposure in medical residents, nurses, and technicians and the proportion of medical residents who sustain a blood and body fluid exposure

after 12 hours on duty (Green-McKenzie and Shofer 2006). The study lasted over a 24 month period and reviewed data on blood and body fluid exposures at a large urban teaching hospital in the United States of America. During the study period, there were 360 eligible health care workers (HCWs) who reported a blood and body fluid exposure. The average yearly rate of reported blood and body fluid exposures was 9.4% for medical residents, 7.9% for nursing staff, 3% for phlebotomists, and 3% for all HCWs. The mean number of hours before blood and body fluid exposures were significantly greater (7.9 (4.9) hours) for medical residents than that of nursing staff (6.3 (3.7) hours; $p = .02$) and technicians (4.8 (2.6) hours; $p < .0001$). Of blood and body fluid exposures reported by medical residents, 30 (24%) occurred during the first four hours of duty, 42 (34%) during hours 4-8, 27 (22%) during hours 8-12, and 24 (20%) after 12 hours. Eight (6%) of the nurses and no technicians

sustained a blood and body fluid exposure after more than 12 hours of duty. The blood and body fluid exposures incurred by nursing staff were almost equally distributed among the three shifts. About half of the blood and body fluid exposures reported by both the medical residents and technicians occurred during the day shift. The authors concluded that medical residents sustained a higher rate of blood and body fluid exposures and they were significantly more likely to have longer duration of time on shift before blood and body fluid exposure. The authors also acknowledged that the injury rate per shift was unable to be determined as data regarding the number of HCWs who routinely worked each shift was not available. Additionally, the study results might be confounded. As data on shift end time was not captured, it did not allow for adjustment of the data for average length of shift. These limitations may have contributed to the absence of significant differences found among the groups.

Another cross sectional study reported the sharp and needlestick injury incidence in nurses working at a university hospital and the contributing factors (İlhan et al 2006). Data were collected from HCWs who worked at a Turkish hospital by completing a self administered questionnaire (response rate 87%). The mean number of weekly working hours was 40.03 (2.15) hours (median 40; range 25–50). The mean of daily working hours was 9.05 (1.09) (median 8; range 4– 16), and about one third of nurses reported they were working with \geq eight hour shifts. The percentage of nurses experiencing a sharp or needlestick injury during their professional life was 79.7%. The incidence of exposure to sharp or needlestick injury in the previous year was 68.4%. The factors increasing the rate of sharp and needlestick injury were: age 24 years and less, \leq four years of nursing experience, working in surgical or intensive care units and working for more than eight hours per day ($p < 0.05$).

Smith et al (2006) conducted a cross-sectional study of 860 nurses from a large hospital in Japan to study the epidemiology of needle stick and sharps injuries (NSIs). Anonymous questionnaires were distributed

to gather information on demographic items, types of shift schedule, the type of device that caused the NSI, whether the device was contaminated, whether the NSI was officially reported to management, and if not, the reasons why it was not reported. Among 860 nurses, there had been a total of 648 NSIs in the previous year. The results demonstrated that working mixed shifts (rotating day and night, as opposed to day shifts alone) was associated with a 1.67-fold increased risk of sustaining any NSI and a 2.72 times greater risk of sustaining an NSI from a contaminated device. The authors recognised the imprecise definition of the shift work schedule in use in the study under examination.

Another cross-sectional study was also conducted by Japanese researchers to analyse various factors related to occupational accidents over a 12 month period (Suzuki et al 2004). The subjects of this study were 4,407 nursing staff working in eight large general hospitals in Japan. Occupational accidents included drug administration errors, incorrect operation of medical equipment, errors in patient identification, and needle stick injuries. Anonymous self-administered questionnaires were used to collect information on mental health, sleep, and occupational accidents, in addition to questions on demographic variables and the shift-work system. Multiple logistic regression analyses on factors leading to occupational accidents during the past 12 months showed statistically significant associations between needlestick injuries and age. However, night/split/irregular shift work was not significantly associated with needlestick injuries (OR: 1.18, 95% CI 0.91 to 1.52). There were no clear operational definitions of occupational accidents, which should be borne in mind when interpreting the study findings.

The purpose of Parks et al's (2000) cross sectional study was to determine whether the occurrence of accidental blood borne pathogen exposure incidents in medical students and residents in training varies during a 24 hour period. The study was carried out in the University of Texas Health Science Centre in Houston over a five year span. Professional level (year

of student or level of resident), time of exposure, means/route of exposure (needle stick, laceration or splash), and type of medical service were recorded. The total number of medical residents and students working during the day ($n = 1102$) was greater than that of night ($n = 296$). As a result, the total number of accidental exposures occurring during the day was much higher than at night (531 versus 214). When the number of accidental exposures was calculated relative to the number of medical students and residents at risk per hour, the day-night difference in rate of exposures was statistically significant ($p < 0.04$, 60 incidents v. 40 incidents per hour per 1,000 medical residents and students at risk). This means that doctors (in training) working nights are at a 1.50 times greater risk of sustaining a blood borne pathogen exposure compared to working days. One merit of this study is that data for the number of residents and medical students at risk of accidental blood borne pathogen exposure per hour of the day and night were adjusted in the results. However, the authors could not correlate the number of accidental exposures with the number of high risk procedures performed during the day and night as the procedural data was not gathered in this study.

One study used catastrophe models to test the exposure to blood and bodily fluids and more conventional occupational accidents among 1,708 health care workers in the USA, who completed a survey measuring HIV-relevant exposures (needlesticks, cuts, splashes, contact with open wounds), the accident rate for broadly-defined injuries, and several occupationally relevant themes: safety climate, shift work, depression symptoms, work pace, verbal abuse, and professional group membership (Guastello et al 1999). Shift work (rotating shifts, permanent evening shift and permanent night shift) was found to be significantly associated with predisposition to greater differences in HIV-relevant and general accident exposures ($p < 0.05$) and to a greater accident risk ($p < 0.01$).

A retrospective review of needlestick injuries was conducted in order to determine the needlestick injury rate among employees according to department,

occupation, activity, shift and full or part time status (Neuberger et al 1984). Data on needlestick injuries of hospital employees was obtained from workers' compensation reports submitted to the medical centre's safety office over 29 month period at a major university teaching hospital in the United States. The needlestick injuries included only those from hypodermic needles where the needle was either previously used on a patient or discarded in a patient care area. Throughout the 29 month period, there were 286 injuries reported. The overall annual incidence of needlestick injuries was 48.8/1,000 employees. Of the reported incidents, almost 90% occurred among nursing personnel, housekeepers, and clinical laboratory personnel. The overall annual rate of needlestick injuries per 1,000 employees was highest during the night shift (134.8). The rate is significantly higher than the day shift ($p < 0.05$) and the evening shift ($p < 0.01$). Overall, the evening shift had the lowest rate.

Studies examining the association between shift work and musculoskeletal disorders

The review identified four studies that analysed the association between shift work and musculoskeletal disorders.

The first study was a case control study aiming to identify and quantify work related and non work related risk indicators for reported over exertion back injuries among nursing personnel. The source population consisted of all nursing personnel employed in Stockholm County hospitals during a 32 month period in Sweden (Engkvist et al 2000). The cases ($n = 240$) were nurses who reported a work related over exertion back injury. Referents ($n = 614$) were selected from the source population matching on sex and age (within five years). All participants completed questionnaires about occupation, type of clinic, working hours, shift work, patient transfers, perceived exertion, back pain, prior back injury, job strain, body mass index, smoking, immigrant status, physical training and self rated fitness. The highest relative risks were observed for work related factors: working at an orthopaedic clinic, patient transfer/shift, and working fulltime. There was a slightly

higher relative risk of working on a rolling schedule (RR 1.3, 95% CI 0.8 to 2.1) compared to working on a fixed schedule; however, the results were not statistically significant. Elevated relative risk was found in nurses who work more than 35 hours per week (RR 2.4, 95% CI 1.6 3.6) compared to nurses who work fewer hours per week. This study design provided a better opportunity to determine the causal relationship. Nevertheless, the definition of rolling schedule was not provided.

A cross sectional study of 1,163 randomly selected actively licensed nurses in two states of the USA was conducted to examine the relationship between a combination of demanding work schedule characteristics and reported musculoskeletal disorders of the neck, shoulders, and back (Lipscomb et al 2002). Data on neck, shoulder and back problems, workplace, position, physical demands, psychological demands, and work schedule characteristics, were collected via an anonymous survey mailed to the participants' homes from October 1999 through February 2000. The nine work schedule characteristics included fulltime work, more than one job, more than eight hours of work per day, more than 40 hours of work per week, six or seven day shifts of work a week, work on two or more weekends a month, work shifts other than days, no more than one break lasting ten minutes or more per shift, and never or rarely breaks out of the unit. The authors reported four of the nine work schedule characteristics (working full time, > eight hours/day, two to four weekends/month, and other than day shift) were significantly related to musculoskeletal disorders in one or more body sites. Adjustment for psychological and physical job demands reduced the odds ratio slightly. Working long hours (> 12 hours/day, > 40 hours/week) elevated the odds ratio for musculoskeletal disorders of the neck (OR 2.30, 95% CI 1.03 to 5.11), a shoulder (OR 2.48, 95% CI 1.07 to 5.77), back (OR 2.67, 95% CI 1.26 to 5.66). Working off hours (weekends and other than day shifts) also elevated the odds ratio for musculoskeletal disorders in the three body sites (neck: OR 1.43, 95% CI 0.94 to 2.18; a shoulder: OR 1.52, 95% CI 0.98 to 2.38;

back: OR 2.08, 95% CI 1.35 to 2.96, respectively). However, the results of musculoskeletal disorders in the neck and a shoulder were not statistically significant. This cross sectional study was limited to the current workforce so that nurses who had left nursing due to musculoskeletal disorders or other health conditions were not included. As a result, the prevalence of reported musculoskeletal disorders and the association of schedules with reported musculoskeletal disorders could have been underestimated. The authors attempted to reduce recall bias by limiting the recall period to the past year and by using a threshold definition for a reported case. Some studies have shown that nurses, as a population, provided valid and reproducible data on risk factors and health outcomes when surveyed (Giovannucci et al 1993; Colditz et al 1987; Colditz et al 1986). However, there was no validation test to prove this. Therefore, the findings need to be interpreted with caution.

Another two studies reported findings not only on musculoskeletal disorders, but also other work related injuries or body system disorders. The first one was a cross sectional study of a sample of 348 nurses drawn from the registry of the Icelandic Nurses' Association to describe and compare the self assessed quality of sleep, occupational health, working environment, illness experience and job satisfaction among female nurses working different combination of shifts (Sveinsdóttir 2006). Data were obtained by self administered questionnaires and analysed according to type of shift (days only, rotating days/evenings, rotating days/evenings/nights). The study findings indicated that nurses working rotating day/evening shifts experienced more severe gastrointestinal and musculoskeletal symptoms when compared with others ($F(2,307) = 6.398; p \leq 0.002$; $F(2,305) = 3.599; p \leq 0.029$). The other cross sectional 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 (Horwitz and McCall 2004). Occupational injuries included musculoskeletal disorders, stress, hearing loss and rheumatism. The

study used Oregon workers' (n=7717) compensation claim data from 1990 to 1997. The injury rate for day shift per 10 000 employees was estimated to be 176 (95% CI 172 to 180), as compared with injury rate estimates of 324 (95% CI 311 to 337) for evening shift and 279 (95% CI 257 to 302) for night shift workers. The average number of days taken off for injury disability was longer for injured night shift workers than for day or evening shift workers. The authors concluded that evening and night shift hospital employees were found to be at greater risk of sustaining an occupational injury compared to day shift workers; however, no measure of effect is reported.

Studies examining the association between shift work and motor vehicle crashes

Besides the above occupational injuries, motor vehicle crashes (MVCs) or near crashes before and/or after work should not be neglected. Two studies conducted in the USA were identified from the literature, the first of which was a cross sectional study carried out to determine the prevalence and risk factors associated with MVCs and near-crashes as reported by emergency medicine (EM) residents following various shifts (Steel et al 1999). All EM-2 through EM-4 residents were invited to answer a self administered survey about whether they had ever been involved in an MVC or near-crash while driving home after a shift. The residents' night shift schedules, self-reported tolerance of night work, ability to overcome drowsiness, sleep flexibility, demographic information, and 'morningness/eveningness' tendencies were also collected. Overall, 62% (957/1554) of the eligible residents returned usable surveys. Seventy-six (8%) residents reported having 96 crashes and 553 (58%) residents reported being involved in 1,446 near-crashes. Nearly three quarters of the MVCs and 80% of the near-crashes followed the night shift. Univariate analysis showed that MVCs and near-crashes were inversely related to residents' shiftwork tolerance ($p = 0.019$) and positively related to the number of night shifts worked per month ($p = 0.035$). The authors acknowledged there was a higher number of MVCs and near-crashes

while driving home after a night shift compared with other shifts. Another cross sectional study assessed health and performance markers of 188 day and night shift nonphysician health care workers (DeMoss et al 2004). Study results revealed night shift workers were significantly more likely to report difficult performing routine orders. However, no significant differences were noted in the likelihood of work or non-work related injuries or motor vehicle crashes between different shifts in the preceding year; nevertheless, this conclusion was not supported by any statistical analysis. Steel et al (1999) stated there could be respondent bias in their study as only two thirds of eligible residents completed the survey. It was more likely for those residents involved in an MVC or a near crash to have returned the survey. Secondly, the definition of 'near crash' was not precise; nor was the distribution of shifts worked by each resident. Lastly, some information was not asked, including the residents' driving distances to work, their baseline driving abilities, and the time, location, and circumstances of the MVCs and near crashes.

DISCUSSION

This systematic review presented 13 studies that examined the association between shift work and work-related injuries among health care workers. These studies can be categorised into three groups, namely studies examining the association between shift work and blood or body fluid exposure; the association between shift work and musculoskeletal disorders; and the association between shift work and motor vehicle crashes.

One potential limitation of this review is the introduction of possible biases via the search strategies. Each individual author may have different interpretations in the review process; nevertheless, all have tried their best to review the published scientific literature on this topic comprehensively and exhaustively. In addition, the strict inclusion criteria guided the independent reviewers through the review process, so the validity of the conclusions could be strengthened and possible biases could be minimised.

Among the seven studies examining the association between shift work and blood or body fluid exposure, one study reported no significant association between night/irregular shift and needle stick injuries (Suzuki et al 2004). The others indicated that shift work was associated with higher risk of blood or body fluid exposure. The different kinds of shift work impacted on higher risk of blood or body fluid exposure included long working schedule (over eight hours) (Green-McKenzie et al 2006; İlhan et al 2006), rotating shifts (Smith et al 2006; Guastello et al 1999), and night shift (Parks et al 2000; Neuberger et al 1984). Among the four studies reporting the association between shift work and musculoskeletal disorders, the highest level of evidence showed no association between rolling shifts and musculoskeletal disorders (Engkvist et al 2000). This study used a case control methodology which allows better opportunity for interpreting causality. The other cross sectional studies showed a higher risk of experiencing musculoskeletal disorders for those working on nonstandard work schedule, which included extended work hours (Lipscomb et al 2002), rotating shift (Sveinsdóttir 2006), and night shift (Horwitz et al 2004). This systematic review only identified two studies examining the association between shift work and motor vehicle crashes. One reported night shift was associated with a higher risk of motor vehicle collisions (Steele et al 1999); and the other found no association between night shift and motor vehicle crashes (DeMoss et al 2004). DeMoss' study did not analyse the relationship between shift work and motor vehicle crashes as its primary research question. The conclusion on this relationship was not supported by statistical analysis. Steele et al (1999) acknowledged the possibility of confounding, such as the residents' driving distances to work, their baseline driving abilities, and the time, location, and circumstances of the MVCs and near crashes.

Overall, the majority of identified studies consistently found shift work was associated with higher risk of work related injuries. However, caution should be exercised when drawing definite conclusions about the relationship between shift work and work related

injuries due to the relatively low level of evidence related to study design. Twelve of the thirteen studies were cross sectional studies, a methodology useful for exploring potential associations between causes and effects but precluded determination of causal relationship/s. Secondly, study participants in some studies were recruited from a single institution; making the results difficult to be generalised to wider populations, especially when the single institutional characteristics were not well described. Thirdly, data collection relied heavily on self reporting, which could lead to biased estimates of injury rates. Some studies have shown that nurses, as a population, provided valid and reproducible data on risk factors and health outcomes when surveyed (Giovannucci et al 1993; Colditz et al 1987; Colditz et al 1986). However, this may not extend to all health care workers. As most of the studies were retrospective, subjects were required to recall an event which happened in the past, which would cause recall bias. Some studies tried to circumvent this problem by analysing data from workers' compensation reports (Horwitz et al 2004; Neuberger et al 1984). Nonetheless, it can be argued that there might be an overestimation of injury rates based on compensation reports, as workers may tend to over report their injuries. Finally, some studies did not provide a precise definition of shift work or a clear description of the kind of injuries that occurred, which impacted on the precision of the results. Therefore, due to the relatively low level of evidence and the limitations of data collection and sampling methods, the association between shift work and work related injuries could not be determined.

CONCLUSIONS AND RECOMMENDATIONS

Based on the exploratory findings from the cross sectional studies, future research on examining the association between shift work and work related injuries amongst health care workers should build on previous research by raising the level of evidence (such as longitudinal studies and case control studies), so that the causal relationship can be quantified.

Health care workers are always expected to deliver safe care and ensure patients' safety. Undoubtedly, their safety is of great concern to society and their health and well-being should be protected. Stakeholders and policy makers should pay attention to this problem. Given the consideration of current and future projected health care workforce shortages, factors that could be detrimental to their health must be identified and well studied. A third of health sector employees are shift workers, therefore a prospective study examining any work-related injuries associated with shift work should be conducted to ensure effective injury prevention measures including best practice shift work policies can be implemented.

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