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Original article

Working Hour Characteristics and Risk of Occupational Accidents - A Case-crossover Study of the Retail Sector

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ABSTRACT

Background: The purpose was to investigate the association between the working hour characteristics of irregular working hours and the first incident occupational accident in the retail sector.
Methods: Employer-owned register data of daily working hours and the first incident occupational accidents in 2021-2023 were used. The final sample of 470 employees was analyzed using a case-crossover design to obtain odds ratios (ORs) with 95% confidence intervals (95% CI) for the seven-day periods of working hours preceding the accidents.
Results: The weekly working hours (OR: 1.02-1.03, 95% CI: 1.00-1.08), shift length (OR: 10.12-12.47, 95% CI: 4.73- 32.9), and evening shifts (OR: 1.02, 95% CI: 1.01-1.04) were associated with an increased likelihood of occupational accidents among both part- and full-time employees. Early morning (OR: 1.03, 95% CI: 1.01-1.04) and morning (OR: 1.02, 95% CI: 1.01-1.03) shifts, and the percentage of short (<4 hour) shifts (OR: 1.06, 95% CI: 1.01-1.12) increased the likelihood of occupational accidents among part-time employees, and the number of consecutive work shifts (OR: 1.55, 95% CI: 1.04-2.30) among full-time employees.
Conclusion: Working evenings and the length of work shifts, or weekly working hours, even for 7 days, were associated with an increased likelihood of occupational accidents among both part-time and full-time employees. Since early morning and morning shifts showed an increased risk among part-time employees, special attention should be paid to them. Thus, shift scheduling in the retail sector merits attention to regularity and avoidance of long or early shifts, supplemented with safety instructions to ensure the health and safety of employees.

1. Introduction

Today's 24/7 society includes many employees working irregular working hours. At the European level, around 20% of employees work in shifts [1]. Night or irregular working hour arrangements are required in services such as commerce and hospitality, including the retail sector where 50% of employees are women [2]. The service sector as a whole is the largest employment sector in Europe, accounting for 25% of total employment [3]. Another specific feature of the retail sector is the prevalence of part-time work, with more than half of the employees working part-time [4,5].

Working hours in the retail sector are characterized by evening work and irregularity as staffing needs to respond to the number of clients [6], whereas working hours in healthcare, which are also irregular, are dominated by morning and day shifts [7]. Such irregular working hours, including varying work shift start and finish times, lengths, and shift intervals (i.e., the time between two consecutive work shifts), are known to be linked with various adverse health-related outcomes, such as type 2 diabetes,

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cardiovascular disease, and certain cancers [8–10]. Although studies addressing these concerns in the retail sector have been scarce, it is known from studies of the healthcare sector that irregular working hours play a role in safety risks, such as occupational accidents [11–14]. Consequently, occupational accidents may lead to absences from work and job restrictions, which have negative health consequences for the employees and are costly for employers [15,16]. Therefore, there is an emergent need to add understanding of the characteristics of irregular working hours that may increase the risk of occupational accidents. Since the early 2010s, the utilization of employer-owned register data on objective working hours for studies of irregular working hours and health- or safety-related risks has provided new possibilities [4,17]. However, until recent years, such studies have mainly focused on the public healthcare sector, which includes mainly full-time working, highly educated nurses [11,12,18–21]. Instead, the sparse studies of working hours in the retail sector are based on young, less educated, and mainly part-time employees [4,22]. All in all, we are unaware of studies that have assessed working hour characteristics associated with occupational accidents.

This study aimed to investigate the association between the working hour characteristics of irregular working hours in the retail sector and the incidence of occupational accidents.

2. Methods

We used a case-crossover design [23] for the working hour data that covered 7 days until the day of the accident (i.e., exposure period), and the preceding 7 days of the exposure window, i.e., control period (Fig. 1). In the case-crossover design, each participant represents a matched set of data for the case and control periods [23,24]. This design was selected based on the assumption that a relatively short time precedes (trigger) the occupational accident as has been suggested before in studies using similar register-based working hour data [12,14,18,19,25].

2.1. Register data and sample

This study utilized occupational accidents and electronic payroll-based working hour data from the employer-owned records of five regions of the chain of companies in the retail sector in Finland, including supermarkets and service station stores that are typically open 24/7, and convenience stores usually open from 7 am to 11 pm. The regions were South-East Finland (number of employees in 2022 = 549), Middle Finland (n = 1394), North Finland (n = 210), the Province of Pirkanmaa (n = 292), and North-East Finland (n = 180).

The occupational accident data between January 1st, 2021, and December 31st, 2023 (n = 3215) available for this study were linked with the daily working hour data for the same period. The occupational accident data were obtained from the employer's insurance company based on the accidents that a) took place either at the workplace or while commuting to or from work, and b) were reimbursed by the insurer due to lost workday(s). The occupational accident data included the date of the accident without any further information about the timing, body part affected, or other specifics. There was missing information for the accident date in 797 accidents and the employee identification number for 235 employees; thus, these were excluded from the sample (Fig. 2). If an individual had several occupational accidents, the date of the first accident was selected. Among those with an accident, most individuals (n = 2015, 63%) had encountered only one accident (Supplemental Table S1). To avoid any reverse causation (i.e., changes in the working hours or other work procedures due to an accident), we excluded those with >1 occupational accident from the analytical sample for this study. In addition, for the analyses, we excluded individuals who did not have 14 consecutive days of working hour data including free days before the accident (n = 1447), and those who were on sick leave at any point during the 7 + 7-day follow-up (apart from sick leave on the date of the accident) (n = 98). This resulted in a final sample of 470 employees.

The working-hour data included the starting and ending times of daily working hours and the reasons for absences (day off, sick leave, maternity leave, annual leave, etc.). The classification of work shifts included the following shift types: early morning shift (starts before 6:00 am and is not categorized as a night shift); morning shift (starting after 3:00 am and ending before 6:00 pm); day shift (starting after 8:00 am and ending before 6:00 pm); evening shift (starting at any time between 6:00 pm and 11:00 pm and not categorized as a night shift), and night shift (≥3 hours between 11:00 pm and 6:00 am) as described in detail in previous studies [4,17,22]. These were further used to calculate the working hour characteristics of three major working hour domains: 1) the length of working hours, including five variables describing weekly or daily working hours, 2) time of the day (shift work), including the proportion of different shifts (i.e., early morning, morning, day, evening, and night shifts within the clock hours above), and 3) shift intensity, including the consecutive work shifts (e.g., the number of consecutive working days, or consecutive evening, and night shifts) and recovery time between the shifts, that is, the <11 hours between two consecutive work shifts, the so-called short shift interval, based on the European Working Time Directive (see in detail: [4,17,22]). The working hour data also included information on sex, age, occupational title, and part-time work, which were included as descriptive characteristics for this study. The data on occupational accidents included only the accident date that occurred during working hours or while traveling to or from the workplace.

2.2. Statistical analyses

The mean of the working hour characteristics was calculated for the 7-day (one week) exposure period, immediately before the occupational accident, and for the 7-day control period before the beginning of the exposure period. Conditional logistic regression

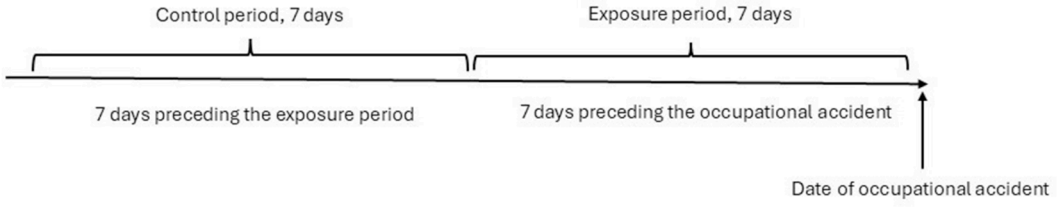

Fig. 1. The case-crossover design with 7-day exposure and control periods before the first incident occupational accident.

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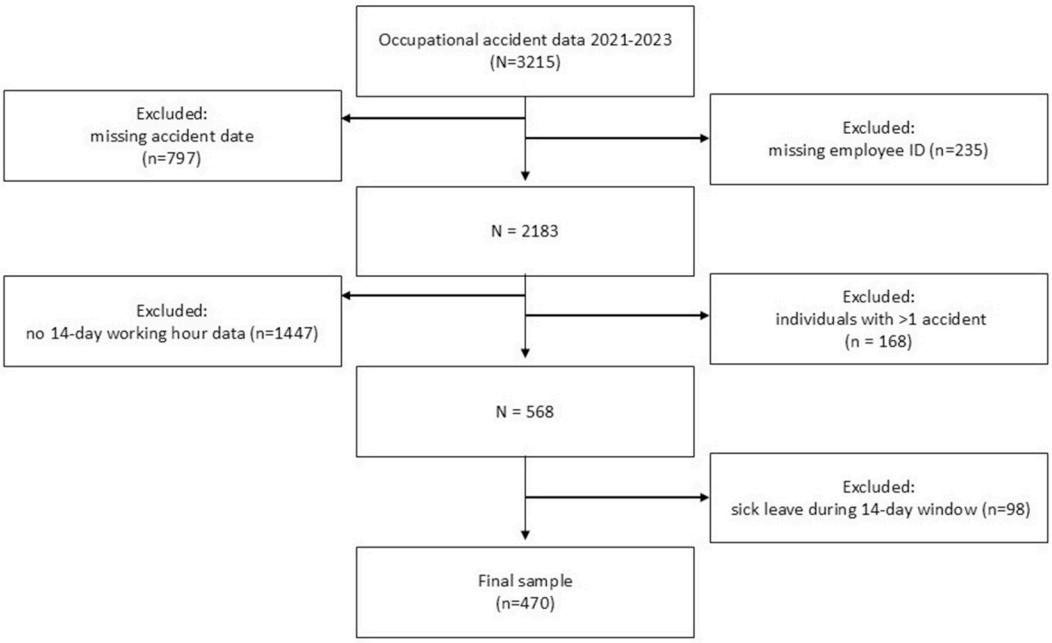

Fig. 2. Flowchart for data construction of the final sample.

models were used to calculate the risk of occupational accidents associated with the exposure and control periods as they eliminate the effect of time-invariant factors and adjust for unmeasured time-varying confounders. In these models, each participant represented a matched set of data for exposure and control periods [23,24]. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were obtained by comparing working hour characteristics in the exposure window to those in the control window in the conditional logistic regression models using maximum likelihood estimation. Furthermore, we treated the working hour characteristics related to the length of working hours, time of day, and shift intensity as continuous variables. In contrast, we tested a threshold for short shift intervals (>25%) and treated that as a categorical variable following the guideline in Finland [4,26]. This analytical strategy means that the obtained point estimates (OR) for continuous variables reflect each one-unit increase. Thus, e.g., for weekly working hours, OR would be per one hour, whereas for the variables of %, the OR would be for one percent increase. Instead, for the threshold for short shift intervals, the OR is for dichotomized, yes versus no. The data management for working hour data was generated using SAS software, Version 9.4 of the SAS System for Windows, and all analyses were conducted in Stata 18.0 MP (StataCorp LLC, College Station, TX).

2.3. Ethics approval

This study was fully based on administrative register data that the participating organizations had permitted access to. Ethical approval for this study was granted by the Ethics Committee of the hospital district of Helsinki and Uusimaa (No. HUS/7298/2023).

3. Results

The mean age of the final sample was 42.8 years (standard deviation [SD]: 10.7) for those working full-time (125 employees, 82% women) and 33.6 years (SD: 13.2) for those working part-time (345 employees, 76% women). The means for the working hour characteristics are shown in Table 1.

The associations between working hour characteristics and occupational accidents (Table 2) indicated that a one-unit increase in weekly working hours (OR: 1.02-1.03, i.e., 2-3%), shift length (10 times higher odds), and percentage of evening shifts (2%) were associated with an increased likelihood of occupational accidents among all, part-time, and full-time employees. A one-unit increase in early morning and morning shifts (2-3%), and the percentage of short (<4 hour) shifts (6%) increased the likelihood of occupational accidents among part-time employees, and a one-unit increase in the number of consecutive work shifts among full-time employees. Other working hour characteristics had inconsistent associations across being part-time or full-time employed.

4. Discussion

This case-crossover study of 470 Finnish retail sector employees aimed to investigate the associations of working hour characteristics with occupational accidents. The results indicated consistent, but minor associations between a one-unit increase in weekly working hours, evening shifts, and occupational accidents as the associations were shown both among part-time and full-time employees. A one-unit increase in shift length increased the odds of occupational accidents 10 times, although this association might be due to random chance. A one-unit increase in early morning and morning shifts, and the percentage of short (<4 hour) shifts had a minor effect on the likelihood of occupational accidents among part-time employees as did the number of consecutive work shifts among full-time employees.

Corresponding with earlier studies of healthcare [12,14,27], a one-unit increase in evening work and the length of working hours played a minor but consistent role in the likelihood of occupational accidents. This suggests the need to consider the length of shifts and amount of evening work in shift scheduling within the retail sector, and to guide the employees to remain alert and manage fatigue during evening work and long shifts. Previous studies on associations between irregular working hour characteristics and occupational accidents have mostly been conducted in the healthcare sector [12,14,18,20,28]. To the best of our knowledge,

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Table 1
Descriptives for the working hour characteristics across the 7-day exposure and control windows

Length of working hours	Part-time employees ($n = 345$)				Full-time employees ($n = 125$)			
	Exposure		Control		Exposure		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Weekly working hours (h)	22.6	8.7	21.3	9.2	26.3	7.6	24.4	9.7
% with long (>37.5 h) working week	18	52	14	46	38	69	14	46
% with long (>48 h) working week	2	19	1	14	5	28	1	14
Shift length (h)	5.9	0.8	5.7	0.6	7.4	0.9	7.8	0.7
% of short (<4 hour) shifts	1	4	1	3	0	3	1	3
Time of the day								
% of early morning (starts before 6:00 am) shifts	13	29	10	22	27	47	22	41
% of morning shifts (starts after 3:00 am and ending before 6:00 pm)	30	36	24	28	52	47	46	42
% of day shifts (starts after 8:00 am and ending before 6:00 pm)	17	21	15	20	11	20	9	19
% of evening shifts (starts between 6:00 and 11:00 pm, not categorized as night)	52	43	44	36	25	36	19	28
% of night shifts (≥3 hours between 11:00 pm and 06:00 am)	3	13	3	12	2	16	2	11
Shift intensity								
Number of consecutive working days	3.0	1.5	2.8	1.5	3.5	1.3	3.1	1.4
Number of consecutive evening shifts	1.4	0.8	1.3	0.8	1.0	0.5	0.9	0.5
Number of consecutive night shifts	2.1	0.9	2.0	1.0	2.6	1.3	1.4	0.7
% of short (<11 hours) shift intervals	4	11	3	8	5	12	3	6
>25% of short shift intervals	0	0	0	0	0	0	0	0

SD, standard deviation.

Table 2
Conditional logistic regression (OR with 95% CI) for the associations between working hour characteristics and occupational accidents ($n = 470$)

Length of working hours	All ($n = 470$)		Part-time ($n = 345$)		Full-time ($n = 125$)	
	OR*	95% CI	OR*	95% CI	OR*	95% CI
Weekly working hours (h)	**1.03**	**1.01, 1.05**	**1.02**	**1.01, 1.05**	**1.03**	**1.00, 1.08**
% with long (>37.5 h) working week	1.00	1.00, 1.00	1.00	1.00, 1.00	1.00	1.00, 1.00
% with long (>48 h) working week	1.00	0.99.1.00	1.00	0.99, 1.01	0.99	0.98, 1.00
Shift length (h)	**10.80**	**6.78, 17.2**	**10.12**	**5.94, 17.2**	**12.47**	**4.73, 32.9**
% of short (<4 hour) shifts	1.05	1.00, 1.09	**1.06**	**1.01, 1.12**	0.98	0.90, 1.08
Time of the day						
% of early morning (starts before 6:00 am) shifts	**1.02**	**1.01, 1.04**	**1.03**	**1.01, 1.04**	1.01	1.00, 1.03
% of morning shifts (starts after 3:00 am)	**1.02**	**1.01, 1.02**	**1.02**	**1.01, 1.03**	1.01	1.00, 1.03
% of day shifts (starts after 8:00 am)	1.01	1.00, 1.02	1.01	1.00, 1.02	1.02	0.99, 1.05
% of evening shifts (starts between 6:00 and 11:00 pm)	**1.02**	**1.01, 1.02**	**1.02**	**1.01, 1.02**	**1.02**	**1.00, 1.04**
% of night shifts (≥3 hours between 11:00 pm and 6:00 am)	1.01	0.99, 1.03	1.01	0.98, 1.04	1.01	0.97, 1.04
Shift intensity						
Number of consecutive working days	1.18	0.99, 1.42	1.09	0.88, 1.33	**1.55**	**1.04, 2.30**
Number of consecutive evening shifts	0.97	0.75, 1.25	0.96	0.74, 1.26	1.10	0.45, 2.67
Number of consecutive night shifts	4.11	0.64, 26.3	—	na	1.01	0.97, 1.04
Recovery						
% of short (<11 hours) shift intervals	**1.02**	**1.01, 1.05**	1.01	0.99, 1.03	**1.06**	**1.01, 1.10**
>25% of short shift intervals	**3.10**	**1.23, 7.78**	1.15	0.40, 3.38	—	na

Statistically significant OR with 95%CI are in boldface.
* All models account for weekly working hours. Statistically significant OR with 95% CI in boldface. CI, confidence interval; na, not able to be assessed due to a low number of observations; OR, odds ratio.

this study is among the first to explore these associations within the retail sector and therefore adds to earlier knowledge [11,12,18–21]. Recent conference papers have highlighted the necessity of investigating working conditions in the retail sector to predict accidents [29–31].

The analyses on the first incident of an occupational accident, assuming that experiencing several accidents could be related to behavioral patterns, such as risk-taking or tempo at work [32]. This decision diminishes the risk of reverse causation, i.e., that working hour characteristics might change after the first accident (i.e., being on sick leave and then returning to work, or not willing to work late evenings or nights) [33]. Another approach related to our design was the use of the case-crossover design, which controls many influential workplace and work-related factors, such as management and team culture, but also employee-specific characteristics like age and sex as each employee in the sample was compared to themselves in two short, subsequent periods. However, the pitfall related to the case-crossover design was that it reduced the sample size for the analyses while at the same time added rigor to the study design. It could also be speculated whether the 7-day window for exposure and control periods was appropriate, since working hour characteristics can be considered cumulative or semi-chronic [25]. Many earlier studies of working hour characteristics and occupational accidents have investigated

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the same exposures and utilized the 7-day window [12,14,18,20,28], aligning with the assumption that working hours shortly preceding the incident may have a triggering effect [25]. Since this was among the first studies in the retail sector using register data for working hours and occupational accidents, using the same time window was justified for comparisons. However, further studies are merited to explore longer or alternative time windows and to investigate the cumulative effects.

Slight differences between part-time and full-time employees in terms of associations between working hour characteristics and occupational accidents were detected. The number of consecutive working days was associated with an increased likelihood of accidents among full-time employees but not among part-time ones. Conversely, early morning and morning shifts were associated with the likelihood of accidents among part-timers only. This might be indicative of the accumulation of workload due to working hours, even if one works part-time, or shift scheduling or work tasks may differ in part-time versus full-time work, aligning with earlier findings of short sick leaves [22]. Thus, it is suggested that retail sector workplaces consider these in their work design and shift scheduling.

Among the strengths, this study had the benefit of using employer-owned register data on working hour characteristics and occupational accidents. Such objective data are free from memory or reporting biases and should be without loss to follow-up. In addition, applying the case-crossover design that compares each employee to themselves using exposure and control time windows added to the credibility of the findings [23,24], while also being a strong design for studies of accidents [14,34]. Another attempt to add rigor to our analytical strategy was to focus on the first incident of an occupational accident as has been done before [12,28].

The study had some limitations. The data on working hours were available only for 2021-2023, allowing us to estimate the associations with accidents within this time frame. Thus, further studies should employ more years of data. Regarding the accidents, we lacked information on the timing (i.e., when the accident occurred, despite the date) and the type of accident, except for whether it took place at work or while traveling to or from work. These aspects would also merit further studies with more complete data. We had no information on any perceived aspects of workload, such as job satisfaction, tiredness, or hurry [32,35]. Again, the utilization of a case-crossover design with a relatively short (7-day) time window should minimize such effects. However, further studies with designs to account for these and even time-varying confounding (e.g., sleep [36], recovery [37], or psychosocial factors [35]) might be merited to clarify further the risk factors for occupational accidents in the retail sector. Another limitation is the proportion of missing data as 32% of the occupational accident data had some missing information and were excluded from the analysis, which should add some caution to the interpretation of the results. All in all, our final analytical sample was relatively small compared to the full, available data. We assume that our results can be hampered by selection bias or by random effects. Thus, further studies should confirm these findings. Another fact that merits caution is the result related to the length of working hours. The point estimate was rather large with a wide 95% CI, which suggests that the sample size, exposure window, or random effects might have played a role despite the case-crossover design. Yet, it is necessary to emphasize the nature of work in the retail sector that consists of varying peaks of work loading [38,39] and irregular working hours [4]. As indicated by the earlier studies of the healthcare sector, such unique characteristics as on-call work for physicians [28] or long shifts among healthcare employees [14] increase the risk of occupational accidents, aligning with our findings. Lastly, since our study was conducted in Finland, the results may be most applicable to other Nordic countries with similar working hours and welfare systems. However, when compared to earlier findings in the healthcare sector (e.g., [12,14,27]), these results contribute to a broader understanding of shift scheduling in the service sector.

To conclude, working evenings and the length of work shifts, or weekly working hours, even during a short period of 7 days, were associated with an increased likelihood of occupational accidents among both part-time and full-time employees engaged in irregular shift work in the retail sector. Since early morning and morning shifts added the likelihood among part-time employees, special attention should be paid to them. Hence, shift scheduling in the retail sector merits attention to regularity and avoidance of long or early shifts, supplemented with safety instructions to ensure the health and safety of employees.

CRediT authorship contribution statement

Annina Ropponen: Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Maria Hirvonen:** Writing – review & editing, Data curation. **Joonas Poutanen:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Pihla Säynäjäkangas:** Writing – review & editing, Methodology. **Eija Haukka:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization.

Disclaimers

None.

Declaration of generative AI in scientific writing

During the preparation of this work, the authors have not used any AI tools for scientific writing or any other ways of processing the data or results of this work.

Conflicts of interest

The authors declare that they have no conflicting interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2025.11.002.

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