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Working hour patterns and risk of occupational accidents. An optimal matching analysis in a hospital employee cohort

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ABSTRACT

Background: Hypothesis-free studies applying advanced statistical analysis of objective working hour patterns and occupational accidents are lacking. This study aimed to identify patterns of working hours among hospital employees and to investigate the associations between the identified patterns and the risk of an occupational accident.

Method: In this cohort study of 4419 hospital employees, we collected electronic payroll-based working hour data (i.e., timing and duration) for each participant and linked them to records of occupational accident register between 2008 and 2018. We used optimal matching to assess similarity between individual working hour patterns for a period of 7 days preceding an accident or, for employees without an accident, a random pseudo-accident date. Using cluster analysis, we categorized employees into working hour pattern clusters. Log-binomial regression was used to examine risk ratios (RR) with 95 % confidence intervals (CI) of an occupational accident between cluster memberships.

Results: 1626 participants experienced an occupational accident which took place either at the workplace (65 %) or while commuting (35 %). Six clusters of working hour patterns were identified. Compared to the cluster with the fewest accidents, clusters with a higher proportion of accidents were characterized by late work shifts and a high proportion of quick returns (<11-hour shift interval,) and long work shifts (>12-hour shift), RR 1.31, 95 % CI 1.13–1.52 for the cluster with the most accidents.

Conclusions: This data-driven study suggests that working late and long with insufficient rest is associated with increased probability of occupational accidents. Working hour arrangements in 24/7 care of hospital merit attention to regularity and sufficient rest to support occupational safety.

1. Introduction

Irregular shift work, i.e., shift work with a non-standard schedule that includes varying work shift start and finish times, lengths, and shift intervals (that is rest periods between work shifts) to fulfill the supply of health care (Sallinen and Kecklund, 2010); is known to increase the risk of several adverse health-related outcomes. These include type 2 diabetes, cardiovascular disease, and certain cancers (Pahwa et al., 2018; Gan et al., 2015; Wang et al., 2011), but also safety risks, such as occupational accidents (Vedaa et al., 2019; Härmä et al., 2020; Matre et al., 2021). Although utilization of employer-owned register data on objective working hours for studies of irregular working hours and health- or safety-related risks has increased, many studies of occupational accidents have investigated only few working hour characteristics (Vedaa et al., 2019; Nielsen et al., 2019; Nielsen et al., 2018; Nielsen et al., 2019) or have tested a-priori hypotheses (Härmä et al., 2020; Ponsin et al., 2020). Until now, explorative studies assessing the complex interplay between working hours and shift intervals (rest periods) in relation to occupational accidents are rare.

The few data-driven hypothesis-free studies of working hour patterns

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have utilized optimal matching analysis (Abbott and Tsay, 2000) to examine the associations of working hour patterns with social contacts beyond family relationships (Cornwell and Warburton, 2014), influential factors for time use (Van Tienoven et al., 2011), and to describe work days and working weeks (Lesnard and Kan, 2011). The interest to apply optimal matching arises from the advantage to consider the structure of working hour patterns by analyzing simultaneously duration, sequence, and timing. In contrast to a traditional analysis that reduces working hours characteristics to dichotomies or few categories (e.g., day vs night shift, sufficient vs insufficient rest period) (Lesnard, 2010), optimal matching enables a holistic analysis of working hour patterns by identifying distinct patterns of work and rest spells during a specific time interval and calculating distances between individual patterns. When applied to working hour data, optimal matching with cluster analysis enables capturing the patterns of working hours in irregular shift work and examining the associations between these patterns and health- and safety-related outcomes, such as occupational accidents. This approach has the potential to provide valuable new insights into working hour arrangements in hospitals.

In this study our aim was to explore and identify working hour patterns among hospital employees working irregular working hours and to investigate the associations between the identified patterns and the risk of occupational accidents.

2. Methods

2.1. Data and the study population

This occupational cohort study utilized electronic payroll-based working hour data from employees of one hospital district in Finland. Daily working hour data between January 1st 2008 and December 31st 2018 (n = 16 472 employees) were linked with occupational accident data obtained from the Finnish Workers' Compensation Center (n = 5131 employees with at least one accident). If an employee had several occupational accidents, the date of the first accident was selected. Among those with an occupational accident, 68 % (n = 3495) had had only one accident during the follow-up. Those employees who did not have any occupational accidents formed a control group. We generated a random pseudo-accident date for the control group. The control group with a pseudo-accident was included in the analysis so that we could examine whether the working hour patterns before an actual occupational accident were different from working hour patterns before a pseudo-accident. Hence, the control group allowed us to examine the associations between working hour patterns and the risk of an occupational accident.

Occupational accidents were defined by the Workers' Compensation Center using the Finnish legislation (the Workers' Compensation Act). Occupational accidents at the workplace also cover accidents during activities other than work tasks and while commuting between the home and the workplace. All occupational accidents are reimbursed to the employer and the employees via a statutory insurance system (see e.g. (Härmä et al., 2020). The data included the date and place of the accidents, (at work/while commuting/during leisure time) and the reported external cause, location, and type of accident (e.g., falling, crashes, violence, physical load).

The employer's register of payroll-based daily working hour data were obtained from the shift scheduling program Titania® including age, sex, work contract (i.e., work contract with shift work, office hours, physician, or else, but for this study only those with the work contract of shift work were included), start/end of work and absences (i.e., days off, sickness and other leaves) (Harma et al., 2015). Using the working hour data, we calculated the long shifts (the proportion of >12 h shifts of all work shifts in the observation window), long working weeks with two cut-points: >40 h/week and >48 h/week, shift intervals (rest hours between shifts), and quick returns (<11 h) (Työterveyslaitos, 2022).

We used working hour data covering a period of 7 days (=the day of the accident and the previous 6 days) until the day of the accident or the pseudo-accident. As all employees with an occupational accident were at work at the 7th day (the day of the accident), we only included pseudo-accident/control participants whose 7th day was a workday. If the date of the actual accident was coded as sickness absence, data on planned work shift instead of actual work shift was used. Furthermore, if the work shift on the accident date had ended before its planned timing, data on planned instead of actual end timing was used. We excluded individuals who did not have 7 consecutive days of working hour data prior to the accident (n = 6 091); not working on the last day of the 7-day period prior to accident (n = 4 280); sickness absence at any point during the 7-day period (apart from sickness absence on the date of the accident) (n = 229); and not working in shift work as determined by the work contract (n = 1453). This resulted in a final sample of 4 419 individuals.

The permission to link working hour data with occupational accident data were received from the hospital district. Ethical approval was not required for this study as the data comprised register-based employer-owned information.

2.2. Statistical analysis

For the analysis, each day was divided into 24 h, creating a sequence of 168 (7*24) successive hours. The hours along the 7 days thus formed an ordered sequence that consisted of two states, coded as work or rest. On the individual-level, the sequences were characterized by alternating working hours and shift interval spells of varying timing and duration.

We used optimal matching with dynamic Hamming distance algorithm (Lesnard and Kan, 2011) to analyze the individual working hour sequences. Optimal matching compares the degree of dissimilarity between each pair of working hour sequences and determines distances between individuals based on their working hour pattern (Abbott and Tsay, 2000). In this kind of matching process, two individuals who have worked at different times during the follow-up are considered more distant from each other than individuals who have worked synchronously. In essence, the optimal matching algorithm thus measures the degree of alignment between the individual working hour patterns. Between each pair of individual sequences, the algorithm assigns a cost for states that do not match (i.e., if some specific hour during the follow-up is coded as "rest" for one person and "work" for the other). For non-matching states, a substitution is required for the states to match, changing the status from "work" to "rest" or vice versa. Because only substitutions, and not insertions or deletions, are used in the dynamic Hamming distance method, the method does not "warp" time and it can be applied only to sequences of the same length.

The dynamic Hamming distance algorithm considers both the timing and duration of working hour and shift interval states because it applies time-varying substitution costs that are derived from transition probabilities between the two states at each time point. This means that a greater cost is assigned to non-matching states that are, according to the transition probabilities, less likely to be asynchronous. The method is particularly well-suited for comparing sequences when the focus is on the timing of the transitions between the states (e.g., whether a work shift starts in the morning or in the evening) and the duration of stay in each state (e.g., the length of working hours and the subsequent shift interval (rest period)).

After using optimal matching to calculate the distances between individuals, we employed cluster analysis with Ward's algorithm (Ward, 1963) on the distances to uncover individuals with similar working hour patterns. Once the optimal number of clusters was determined, each individual was assigned to a cluster. Finally, we used log-binomial regression to examine the association between cluster membership and the risk of an occupational accident with relative risk (RR) and 95 % confidence intervals (CI). The analyses were conducted using R 4.0.5 with packages TraMiner (Gabadinho et al., 2011) and WeightedCluster (Manual, 2013).

3. Results

Of the 4 419 participants, 1626 had at least one occupational accident during the follow-up. Their mean age was 43.1 years (12.3 SD) and 90 % were women, whereas in the control group with a pseudo-accident, mean age was 40.1 years (13.4 SD), and 89 % were women. Most commonly, the accident resulted in a cut or wound (n = 728, 45 %) or in a dislocation or sprain (n = 520, 32 %). Most (n = 1059, 65 %) of the occupational accidents took place at the workplace. Among the accidents that took place at the workplace, the accident was most often caused by a sharp object (n = 364, 34 %). Out of the accidents, 567 (35 %) took place while commuting and most often they were due to stumbling (n = 436, 77 % of all commuting accidents).

Among the 4 419 hospital employees, there were a total of 20 153 work shifts with a mean of 4.6 work shifts per an employee, and 3 422 unique sequences of working hours during the 7-day period. The sequences of working hours including identification of work shifts and shift intervals (timing, length) were further grouped using cluster analysis. After careful examination of the cluster quality measures (Supplementary Fig. 2) and for reasons of manageability and parsimony, a six-cluster solution was selected. Detailed illustrations of the clusters are shown in Supplementary Figs. 1–4.

Fig. 1 presents chronograms (i.e., state proportion plots) for each cluster, showing the distribution of work and rest at each hour during

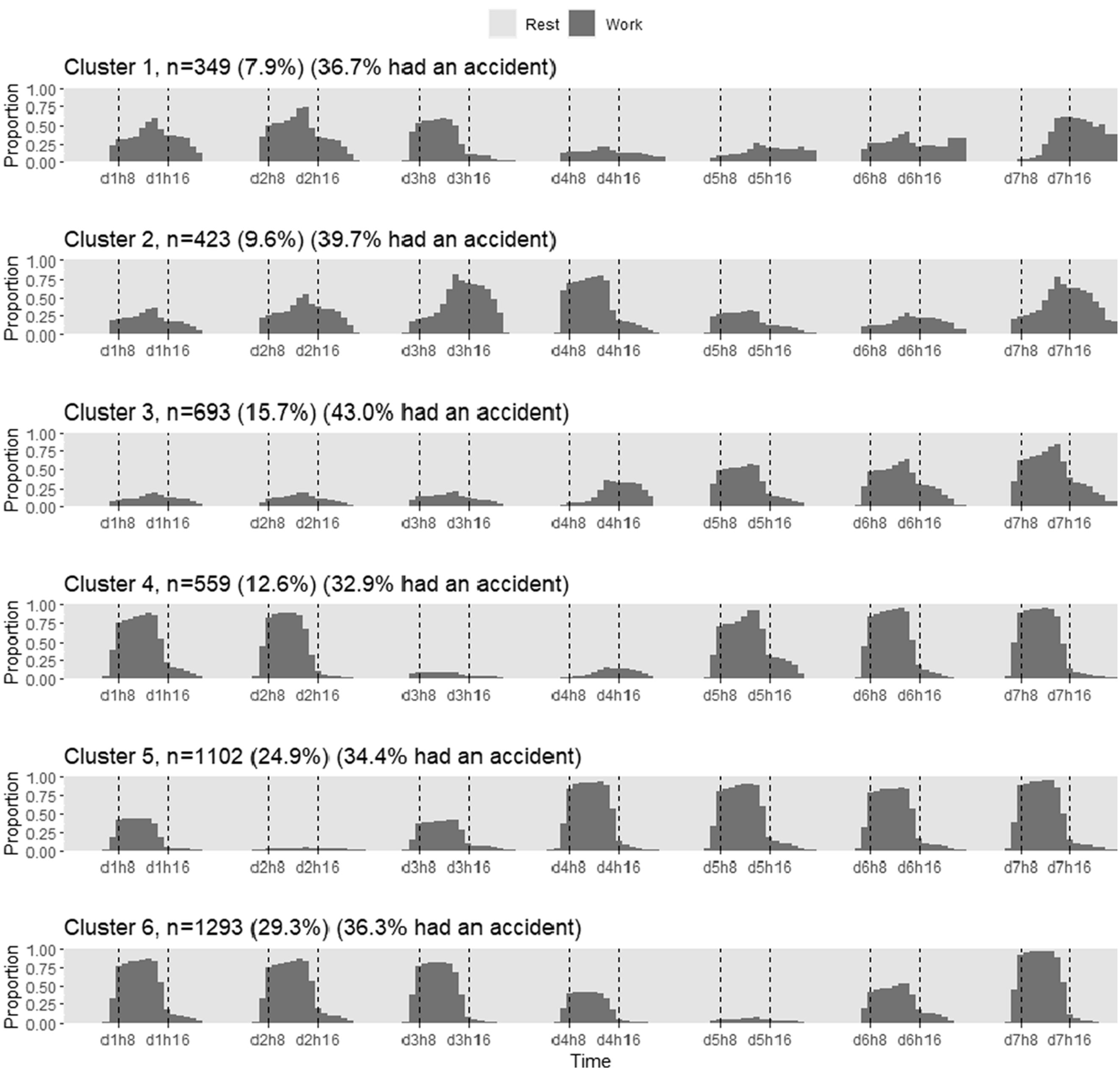

Fig. 1. A chronogram (i.e., a state proportion plot) describing the distribution of work and rest states at each hour during the 7-day follow-up period in each cluster. For each cluster, the Fig. 1 should read from left to right, i.e., from day 1 that is the 7th day preceding the accident or the pseudo-accident to day 7 which is the last day of the follow-up and the day of the accident or pseudo-accident. D = day and h = hour: “d1h8” indicates the first day of follow-up, and time at 8o’clock at that day. “d7h16” is 16o’clock at the day of the accident or the pseudo-accident etc. The clusters were 1: Very late and very long shifts, very long weekly hours, insufficient rest, 2: Late and long shifts, long weekly hours, very insufficient rest, 3: Day shifts, mostly regular length shifts, long weekly hours, rather sufficient rest, 4: Morning shifts, mostly regular length shifts, long weekly hours, 5: Morning shifts, mostly regular length shifts, regular weekly hours, sufficient rest, and 6: Morning shifts, mostly regular length shifts, relatively regular weekly hours, sufficient rest.

the 7-day period. The proportion of those with occupational accident in various clusters was between 33 and 43 % although the cluster sizes varied from 8 % (n = 349) in the Cluster 1–29 % (n = 1293) in the Cluster 6. Clusters 1 through 3 had the highest proportions of occupational accidents and above average proportions of occupational accidents that occurred at the workplace and not during commuting (proportions of accidents at the workplace were 77 %, 68 %, and 67 % for Cluster 1,2, and 3, respectively). As the chronograms in Fig. 1 indicate, in terms of the 7th day of the follow-up (day of the accident or the pseudo-accident), Clusters 1,2 and 3 were characterized with work mainly during the day and evening, whereas Clusters 4, 5, and 6 were characterized with work during the morning and day.

Table 1 presents descriptive results of the six identified clusters by employee and working hour patterns, along with proportions of accidents within each cluster. Although we aimed to find individuals with similar working hour patterns, there was inevitably some within-cluster heterogeneity in the working hour patterns. This was reflected in the relatively large variation around the means of certain cluster specific working hour patterns such as shift intervals (rest hours between shifts) and weekly working hours (see Table 1). Due to this within-cluster heterogeneity, we relied more on comparisons between proportions (instead of means) when describing differences between the clusters (Table 1).

Cluster 1 named as “Very late and very long shifts, very long weekly hours, insufficient rest” was characterized by the work shifts starting at latest hours, highest proportion of long shifts and long working weeks, higher proportions of quick returns, and an average proportion of accidents. Also, the mean age of the employees was lower than in the whole sample. *Cluster 2* named “Late and long shifts, long weekly hours, very insufficient rest” was characterized by work shifts starting later, highest proportion of quick returns, a higher proportion of long shifts and long working weeks, and a higher proportion of accidents. The employees were younger than in the full sample. *Cluster 3* named “Day shifts, mostly regular length shifts, long weekly hours, rather sufficient rest” included older employees than in the full sample. Furthermore, cluster 3 was characterized by fewer work shifts per week, slightly later starting work shifts, a higher proportion of quick returns, a slightly higher proportion of long shifts, a lower proportion of long working weeks, and the highest proportion of accidents. *Cluster 4,* named “Morning shifts, mostly regular length shifts, long weekly hours”, was characterized by morning shifts, lower proportion of long shifts, slightly higher proportion of quick returns, a higher proportion of long working weeks, and the lowest proportion of accidents. *Cluster 5* with name “Morning shifts, mostly regular length shifts, regular weekly hours, sufficient rest” was characterized by morning shifts, lower proportion of long shifts, quick returns, long working weeks, and accidents. *Cluster 6* had older employees than in the whole sample and was very similar to Cluster 5: morning shifts, (slightly) lower proportion of long shifts, quick returns, and long working weeks, and slightly lower proportion of accidents. Therefore Cluster 6 was named “Morning shifts, mostly regular length shifts, relatively regular weekly hours, sufficient rest”. Overall, clusters 1, 2, and 3 with the latest work shifts and the highest proportions of quick returns and long work shifts had the highest proportions of occupational accidents.

Table 1
Characteristics of employees, work shifts, weekly working hours, and occupational accidents in the six clusters.

Characteristics of		All employees	Clusters **1** Very late and very long shifts, very long weekly hours, insufficient rest	**2** Late and long shifts, long weekly hours, very insufficient rest	**3** Day shifts, mostly regular length shifts, long weekly hours, rather sufficient rest	**4** Morning shifts, mostly regular length shifts, long weekly hours	**5** Morning shifts, mostly regular length shifts, regular weekly hours, sufficient rest	**6** Morning shifts, mostly regular length shifts, relatively regular weekly hours, sufficient rest
	%	100	8	10	16	13	25	29
	n	4419	349	423	693	559	1102	1293
Employees	Women (%)	90	89	88	90	88	90	90
	Age, years, mean (SD)	41.2 (13.1)	38.6 (12.5)	39.1 (13.2)	42.3 (12.8)	41.0 (13.7)	40.8 (12.9)	42.5 (13.1)
Work shifts	Work shifts (n of observations)	20,153	1627	1904	2397	2837	5225	6163
	Work shifts/employee, mean (SD)	4.6 (1.1)	4.7 (1.1)	4.5 (1.2)	3.5 (1.5)	5.1 (0.6)	4.7 (0.6)	4.8 (0.8)
	Work shift length, mean (SD)	8.0 (0.8)	8.7 (1.1)	8.2 (0.9)	8.0 (1.0)	7.9 (0.6)	7.9 (0.7)	7.9 (0.6)
	Work shift starting time*, mean (SD)	8:50 (1:45)	12:20 (1:35)	10:45 (1:35)	9:25 (1:50)	8:10 (1:25)	7:55 (1:20)	7:55 (1:15)
	Shift intervals, mean, (SD)	27.5 (13.5)	29.2 (17.0)	28.1 (9.8)	23.8 (13.4)	26.3 (7.5)	23.5 (13.5)	32.5 (12.0)
	% of long (≥12 h) shifts	2	6	4	3	1	1	1
	% of quick returns (<11 h)	7	11	15	13	8	4	5
Weekly working hours	h/week, mean (SD)	36.3 (8.9)	40.0 (9.8)	36.7 (10.6)	27.5 (11.9)	39.9 (5.8)	37.4 (5.1)	37.4 (6.5)
	% of long (>40 h) working weeks	25	45	35	14	34	18	23
	% of very long (>48 h) working weeks	5	16	8	4	6	2	4
Occupational accidents	(%)	37	37	40	43	33	34	36

* Decimals are transformed to minutes and rounded to 5-minute accuracy.

The associations between cluster membership and the risk of occupational accident were examined using log-binomial regression, adjusting for age, sex, and weekday at last day of the follow-up (i.e., the day of the accident or pseudo-accident). Because Cluster 4 members had the lowest risk of occupational accidents and the most regular working week (approximately 5 workdays and 2 consecutive days of rest during the follow-up), Cluster 4 was used as a reference category in the analysis (see Fig. 2 for illustration of associations of Table 2). Compared to the Cluster 4 with most regular working week, in the adjusted model, employees in Cluster 2 had a higher risk RR 1.21 (1.01, 1.44) and Cluster 3 employees had a higher risk of RR 1.28 (1.10, 1.50) of encountering an occupational accident. Besides the cluster characteristics, age in ten-year increments was an important predictor (RR 1.11, 95 %CI 1.08, 1.14) for an occupational accident. The comparison of weekdays at the last day of the follow-up (Monday as reference) indicated no weekday specific effect on the risk of an occupational accident (Table 1).

As a sensitivity analysis, we conducted the analysis using Cluster 5 as the reference category and found rather similar results (see Supplementary Table 1).

4. Discussion

This study with objective working hour data from employer-owned register and occupational accidents from national register for one hospital district in Finland aimed to identify patterns of working hours among 4419 hospital employees and to investigate the associations between the identified patterns and the risk of occupational accidents. Although we identified some within-cluster heterogeneity in the working hour patters, six distinct clusters of patterns were detected. Both the proportion of actual occupational accident in the clusters (33–43 %) and the cluster sizes from 8 % to 29 % varied suggesting that patterns of working hours would also vary on their role for the risk of occupational accidents. This adds to the earlier research based on few working hour characteristics (Vedaa et al., 2019; Nielsen et al., 2019; Nielsen et al., 2018; Nielsen et al., 2019) or having tested a-priori hypotheses (Härmä et al., 2020; Ponsin et al., 2020).

The clusters 1–3 had the highest proportions of occupational accidents. Besides accidents, Cluster 1 “Very late and very long shifts, very long weekly hours, insufficient rest” was characterized by the work

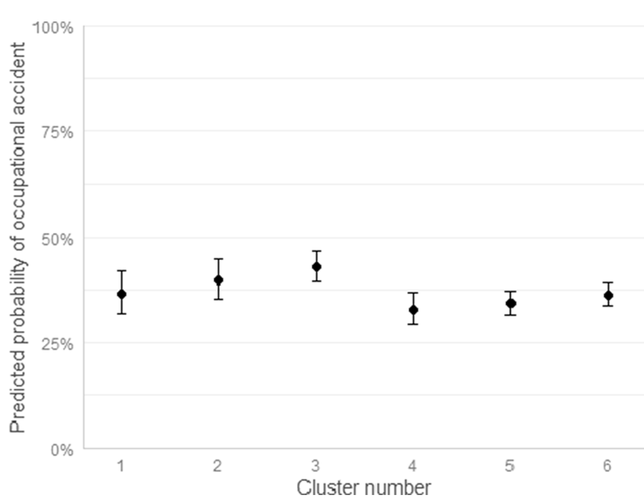

Fig. 2. Predicted probability of occupational accident by cluster membership. The clusters were 1: Very late and very long shifts, very long weekly hours, insufficient rest, 2: Late and long shifts, long weekly hours, very insufficient rest, 3: Day shifts, mostly regular length shifts, long weekly hours, rather sufficient rest, 4: Morning shifts, mostly regular length shifts, long weekly hours, 5: Morning shifts, mostly regular length shifts, regular weekly hours, sufficient rest, and 6: Morning shifts, mostly regular length shifts, relatively regular weekly hours, sufficient rest.

Table 2
Results of log-binomial regression for the association between cluster membership and the risk of occupational accident.

Predictor	Unadjusted		Adjusted*	
	RR	95 %CI	RR	95 %CI
Cluster 1 vs 4[#]	1.11	0.93, 1.33	1.15	0.95, 1.39
Cluster 2 vs 4[#]	**1.21**	**1.02, 1.43**	**1.21**	**1.01, 1.44**
Cluster 3 vs 4[#]	**1.31**	**1.13, 1.52**	**1.28**	**1.10, 1.50**
Cluster 5 vs 4[#]	1.04	0.91, 1.21	1.03	0.87, 1.22
Cluster 6 vs 4[#]	1.10	0.96, 1.27	1.10	0.95, 1.30
Sex (women)			1.01	0.89, 1.16
Age (per 10-year increment)			**1.11**	**1.08, 1.14**
Tuesday vs Monday			0.89	0.78, 1.01
Wednesday vs Monday			0.97	0.84, 1.11
Thursday vs Monday			0.94	0.81, 1.09
Friday vs Monday			1.05	0.91, 1.21
Saturday vs Monday			1.12	0.94, 1.33
Sunday vs Monday			0.99	0.82, 1.18

*Adjusted for sex, age and weekday at last day of the follow-up (i.e., the day of the accident or the pseudo-accident).

[#] The clusters were 1: Very late and very long shifts, very long weekly hours, insufficient rest, 2: Late and long shifts, long weekly hours, very insufficient rest, 3: Day shifts, mostly regular length shifts, long weekly hours, rather sufficient rest, 4: Morning shifts, mostly regular length shifts, long weekly hours, 5: Morning shifts, mostly regular length shifts, regular weekly hours, sufficient rest, and 6: Morning shifts, mostly regular length shifts, relatively regular weekly hours, sufficient rest.

shifts starting at latest hours, highest proportion of long shifts and long working weeks, and higher proportions of quick returns; Cluster 2 “Late and long shifts, long weekly hours, very insufficient rest” was characterized by work shifts starting later, highest proportion of quick returns, and a higher proportion of long shifts and long working weeks; and Cluster 3 “Day shifts, mostly regular length shifts, long weekly hours, rather sufficient rest” had fewer work shifts per week, slightly later starting work shifts, a higher proportion of quick returns, a slightly higher proportion of long shifts, and a lower proportion of long working weeks.

The association of the working hour patterns with occupational accidents provide support both for the role of late work shifts (i.e., evenings), and the length of working hours for the risk of occupational accidents being in line with earlier studies [6910]. The clusters 4–6 with less occupational accidents had more employees compared to cluster 1–3. Cluster 4 “Morning shifts, mostly regular length shifts, long weekly hours” included morning shifts, lower proportion of long shifts, slightly higher proportion of quick returns, and a higher proportion of long working weeks; Cluster 5 “Morning shifts, mostly regular length shifts, regular weekly hours, sufficient rest” had morning shifts, lower proportion of long shifts, quick returns, and long working weeks; and very similarly to Cluster 5, Cluster 6 “Morning shifts, mostly regular length shifts, relatively regular weekly hours, sufficient rest” with morning shifts, (slightly) lower proportion of long shifts, quick returns, and long working weeks. These clusters 4–6 point towards more regular working hours including morning shifts. This timing of work shifts in irregular working hours is in line with earlier Nordic working hour studies [1722], whereas the role for occupational accidents adds to the literature.

This is among the first studies to apply optimal matching analysis (Abbott and Tsay, 2000) for patterns of the working hours, and subsequent associations with occupational accidents. Earlier studies applying optimal matching have examined e.g., social contacts (Cornwell and Warburton, 2014), influential factors for time use (Van Tienoven et al., 2011), and work days and working weeks (Lesnard and Kan, 2011). Hence these results also add to the assumed pathway from irregular working hours in shift work to health-or safety-related consequences. Both late work shifts and long working hours (in Clusters 1–3) might contribute to the insufficient sleep (Alhainen et al., 2021), and recovery and disrupted circadian rhythms (Sallinen and Kecklund, 2010; Åkerstedt et al., 2017). Regarding recovery, we also detected quick returns and insufficient rest in the clusters hence providing support for this assumption. In Finland health care sector has a large proportion of women (Leinonen et al., 2018), whereas men might work more long working hours or night or alternatively opt-out of strenuous working conditions (Aittomäki et al., 2005). We tested the sex difference but did not detect a sex effect. Instead, age was related to the cluster membership. This might be related to the assumption that younger and older employees might respond differently to long or late (evening or night) working hours (Cai et al., 2019; Stock et al., 2019).

The method of optimal matching is among the strengths of this study as it allowed us to consider the structure of working hours by analyzing duration, sequence, and timing at once. Hence, optimal matching enabled us to identify distinct patterns of work and rest spells during the seven day period and calculate distances between the patterns (Lesnard, 2010). Furthermore, with cluster analysis we were able to capture the patterns of working hour characteristics in irregular shift work and examining the associations between these patterns and safety-related outcome i.e., occupational accidents in this study. Since we utilized register data both for working hours and accidents, our data with ten-year follow-up was free from memory, reporting or selection bias and without loss to follow-up. This study has also limitations. Since leisure-time accidents are not compensated by the Finnish Workers' Compensation Center, they were not included. It is possible that long working hours or fatigue after the work cause some accidents also during leisure-time that could modify the association of the observed working hour clusters with accidents, even not strictly "occupational" based on the Finnish legislation. Furthermore, we were not able to investigate associations between working hours patterns and different types of occupational accidents (e.g., needle sticks) which should be addressed in further studies with larger sample size. Although such studies might be possible in countries with similar data, our results might be generalizable for Nordic countries with similar working hour arrangements in public hospitals and welfare systems.

5. Conclusions

Working late and long with insufficient rest even a 7-day period might be linked with increased probability of an occupational accident among hospital employees in irregular shift work. Hence working hour arrangements in 24/7 care of hospital merit attention to regularity and sufficient rest to support safety of employees.

Data availability statement

The data that support the findings of this study are available from the hospital district but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the hospital district.

Patient consent for publication

The consent to participate was not applicable since the data comprised employer-owned employment information.

Ethics approval

This study was fully based on administrative register data that the hospital district had permitted the access. Research using such data does not need to undergo review by an ethics committee according to Finnish legislation (Medical Research Act).

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CRediT authorship contribution statement

Annina Ropponen: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Investigation, Funding acquisition, Data curation, Conceptualization. **Kia Gluschkoff:** Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation. **Jenni Ervasti:** Writing – review & editing, Funding acquisition, Conceptualization. **Mika Kivimäki:** Writing – review & editing, Funding acquisition, Conceptualization. **Aki Koskinen:** Writing – review & editing, Data curation. **Oxana Krutova:** Writing – review & editing. **Laura Peutere:** Writing – review & editing. **Marianna Virtanen:** Writing – review & editing, Funding acquisition, Conceptualization. **Mikko Härmä:** Writing – review & editing, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

Not applicable.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssci.2022.106004.

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