Original article

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Short time between shifts and risk of injury among Danish hospital workers: a register-based cohort study

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Objectives Short time between consecutive work shifts (quick returns, ie, ≤11 hours between shifts) is associated with sleepiness and fatigue, both of which have been linked to risk of injury. This paper aims to study quick returns between work shifts and risk of injury among Danish hospital workers.

Method The study population included 69 200 employees, primarily working at hospitals, corresponding to 167 726 person years at risk between 2008–2015. Information on working hours was obtained from payroll data in the Danish Working Hour Database and linked, at an individual level, with data on 11 834 injury records identified in the National Patient Register and the Danish Register of Causes of Death. Multivariate Poisson regression models were used to calculate incidence rate ratios (IRR) with 95% confidence intervals (CI).

Results Results showed the shorter the time between shifts, the higher the risk of injury. Thus, an elevated risk of injury was observed after quick returns compared with the standard 15–17 hours between shifts (IRR 1.39, 95% CI 1.23–1.58). Furthermore, when assessing the number of days since a quick return, the risk of injury was especially high within the first two days (day 1: IRR 1.39, 95% CI 1.23–1.58; day 2: IRR 1.39, 95% CI 1.21–1.58) following a quick return.

Conclusions Our results suggest that quick returns increased the risk of injury, in particular within the first two days following a quick return. These findings point towards avoiding or reducing the number of quick returns in order to lower employees' risk of injury.

Key terms break; change-over; compressed work week; Denmark; payroll data; quick return; rest; short interval; short work shift interval.

Shift work is a way for workplaces to meet demands outside of regular daytime operating or service hours, such as the need for healthcare around the clock, thus, it is common among healthcare workers (1, 2). According to the European Union's Working Time Directive, all employees should be allowed at least 11 consecutive hours of rest from work per 24-hour period (3). When the time between two consecutive work shifts is ≤11 hours, it can be characterized as a quick return (4). The frequency of quick returns in the healthcare industry is not well reported, but two Norwegian studies suggest that approximately 80% of nurses have had ≥1 quick return (<11 hours) during the past year (5, 6) and, on average, 3 quick returns per month (6).

Quick returns have been associated with difficulties unwinding after work (7), work-life imbalance (7–9) and dissatisfaction with working hours (7). Both the timing and duration of time between consecutive work shifts are important for sleep length (10–12). Sleep length between shifts has been shown to increase with longer

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time between shifts and be longer when time between shifts occurs at night than at daytime (10). Thus, quick returns have been associated with poor sleep quality (7, 13), sleepiness and fatigue (4, 5, 13, 14), insomnia (5) and shorter sleep length (4, 7, 15). This may compromise safety as short sleep durations (16, 17), sleep problems (18) and sleepiness (19, 20) have been associated with higher risk of occupational (16–18) and traffic (19, 20) injuries. Moreover, sleep deficit across several days has been associated with cumulative lower cognitive performance (21), which is also suggested as a mechanism between working hours and injury (22). Accordingly, risk of injury may be accumulated across days with quick returns due to less restitution.

In a recent systematic review of quick returns and health outcomes, only one study examining the association with injury was included (4). Although this study suggested a higher risk of occupational injury after quick returns in the steel industry (23), this finding was later questioned by one of the authors due to possible bias (4, 24). A more recent study among nurses in the US suggested that those with quick returns had a higher risk of needlestick injuries compared with nurses without quick returns (25). The study relied on self-reported data on quick returns and injury and limited confounder adjustment. Given the paucity of existing studies and the implications quick returns may have for worker safety, there is a need for studies of quick returns that use objective measurements of working hours and injuries (4).

In this study, we aimed to assess how duration of time between shifts – and, specifically, quick returns – affect risk of injury. Additionally, we evaluated the association between injury and days since a quick return as well as the number of quick returns in the past week. Finally, the risk of injury after quick returns that occurred at different times of the day were assessed. This was done by use of payroll data as objective measurements of working hours linked to register-based objective data on injuries.

Method

Data

Daily information on all work shifts in the Danish Working Hour Database (DWHD) was linked individually by use of the unique Danish personal identification number (26) to register-based information on injuries. DWHD is a dynamic cohort based on payroll data and includes daily information on precise starting and ending times of each shift for all public hospital employees in Denmark and some public administrative employees (27). Injuries were identified in the National Patient Register and the Danish Register of Causes of Death, which contain information on all in- and outpatients in Danish hospitals (28) and information on causes of deaths of all residents in Denmark (29), respectively. Information on covariates was obtained from the DWHD and Statistic Denmark's Employment Classification Module (30).

Study population

The study population has previously been described in detail (31). In brief, we included all employees in the DWHD from two regions of Denmark (urban and rural area), between 18 and 65 years old and with at least one year of work experience registered in the DWHD between 2007–2015. Employees were censored after the time they had an injury, terminated their employment registered in the DWHD, turned 65 years old, died or emigrated. Employees were temporarily censored (ie, did not contribute to time at risk) when they worked part-time (annually <30 hours/work week), were not primarily employed by the regions (eg, students), or worked <20 hours the past week (eg, due to holiday). The final study population consisted of 69 200 employees totaling 167 726 person years.

Exposures

All exposures were assessed by calendar day (starting from 00:00), and we included all shifts that consisted of ≥3 hours of work. Time between shifts was defined as the number of hours from the end of one shift to the beginning of the next shift, registered on the day the second shift started (index day, where the outcome was measured). Time between shifts was evaluated continuously (1–17 hours) and categorically (1–2, 3–5, 6–8, 9–11, 12–14 and 15–17 hours). We defined ≤11 hours between shifts as a quick return. Number of quick returns the past week was defined as the frequency of quick returns the past week, measured from index day (day 0) to six calendar days back (continuously; range 1–7 quick returns). Days since a quick return was defined as the number of days from (the end of) a quick return to the index day with no quick returns in between. Days since a quick return was analysed in separate analysis for each number of days since a quick return and continuously (0–6 days since a quick return). Time of day of a quick return was categorized as: quick return before the start of a day shift (second shift started between 04:00–11:59 hours); quick return before the start of an evening shift (second shift started between 12:00–19:59 hours); and quick return before the start of a night shift (second shift started between 20:00–03:59 hours). In the analyses of time of day of a quick return, we included quick returns of 6–11 hours and allowed extra follow up time (both the day before and the index

day), to ensure enough time for injuries to be registered before night shifts due to the assessment by calendar day. In the case of two quick returns, we used the one on the index day, closest in time to a potential injury.

We used 15–17 hours between shifts, corresponding to the time between two 8-hour shifts starting at the same time of day, as reference. To ensure a consistent work exposure, on-call shifts were considered leisure time since these can take place at work or at home and be mix of regular work shift and leisure time (32). Time between shifts of less <1 hour was excluded, as this could be attributed to breaks unrelated to rest (eg, lunch breaks or running errands). In the event of more than one registration of time between shifts on the same calendar day, we only considered the shortest time between shifts.

Outcome

Injuries (including occupational, commuting and leisure time injuries) caused by accidents between 2007– 2015 were identified, and the first injury for each person was included in this study. To include all types of injuries and avoid potential bias from different reporting of less severe injuries at different shifts (33, 34), this study included injuries registered at an emergency department or death certificate. From the National Patient Register, we included all injuries caused by accidents that resulted in a visit to an emergency department. From the Danish Register of Causes of Death, we included all deaths that were registered as caused by accidents or with a primary or secondary ICD10 code related to injury. Injuries were registered on the day of the emergency department visit or death. For specific codes see the online, open access study protocol (35).

Table 1. Baseline characteristics of the study population (employees = 69 200, person years = 167 726, injuries = 11 834) from the dynamic cohort in the Danish Working Hour Database 2008–2015.

Baseline [a]	Ever quick return [b] N=36 875		Never quick return [b] N=32 325	
	N	%	N	%
Age (years)				
18–24	2054	5.6	1645	5.1
25–34	12 103	32.8	8981	27.8
35–44	9779	26.5	8210	25.4
45–54	9271	25.1	7959	24.6
55–65	3668	10.0	5530	17.1
Sex				
Women	28 295	76.7	23 997	74.2
Occupation				
Administrative work	4762	12.9	11 183	34.6
Medical secretary	2105	44.2	2758	24.7
Patient contact	27 825	75.5	15 741	48.7
Nurses	13 173	47.3	2857	18.2
Medical doctor	6113	22.0	4268	27.1
Hospital porter	4288	15.4	5401	34.3
Technical staff	4288	11.6	5401	16.7
Medical laboratory technologist	1281	29.9	1318	24.4
Socioeconomic status				
High	8509	23.1	11 077	34.3
Intermediate	18 498	50.2	10 395	32.2
Low	9868	26.8	10 853	33.6
Shift work [c]	34 834	94.5	7638	23.6
Regions				
Urban	22 785	61.8	20 548	63.6
Rural	14 090	38.2	11 777	36.4

[a] All employees' first registration during the study period (at entrance).
[b] Quick returns within entire study period.
[c] Ever shift work during the study period.

Covariates

Sociodemographic and work-related factors have been related to risk of injury (36–38) and were included to address potential confounding. We included calendar year (categorical), season (categorical), weekday (categorical), age (18–24, 25–34, 35–44, 45–54, 55–65 years), sex (categorical), weekly working hours (continuous), Danish Region (categorical) and shift work (evaluated monthly as ≥12 evening or night shifts the past 12 months) based on data from DWHD. In addition, information on occupation (administrative work, jobs with patient contact and technical staff) and socioeconomic status (SES) (high, intermediate and low) were included, based on main annual income described by the Danish classification of ISCO-codes from Statistic Denmark's Employment Classification Module (30). For exact categorization of DISCO-codes in occupation and SES, see (31).

Statistical method

Data were analyzed by Poisson regression using the natural logarithm of person days as the offset. The daily information on work shifts allowed employees to contribute with risk time to both the exposed and the unexposed group. Repeated measures within employees were accounted for with Generalized Estimating Equations (GEE) (39) with an independent correlation structure. We calculated incidence rate ratios (IRR) with 95% confidence intervals (CI). In model 1, we adjusted for calendar year and season. In model 2 (main model), we adjusted for model 1 and age, sex and occupation. In model 3 additional potential confounders were included, and we adjusted for model 2 and weekly working hours, weekday, shift work, SES and region. In the analyses of quick returns at different time of day, we used covariates from model 2.

A sensitivity analysis tested for additional potential unmeasured confounding between employees with and without quick returns. This was done by restricting the population to employees with at least one quick return the past year, analogous to a previous study (40).

All statistical analyses were conducted in SAS 9.4 (SAS Institute, Cary NC, USA).

Results

During the study period, 11 834 employees had an injury (34% occupational, 11% transport, 42% leisure time, 13% unknown activity). Table 1 presents demographic characteristics of the study population. At baseline the mean age was 40.5 [standard deviation (SD) 11.2] years and the majority of employees were females (76%). Compared with employees without a quick return during the study period, those with a quick return were younger and more often had jobs with patient contact, an intermediate SES and shift work.

Half of all employees had ≥1 quick return during the study period (53%). On average per year, 65% of nurses, 38% of medical doctors and 26% of medical secretaries had ≥1 quick return. Among those with quick returns, the average per employee was 9 quick returns per year. In the study period the median length of the shift before and after 1–11 hours between shifts, was around 8-hours (7.5–8.3 hours), except in 1–5 hours between shifts where the shift after was shorter (4.0–5.0 hours).

Results of quick returns and injury are shown in table 2 in three adjusted models. In model 2, for each one hour increase in rest time, there was a 5% decrease in injury risk (IRR 0.95, 95% CI 0.93–0.96). Also in the categorized time between shifts, lower risks with more time between shifts were observed, except a very high estimate in 3–5 hours between shifts. A 39% higher risk of injury in model 2 was shown on days with a quick return compared to the reference of 15–17 hours between shifts (IRR 1.39, 95% CI 1.23–1.58). Moreover, a linear decreasing trend across days since a quick return was observed. We found a high risk of injury on the same day and on the following day after a quick return (IRR 1.39, 95% CI 1.23–1.58; IRR 1.39, 95% CI 1.21–1.58) compared with the reference of 15–17 hours between shifts. The estimates of risk of injury were elevated two to six days after a quick return (IRR 1.13–1.23), but in model 3 only the first two days showed an elevated risk. Furthermore, our results did not suggest that risk of injury increase linearly with the number of quick returns during the past week (P=0.570). Results in model 3 were similar to model 2, although estimates were attenuated.

Table 2. Incidence rate ratio (IRR) of injury with 95% confidence interval (95% CI), by time between shift, quick returns, number of quick returns and days since quick return, in three adjusted models. [ref=reference.]

	Injury cases	Person years	Model 1 [a]			Model 2 [b]			Model 3 [c]		
	N=11 834	N=167 726	IRR	95% CI	P-value	IRR	95% CI	P-value	IRR	95% CI	P-value
Time between shifts (hours)											
1–2	17	155	1.57	0.97–2.52	<0.001	1.52	0.94–2.45	<0.001	1.46	0.90–2.35	0.075
3–5	19	118	2.31	1.46–3.63		2.24	1.42–3.53		2.09	1.33–3.30	
6–8	116	1078	1.56	1.30–1.88		1.36	1.13–1.64		1.11	0.91–1.34	
9–11	107	1080	1.42	1.17–1.72		1.32	1.09–1.60		1.10	0.90–1.34	
12–14	232	2656	1.27	1.11–1.45		1.24	1.09–1.41		1.11	0.97–1.26	
15–17 (ref)	4597	66 189	1			1			1		
Continuous (1–17)	5088	71 276	0.93	0.92–0.95	<0.001	0.95	0.93–0.96	<0.001	0.96	0.95–0.98	<0.001
Quick return (hours)											
15–17 (ref)	4597	66 189	1		<0.001	1		<0.001	1		0.032
≤11	259	2431	1.53	1.35–1.73		1.39	1.23–1.58		1.17	1.02–1.33	
Number of quick returns past week											
Continuous	1359	15 010	0.92	0.83–1.03	0.117	0.97	0.87–1.08	0.570	0.99	0.89–1.11	0.888
Days since quick return											
Day 0: 15–17 hours (ref)	4597	66 189	1		<0.001	1		<0.001	1		0.032
Day 0: quick return	259	2431	1.53	1.35–1.73		1.39	1.23–1.58		1.17	1.02–1.33	
Day 1: 15–17 hours (ref)	4560	68 061	1		<0.001	1		<0.001	1		0.010
Day 1: quick return	231	2308	1.49	1.30–1.70		1.39	1.21–1.58		1.22	1.06–1.40	
Day 2: 15–17 hours (ref)	4418	69 472	1		0.006	1		0.050	1		0.612
Day 2: quick return	182	2263	1.26	1.08–1.46		1.17	1.01–1.36		1.04	0.89–1.21	
Day 3: 15–17 hours (ref)	4433	69 058	1		0.024	1		0.130	1		0.996
Day 3: quick return	171	2191	1.21	1.04–1.41		1.13	0.97–1.32		1.00	0.85–1.17	
Day 4: 15–17 hours (ref)	4524	68 538	1		<0.001	1		0.013	1		0.545
Day 4: quick return	182	2073	1.33	1.14–1.54		1.23	1.06–1.43		1.05	0.90–1.22	
Day 5: 15–17 hours (ref)	4657	68 018	1		0.002	1		0.021	1		0.559
Day 5: quick return	174	1948	1.30	1.12–1.52		1.22	1.04–1.42		1.05	0.90–1.23	
Day 6: 15–17 hours (ref)	4551	65 832	1		0.006	1		0.029	1		0.288
Day 6: quick return	160	1796	1.28	1.10–1.50		1.21	1.03–1.42		1.10	0.93–1.29	
Days since quick return					0.039			0.022			0.028
Continuous (0–6 days)	1359	15 010	0.97	0.94–1.00		0.97	0.94–1.00		0.97	0.94–1.00	

[a] Adjustment: model 1: year and season.

[b] Adjustment: model 2: model 1 + age, sex, occupation.

[c] Adjustment: model 3: model 2 + weekly working hours, weekday, shift work, socioeconomic status and region.

Thus in model 3 the risk of injury was 17% higher on days with a quick return compared with the reference (IRR 1.17, 95% CI 1.02–1.33). Table 3 shows the risk of injury and the timing of the quick return. No results were statistically significant. However, estimates indicated a higher risk of injury after a quick return before an evening shift (IRR 1.32, 95% CI 0.94–1.85), when compared to a quick return before a day shift, though statistically non-significant.

The sensitivity analysis (see online appendix, www.sjweh.fi/show_abstract.php?abstract_id=3770) restricted to only employees with quick returns showed attenuated estimates in line with results in model 3.

Discussion

Our results revealed that the shorter the time between consecutive shifts, the higher the risk of injury. A quick return (≤11 hours between shifts) was associated with a 39% (IRR 1.39, 95% CI 1.23–1.58) high risk of injury compared with the reference of 15–17 hours between shifts, when adjusted for year, season, age, sex and occupation. Furthermore, analyses showed that risk of injury was highest within the first two days of a quick return. However, the risk decreased with the number of days since a quick return, and more quick returns the past week, did not increase the risk of injury accumulatively. When additional adjustment for weekly working hours, shift work, weekday, SES and region were included, estimates were attenuated but the main conclusions did not change. This was also the case in the sensitivity analysis, which was restricted to employees with quick returns. Finally, the analysis of risk of injury did not show significant differences by time of day of the quick return. However, the non-significant estimates indicated a higher risk of injury after quick returns before evening shifts compared to quick returns before day shifts.

Our results are in line with the few previous studies on quick returns and injury (23, 25). In the steel industry, workers with a schedule including a quick return (8 hours between two shifts) showed a higher risk of occupational injuries compared with workers without a quick return (23). However, this finding may be limited by differences in number of preceding successive shifts, which is also linked to risk of injury (24). In a study among 2273 nurses in the US, results pointed towards an elevated risk of needlestick injuries after self-reported weekly quick returns (<10 hours between two shifts) when investigated both longitudinal (RR of 1.26, 95% CI 0.95–1.67) and cross-sectionally (OR 1.46, 95% CI 1.15–1.86) (25). This is in line with our results on quick returns (IRR 1.39, 95% CI 1.23–1.58). In terms of time between shifts, the categories 1–2 and 3–5 hours were rare and contained very few cases, which can cause unstable estimates. Also, though quick returns between 6–11 hours often fell between two 8-hour shifts, the shift after 1–5 hours between shifts was often shorter. Thus, the risk of injury in 1–5 hours between shifts may reflect more the effect of a long work day, instead of a quick return where employees can return to their home and rest. These unusual events of 1–5 hours between shifts could be due to on-call shifts or split shifts, where the work day is split into at least two work periods (41, 42).

The mechanisms linking quick returns to risk of injury are not yet determined. Inadequate time for rest could explain the higher risk of injury with shorter time between shifts. Also, our results suggest that quick returns present a high acute risk of injury, which fits well with sleepiness and fatigue as the main mechanisms. The two-process model of sleep regulation posits how sleep propensity and duration is a function of a sleep-dependent and a circadian process (43). Quick returns before day, evening and night shifts present rest opportunities at different times of day. A quick return during daytime may include long prior awakening and difficulty in maintaining sleep due to the circadian rhythms. This can result in a short duration and poorer quality of sleep than during the night (43, 44). Moreover, besides commuting, time between shifts may also include time for socializing and domestic work, which may reduce the rest opportunity during quick returns at day and evening time. This study found no overall difference in risk of injury between quick returns at different times of day. Though statistically non-significant, estimates indicated a high risk of injury in relation to quick returns before evening shifts, when the rest opportunity is during daytime. However, the precision of these estimates may be low as quick returns before evening and night shifts included few cases.

This study has the advantage of a large study population and objective register-based precise daily measures of exposure and outcome. Thus, very detailed measures of time between shifts are included and recall bias is eliminated. The daily measures of exposure and

Table 3. Incidence rate ratio (IRR) of injury with 95% confidence interval (95% CI), by quick returns at different time of day. Quick returns (6–11 hours) at the index day or the day before were included. Quick returns before a day shift: second shift start between 04:00–11:59 hours; Quick returns before an evening shift: second shift start between 12:00–19:59 hours; Quick returns before a night shift: second shift start between 20:00–03:59 hours. Estimates were adjusted for: year, season, age, sex and occupation.

	Injury cases	Person years	IRR	95%CI	P-value
Quick return before a					0.221
Day shift (ref)	327	3288	1		
Evening shift	38	276	1.32	0.94–1.85	
Night shift	76	709	0.91	0.70–1.17	

outcome also allowed employees to contribute with time at risk to both the exposure and reference group. Therefore, unmeasured confounding from differences between employees working different types of shifts is reduced.

Findings should be considered in light of this study's limitations. Shifts including on-call work of 1–11 hours could be registered as quick returns, yet both the shift before and after the on-call shift would have to be ≥3 hours long. However, estimates may be conservative as the actual number of quick returns may be higher due to unregistered hours, shifts of <3 hours, and on-call shifts in combination with two regular shifts. In addition, there was longer time for injuries to be registered on the same day as quick returns before a day shift compared with quick returns after evening and night shifts. For example quick returns before night shifts (in Denmark typically starting at 23:00 hours) were registered on the day the night shift began, which may leave only one hour for registration of an injury on the same day. Thus, the association between quick returns before a night shift and injury may be underestimated. In the analyses of time of day of quick returns, this difference was reduced by including an exposure window of two days.

Moreover, the exact time of injury is not known. Consequently, the injury could occur before the quick return within the same calendar day. However, we do not expect any major bias as we assume most people will go home after an injury that requires a visit to an emergency department. Furthermore, for an injury to cause a registration of a quick return, both the work shift before and after should be ≥3 hours long.

Although analyses were adjusted by several potential confounders, additional confounding may persist, particularly related to organization of working hours, eg, shift length, time of day of shift, breaks within shifts, and consecutive shifts (16). Employees with quick returns are likely to have longer weekly working hours in the week of the quick return. In addition, quick returns imply shift work in that ≤11 hours between two shifts will result in shift work (eg, day to night shifts). The effects of these work schedule characteristics are difficult to disentangle. Thus, adjusting for weekly working hours and shift work in model 3 may result in multicollinearity (95% of all quick return observations also had shift work and on average 2.9 weekly working hours >15–17 hours). Still, after adjusting for weekly working hours and shift work in the more conservative model 3, we found a higher risk of injury in the first two days after a quick return though estimates were attenuated. However, having long weekly working hours and shift work can also be considered part of the quick return. Quick returns may be a more important factor than night shifts in relation to sleepiness (5), fatigue (5, 7), and sleep quality (7). Thus, if sleepiness is a mechanism linking quick returns and injury, this could also be the case for risk of injury.

This study included all injuries as sleepiness from working hours may persist after work and increase risk of injury both at work, but also during commuting and leisure time. However, future studies are needed to enlighten the mechanisms and associations between working hour arrangements and different types of injuries (eg, occupational and leisure time injuries). The study population included both urban and rural areas of Denmark and employees with different work schedules (27). If the mechanism between quick returns and injury is biological, such as sleepiness, we assume these results can be generalized to other occupations and countries as well as minor injuries.

In conclusion, we find a higher risk of injury (including occupational, commuting and leisure time injuries) after quick returns compared with the standard 15–17 hours between two shifts. The risk of injury increases with shorter time between shifts and is particularly high within the first two days of a quick return. Our findings suggest that quick returns should be kept to a minimum, and preferably avoided, in order to prevent injuries.

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