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Exposure to working-hour characteristics and short sickness absence in hospital workers: A case-crossover study using objective data

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ABSTRACT

Introduction: Shift work characteristics, such as the number of night shifts or quick returns, are linked to disturbed sleep and greater work-life conflict, but little is known about their association with short sickness absences. Studies utilizing objective working-hour characteristic data can provide knowledge on specific shift work characteristics that may associate with sick leave. We investigated the association between working-hour characteristics in shift work and the incidence of short (1–3 days) sickness absences.

Participants and methods: The individual-level data were collected from the employers' electronic working time records of the Finnish Public Sector study. The final analytical sample was restricted to the first incidence of short sickness absence (1–3 days) from January 1, 2008 to the end of 2015. We studied employees with shift work contracts (n = 12 156) and day work contracts (n = 6225). Of these, 89% were female workers, with a mean age of 37.1 years, and 12% worked part-time. We calculated type of shift (morning, day, evening, and night), quick returns (< 11 h between two work shifts), length of work shift and weekly working time. We utilized case-crossover study design to compare the working-hour characteristics of the 28 days preceding sickness absence (exposure window) and those of the 28 days before the exposure window (control window), using conditional logistic regression models for odds ratios with 95% Confidence Intervals (95%CI).

Results: Exposure to ≥ 2, and especially ≥ 4 consecutive night shifts associated with an increased likelihood of short sickness absence (OR 1.24, 95%CI 1.12–1.38 and OR 1.54, 95%CI 1.10–2.15, respectively) among shift workers, whereas a high number (> 25%) of evening shifts and having ≥ 2 consecutive evening shifts associated with lower odds of sickness absence. Over 40-hour weeks (OR 1.29, 95%CI 1.20–1.39), over 48-hour weeks (OR 1.24, 95%CI 1.01–1.54) and quick returns (OR 1.02, 95%CI 1.01–1.02) increased the likelihood of sickness absence. Having only a few (0–1 or 2–3) quick returns over 28 days decreased the likelihood of sickness absence (ORs 0.46 and 0.67), whereas having ≥ 5 quick returns over 28 days increased it (OR 1.88, 95%CI 1.76–1.99). These associations were similar among both shift and day workers.

Conclusions: Long working hours, several consecutive night shifts and quick returns increase the risk of short sickness absence. These working-hour characteristics should be avoided in shift scheduling to minimize sickness absence and increased costs for the employer.

What is already known about the topic?

- Working-hour characteristics such as the number of night shifts or quick returns are associated with disturbed sleep and greater work-life conflict.
- Little is known about the association between working hours and short sickness absences.

- Data on objective working-hour characteristics can add to the knowledge on the specific shift work characteristics that may associate with sick leave.

What this paper adds

- Consecutive night shifts, long weekly working hours and quick returns are associated with short sickness absences.
- Unhealthy working-hour characteristics should be paid special attention in shift scheduling to avoid sickness absence.

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- Good shift scheduling could assist in reducing increased costs for the employer due to sickness absences.

1. Introduction

Work in rotating shifts or at night is common among about 20% of employees in both Europe and the USA (Boivin and Boudreau, 2014; Eurofound, 2016). In today's society, shift work is an important part of work life for maintaining economic and social demands, and is especially prevalent in hospitals (Dall'Ora et al., 2018; Sagherian et al., 2017a), affecting female workers in particular. Many meta-analyses show that, shift work has been linked to an increased risk of several chronic diseases, such as breast cancer (Pahwa et al., 2018), type II diabetes (Gan et al., 2015), and cardiovascular disease (Kecklund and Axelsson, 2016; Wang et al., 2018), as well as obesity (Liu et al., 2018; Peplonska et al., 2015). Services and production in the 24/7 world require work in shifts during unsocial hours and this may affect workers' recovery and sleep. Insufficient sleep and recovery, and circadian disruption due to night shifts may have long-term negative effects on employees' health (Åkerstedt et al., 2017,2007). Variation in working hours may also increase work-life conflict (Karhula et al., 2018). Many of these negative effects of shift work have been studied among hospital-employed female workers (Härmä et al., 2018; Johnson et al., 2014; Karhula et al., 2018; Kunst et al., 2014; Lin et al., 2015, 2014; Vedaa et al., 2017).

Sickness absence is a well-known health indicator and is associated with psychosocial non-health aspects of work (Marmot et al., 1995). The association between shift work and sickness absence has been rarely investigated, and earlier studies have mainly compared shift and day work using survey data (Catano and Bissonnette, 2014; Niedhammer et al., 2017; Åkerstedt et al., 2017). However, recent studies have indicated that shift characteristics such as the number of night shifts or quick returns are associated with disturbed sleep and work-life conflict in shift work (Härmä et al., 2015b; Karhula et al., 2018; Vedaa et al., 2017) but also with more episodes sickness absence (van Drongelen et al., 2017). Also, long (>12 h) shifts and even fatigue in long shifts have been linked with sickness absence (Dall'Ora et al., 2018; Sagherian et al., 2017b). Hence studies utilizing more specific working-hour characteristics would be merited as studies of sickness absence and could shed light on the risks involved and the possibilities to promote shift workers' health. Furthermore, objective, payroll based data on working hours could also provide precise information exposure to various working-hour characteristics without memory bias, attrition or selection (Härmä et al., 2015b).

In Nordic countries, employees can usually take one to three sickness absence days by self-certification. These very short absences are mainly health-related, but may also represent different causes of absence than longer SAs which require medical certification. Studies have indicated that these short, self-certified SAs may reflect self-perceived health with or without underlying disease (Marmot et al., 1995). Furthermore, a short time off work could be assumed to reflect insufficient recovery due to insufficient sleep or detachment from work (Boschman et al., 2017; Marmot et al., 1995; Vedaa et al., 2017). Another factor that may influence

short sickness absence is the association with motivational issues (Janssen et al., 2003; Suadicani et al., 2014) which implies that short absences may be used as a form of self-control over working times (Ala-Mursula et al., 2002). Hence, since short SAs are known to predict longer sickness absences, and their role as a proxy for health status and as an indicator of work ability merits attention (Hultin et al., 2012; Laaksonen et al., 2013).

The aim of this study was to investigate the association between working-hour characteristics in shift work and the incidence of short (1–3 days) sickness absence among hospital employees.

2. Data and methods

2.1. Design

This study was designed to utilize the case-control design in which each participant represented a matched set of data for case and control exposures (Maclure and Mittleman, 2000, Mittleman et al., 1995). Hence, we compared the mean of the working-hour characteristics for the case windows (Fig. 1) i.e. 28 days (four weeks) immediately prior to the onset of a short sickness absence, and for the control window (four weeks, i.e. 28 days prior to beginning of case window).

2.2. Sample

We collected individual-level data from the employers' electronic working time records of five hospital districts and one division of social and health care services in a municipality participating in the Finnish Public Sector study (Härmä et al., 2015b; Kivimaki et al., 2009). Total data included 43 589 employees from January 1, 2008 to December 31, 2015. The final analytical sample was restricted to those with the first incidence of short (1–3 days) sickness absence since January 1, 2008, (n = 21 130) and existing information on work shifts during the full eight weeks before the sickness absence. Later, only those with a shift work contract, n = 12 156, or day work contract, n = 6 225 were included. Physicians were excluded from the analyses due to incomplete working time data for on-call work. Based on the preliminary analysis showing no differences between the sickness absence of full- and part-time workers, we chose to also include part-time workers (11% of day workers and 14% of shift workers) in the analyses.

2.3. Working-hour data

The payroll-based daily working-hour data concerning the beginning of 2008 to the end of 2015 were retrieved using the shift scheduling program Titania®. The scheduling program includes both the planned and actual working time data and also work unit and shift rota unit, see in detail (Härmä et al., 2015b), but in this study only actual data was utilized. The working-hour data included the starting and ending times of daily working hours and the reasons for any absences (day off, sick leave, maternity leave, annual leave, etc.). The classification of work shifts included shift types: morning shift (starting after 03:00 h and ending before 18:00 h);
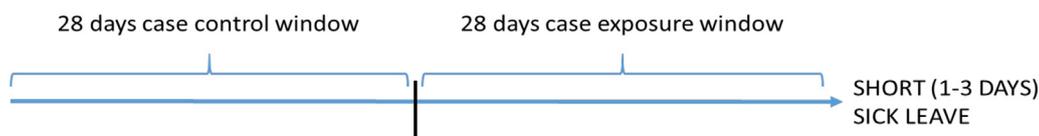

Fig. 1. Case exposure and control windows.

day shift (starting after 08:00 h and ending before 18:00 h);

evening shift (starting at any time between 18:00 and 23:00 h and not categorized as a night shift); and

night shift ($\geq$ 3 h between 23:00 and 06:00 h) as described in detail earlier (Härmä et al., 2018, 2015b).

These were further used to calculate the working-hour characteristics of three major working-hour domains:

the length of working hours, including seven variables describing weekly or daily working hours calculated for 28 days (four weeks);

time of day (shift work), including proportion of different shifts; and

shift intensity, including the consecutive work shifts and recovery time between the shifts (see in detail: (Härmä et al., 2018, 2015a,b)).

As regards length of working hours, we utilized dichotomized cut-off points based on earlier recommendations (cut-off point > 25% for > 40 h/week and for > 48 h/week) and quick returns (< 11 h, > 25% cut-point)(Härmä et al., 2015a). We also tested different thresholds for shift intensity, based on the recommendations (Härmä et al., 2015a) and thresholds utilized in earlier studies (Jensen et al., 2016a, b; Nabe-Nielsen et al., 2016). The thresholds were derived from the number of consecutive evening and night shifts and classified into two categories: $\geq$ 4 shifts, and $\geq$ 2 shifts (Table 1). In the statistical analyses, working-hour characteristics related to the length of working hours, time of day, and shift intensity (Table 1) were considered continuous variables. In contrast, the tested thresholds for working-hour characteristics, i.e. thresholds for consecutive night and evening shifts, number of quick returns, and > 25% cut-off points, were dichotomous (i.e. yes/no) variables, which means that those within the threshold limit were classified into "1" and those below the threshold "0".

2.4. Statistical analyses

Conditional logistic regression models were constructed to quantify the risk of short sickness absence onset associated with the case and control windows. Odds ratios (OR) and 95% confidence intervals (95%CI) were derived by comparing exposure in the case window to that in the control window. In this dataset, individuals' working-hour characteristics varied daily, and we selected the case and control windows solely on the basis of the first incidence of short sickness absence.

To the best of our knowledge, we found only one earlier study that provided a reference of seven days (Dall'Ora et al., 2018) for selecting exposure and control window lengths for evaluating the associations between working-hour characteristics and short sickness absence. Hence, we ran sensitivity analyses to check if the length of the windows played a significant role in the associations. First, we tested the effect of the very short exposure window by limiting the exposure window to seven days as done earlier (Dall'Ora et al., 2018) instead of the 28 days of the control window. The direction and magnitude of the main working-hour characteristics remained the same as those in the analyses, with 28 days of exposure window (data not shown). Second, we tested the effect of the length and location of the control window. Neither extending the control window to three months (90 days), 12 months, nor locating the control window in the same week a year

Table 1
Means and proportions (with 95% Confidence Intervals, CI) of working-hour characteristics in case exposure and control windows.

Working-hour characteristics	Shift work contract n = 12 156				Day work contract n = 6 225			
	Exposure window		Control window		Exposure window		Control window	
	mean	95%CI	mean	95%CI	mean	95%CI	mean	95%CI
Length of working hours								
Daily working hours (h)	8.4	8.4, 8.4	8.4	8.4, 8.5	7.8	7.8, 7.8	7.8	7.8, 7.8
Weekly working hours (h)	28.8	28.7, 29.0	28.1	27.9, 28.2	29.1	28.9, 29.3	28.3	28.1, 28.5
>40 h weeks of all working weeks	20%	20, 20	18%	18, 18	12%	11, 12	11%	10,11
>48 h weeks of all working weeks	5%	5, 6	5%	5, 5	1%	1, 1	1%	1, 1
>12 h shifts	2%	2, 2	2%	2, 2	0%	0, 0	0%	0, 0
Time of day								
Morning shifts	30%	29, 30	30%	30, 30	51%	51, 52	51%	50, 51
Day shifts	7%	7, 7	7%	7, 7	6%	6, 6	6%	6,6
Evening shifts[*]	8%	8, 9	8%	8, 8	0%	0, 1	0%	0, 1
Night shifts[*]	8%	8, 8	8%	8, 8	1%	1, 1	1%	1,1
Shift intensity								
Quick returns	30%	29, 30	28%	28, 29	28%	28, 29	27%	27, 27
Number of consecutive shifts	2	2, 2	2	2, 2	3	3, 3	2	2, 3
Thresholds								
0–1 quick returns/4 weeks	9%	9, 10	14%	14, 15	6%	5, 6	10%	10, 11
2–3 quick returns/4 weeks	23%	22, 23	29%	28, 30	32%	31, 33	38%	37, 39
4 quick returns/4 weeks	19%	18, 20	19%	18, 20	26%	25, 28	36%	35, 37
$\geq$ 5 quick returns/4 weeks	49%	48, 50	38%	37, 39	36%	35, 37	16%	15, 17
> 25% quick returns of all shift intervals	10%	10, 11	12%	11, 12	2%	1, 2	2%	2, 3
	%	95%CI	%	95%CI	%	95%CI	%	95%CI
Length of working hours								
> 25% > 40 h weeks of all work weeks	18%	18, 19	16%	15, 16	12%	11, 12	10%	9, 11
> 25% > 48 h weeks of all work weeks	2%	2, 2	2%	1, 2	0%	0, 0	0%	0, 0
Time of day								
> 25% evening shifts of all shifts	8%	7, 8	9%	8, 9	0%	0, 0	0%	0, 0
> 25% night shifts of all shifts	6%	6, 7	6%	6, 7	1%	1, 1	1%	1, 2
Shift intensity								
Number of consecutive evening shifts $\geq$ 4 shifts	0%	0, 0	0%	0, 0	0%	0, 0	0%	0, 0
Number of consecutive evening shifts $\geq$ 2 shifts[*]	6%	6, 7	6%	5, 6	0%	0, 1	1%	0, 1
Number of consecutive night shifts $\geq$ 4 shifts	1%	1, 1	1%	1, 1	0%	0, 0	0%	0, 0
Number of consecutive night shifts $\geq$ 2 shifts[*]	15%	14, 16	14%	13, 15	1%	0, 1	1%	0, 1

[*] Very few evening or night shifts were detected among workers with a day work contract. Those have also worked nights for urgent needs for staffing or for some other reasons that may relate to personal life situation or else.

before the 28 days exposure window had a major effect on the associations (data not shown). Therefore, we decided to report only the 28-day case and control windows. Third, since the working-hour data was nested within five hospital districts and one division of social and health care services in a municipality, we tested the effect of these sampling units by stratifying the analyses for them. All the results retained magnitude and direction (Appendix A, Table A1,A2). Fourth, we assumed that the job titles would play a role in the associations between working-hour characteristics and short sickness absence. Based on the 244 job titles in our data, we classified the titles into nurses, nursing assistants, and others. Then we stratified the analyses for these 3 groups of job titles and found that the results remained the same as in the analyses of all the job titles together, see appendix, Table A3.

Power calculations: The sample size was evaluated for power and with one-to-one matching, i.e. case-control design (Dupont, 1988). With alpha set at 0.01, a sample of 450 discordant pairs; 2097 pairs in total (4194 individuals) would provide a 99% probability of detecting an OR of 1.5 or greater across the plausible range of exposure prevalence in the control window (0.10). Hence our data should be large enough for reliable findings. We used Stata SE version 13.1 (StataCorp., College Station, Texas, USA) for the analyses.

2.5. Ethical consideration

The FPS Study was approved by the ethics committee of the Hospital District of Helsinki and Uusimaa, Finland (HUS; HUS 1210/2016).

3. Results

The mean age of the shift workers (n = 12 156) was 37.1 years (standard deviation [SD] 12.4) and of the day workers (n = 6 225)

42.3 years (SD 12.0). The majority of the workers in both groups were female workers: 89% in shift work and 91% in day work. The main job titles in the shift work group were nurse (44%), practical nurse (7%) and licensed practical nurse (5%), whereas the most frequent job titles among the day workers were nurse (22%), department secretary (14%) and laboratory assistant (7%).

Table 1 shows the descriptive statistics of working hour characteristics among day and shift workers during the 28-day case exposure and control windows. The exposure and control windows were comparable both in shift and day workers.

Comparison between the case exposure and control windows of 28 days indicated that the number of morning and night shifts were not directly associated with sickness absence. However, in the analyses of shift intensity, ≥ 2 consecutive night shifts, and ≥ 4 consecutive night shifts were associated with increased short sickness absence (OR 1.24, 95%CI 1.12–1.38 and OR 1.54, 95%CI1.10–2.15, respectively) among employees with shift work contracts and based on the comparison between exposure and control windows. On the other hand, a high number (> 25%) of evening shifts and having ≥ 2 consecutive evening shifts were associated with lower odds of sickness absence (Table 2).

The length of working hours and shift intensity were systematically associated with an increased risk of short sickness absence (Table 2). The associations were similar among employees with both shift and day work contracts. In particular, the tested threshold for length of working hours and shift intensity indicated that a > 25% prevalence of long (both > 40 h and > 48 h/week) working weeks and a > 25% prevalence of quick returns were associated with a higher likelihood of short sickness absence, except the latter only among shift workers. However, a closer look revealed that ≥ 5 quick returns were associated with a higher likelihood and OR 1.88 among shift workers, and OR 3.67 among day workers.

Table 2
Conditional logistic regression (odds ratios, OR, with 95% Confidence intervals, CI) for associations between working-hour characteristics (28 days exposure and 28 days control windows) and first incidence of short sickness absence.

Working-hour characteristics	Shift work contract		Day work contract	
	OR	95%CI	OR	95%CI
Length of working hours				
Daily working hours (h)	1.00	0.95, 1.05	0.96	0.85, 1.08
Weekly working hours (h)	**1.02**	**1.01, 1.02**	**1.02**	**1.01, 1.02**
> 40 h weeks of all work weeks (%)	**1.01**	**1.01, 1.01**	**1.01**	**1.00, 1.01**
> 25% > 40 h weeks of all work weeks	**1.29**	**1.20, 1.39**	**1.23**	**1.07, 1.41**
> 48 h weeks of all work weeks (%)	**1.01**	**1.00, 1.01**	**1.01**	**1.00, 1.02**
> 25% > 48 h weeks of all work weeks	**1.24**	**1.01, 1.54**	1.46	0.72, 2.96
> 12 h shifts	1.00	0.99, 1.01	0.98	0.95, 1.01
Time of day				
Morning shifts (%)	0.99	0.99, 1.00	1.00	1.00, 1.00
Day shifts (%)	1.00	0.99, 1.00	1.00	1.00, 1.01
Evening shifts (%)[*]	1.00	1.00, 1.00	1.00	0.97, 1.02
> 25% evening shifts of all shifts[*]	**0.80**	**0.71, 0.90**	1.00	0.40, 2.52
Night shifts (%)[*]	1.00	1.00, 1.01	1.00	0.99, 1.01
> 25% night shifts of all shifts[*]	0.93	0.80, 1.08	0.87	0.48, 1.58
Shift intensity				
Quick returns	**1.02**	**1.01, 1.02**	**1.05**	**1.04, 1.06**
> 25% quick returns of all shift intervals	**1.20**	**1.12, 1.28**	**0.49**	**0.36, 0.66**
0–1 quick returns/4 weeks	**0.46**	**0.42, 0.51**	**0.42**	**0.36, 0.49**
2–3 quick returns/4 weeks	**0.67**	**0.63, 0.72**	**0.71**	**0.65, 0.78**
4 quick returns/4 weeks	1.00	0.93, 1.07	**0.62**	**0.57, 0.68**
≥ 5 quick returns/4 weeks	**1.88**	**1.76, 1.99**	**3.67**	**3.30, 4.08**
Number of consecutive shifts	1.01	0.98, 1.05	**1.05**	**1.00, 1.10**
Number of consecutive evening shifts ≥ 4 shifts[*]	1.20	0.66, 2.17	2.33	0.60, 9.02
Number of consecutive evening shifts ≥ 2 shifts[*]	**1.21**	**1.07, 1.37**	0.70	0.35, 1.39
Number of consecutive night shifts ≥ 4 shifts[*]	**1.54**	**1.10, 2.15**	na	–
Number of consecutive night shifts ≥ 2 shifts[*]	**1.24**	**1.12, 1.38**	1.21	0.60, 2.46

na = not able to be assessed due to small number of employees. Significant associations are in bold.
[*] Very few evening or night shifts were detected among workers with a day work contract. Those have also worked nights for urgent needs for staffing or for some other reasons that may relate to personal life situation or else.

Based on the assumption that time spent on the job might play a role in the associations, we tested the effect of the length of working hours by adding the weekly working hours to the models. All the associations retained their magnitude and direction.

4. Discussion

This study of hospital employees at six hospital districts with 12 156 shift workers and 6 255 day workers with first incidence of short (1–3 days) sickness absence in 2008–2015 indicated that objective working-hour characteristics are associated with short sickness absence. We may have been the first to utilize case-crossover design in studying working-hour characteristics and sickness absence. In a case-crossover design, each employee with short sickness absence serves as his/her own control and each employee's exposure in a defined time interval before the short sickness absence (case window) is compared with the exposures of the same employee in a comparable interval in the past (control window). This design offers several advantages. The design with within-matched pairs controls for sex, age, socioeconomic status, job titles, or organizational characteristics, which are potential sources of confounding in case-control or cohort studies. Furthermore, as no separate comparison group of employees is needed, the chance of selection bias is controlled.

In this study, the shift schedules were mostly irregular, as shown in the varying number of consecutive shifts and occasional quick returns (< 11 h between two work shifts), see Table 2. The studied working-hour characteristics have high intra- and inter-individual variability based on an earlier study partially based on the same dataset (Härmä et al., 2015b). In this study, the working-hour characteristics showed systematic associations with short sickness absence. Short recovery time between the shifts (quick returns), having over two and especially over four consecutive night shifts and long weekly working hours were associated with a higher likelihood of short sickness absence, which is in line with our earlier studies on the association of the same working-hour characteristics with fatigue, sleep (Härmä et al., 2018) and work-life conflict (Karhula et al., 2018). Furthermore, our results agree with recent findings of female hospital workers regarding the effects on long shifts and fatigue as predictors of sickness absence (Dall'Ora et al., 2018; Sagherian et al., 2017b). The number of worked night shifts associated with only a very small increase in the likelihood of short sickness absence. This is line with a Dutch study on longer sickness absence (van Drongelen et al., 2017). The results also support earlier findings on the negative association between quick returns and sickness absence (Vedaa et al., 2017). Of interest is the finding that the associations were even stronger among employees with day work contracts, possibly because these workers were contracted for regular day work.

We were also able to test dose-response effects, i.e. the effect of the number of consecutive night and evening shifts and the number of quick returns, utilizing thresholds based on prior studies (Jensen et al., 2016a, b; Nabe-Nielsen et al., 2016). The finding that four or more consecutive night shifts associated with short sickness absence may reflect increased fatigue, sleep deprivation (Härmä et al., 2018) or higher circadian disruption (Boivin and Boudreau, 2014; Vetter et al., 2015). However, further studies are needed to confirm this association, since we may have lacked statistical power to detect significant associations due to the relatively small number of employees with many consecutive night or evening shifts. The results also showed an association between frequent quick returns ($\geq$ 5 quick returns in 28 days) and increased short sickness absence. Having only one or less quick returns in a month did not influence sickness absence. This finding is important in terms of shift scheduling in irregular shift work.

In addition to the working-hour characteristics estimated on a weekly basis (Härmä et al., 2015b), we also added weekly working hours to the model to estimate the other working-hour characteristics with short sickness absence. The associations retained their significance and magnitude, supporting the assumption of need for recovery (Boschman et al., 2017; Marmot et al., 1995; Vedaa et al., 2017), or alternatively that short absences may be used as self-control for shorter working times (Ala-Mursula et al., 2002). These findings would be useful for those working at hospitals and for those responsible for shift scheduling and nursing management. Our results show that special attention should be paid to avoiding unhealthy working-hour characteristics such as consecutive work shifts and quick returns, in order to reduce sickness absence and the related costs to the employer (Ropponen et al., 2017). In regard to SAs, employers also carry a great burden due to lost working hours and face difficulties in finding substitutes at short notice, especially if the sickness absence spells are frequent.

The strengths of this study are its large, representative sample with no loss to follow-up over eight years, its prospective study design, and the use of objective pay-roll-based registry data on working hours. Furthermore, the unique opportunity to evaluate first incidence of short (1–3 days) sickness absence was enabled by the day-to-day working hour data. The objective data also assured precise information without memory bias, attrition or selection based on exposure (Härmä et al., 2015b). Hence this kind of data provide the possibility to analyse irregular shift systems and therefore complicated and changing working-hour characteristics, adding to the existing knowledge from epidemiological studies which have mainly utilized self-reported working hours or shift types in shift work (Catano and Bissonnette, 2014; Härmä et al., 2017; Åkerstedt et al., 2017). Furthermore, in comparison to a recent study in Norway (Vedaa et al., 2017), we had the benefit of a case exposure-control design using matched-pair interval approach which provided us with a unique opportunity to investigate short sickness absence. One limitation of this study is that it was based on hospital employees with irregular shift systems, mainly female workers. Therefore, the results cannot be directly generalized to non-hospital work or male-dominated sectors. Another limitation is the number of employees with consecutive evening or night shifts. This may be due to the selected exposure and control time windows, and although we ran sensitivity analyses for various time windows, we cannot rule out the effect of selected time windows. Yet we acknowledge that despite our case-crossover design, we did not have possibility to control potential time-dependent individual variation due to changes in e.g. work tasks. However, since the control window was close to the case window, bias due to this variation is unlikely. These should be kept in mind while interpreting the results.

5. Conclusions

Working-hour characteristics associated with consecutive night shifts, long weekly working hours and quick returns are associated with short sickness absence. These unhealthy working-hour characteristics should be paid special attention in shift scheduling to avoid unnecessary sickness absence and increased costs for the employer.

Conflict of interest

None.

Contributorship statement

AR, MH and SP were responsible for the conception and design of the study, MH and AK for acquisition of data, and AR for analysis. All the authors were responsible for interpreting data, AR drafted the article, and all the authors revised it critically for important intellectual content. All the authors gave their final approval of the version to be submitted.

Appendix A

Table A1
Conditional logistic regression (odds ratios, OR, with 95% Confidence intervals, CI) for associations between working-hour characteristics (28 days exposure and 28 days control windows) **in shift work** and first incidence of short sickness absence stratified by five hospital districts and one division of social and health care services (unit 1–6) in a municipality among female hospital workers.

Working-hour characteristics	Shift work contract											
	Unit 1 (n = 4761)		Unit 2 (n = 1230)		Unit 3 (n = 928)		Unit 4 (n = 2901)		Unit 5 (n = 1413)		Unit 6 (n = 556)	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Length of working hours												
Daily working hours (h)	0.98	0.90, 1.06	0.90	0.76, 1.07	0.93	0.80, 1.09	1.07	.97, 1.18	1.09	0.95, 1.24	0.89	0.68, 1.16
Weekly working hours (h)	1.02	1.01, 1.02	1.00	0.99, 1.01	1.00	0.99, 1.02	1.02	1.01, 1.03	1.02	1.01, 1.03	1.01	1.00, 1.03
> 40 h weeks of all work weeks (%)	1.01	1.01, 1.01	1.01	0.99, 1.01	0.99	0.99, 1.00	1.01	1.01, 1.01	1.01	1.00, 1.01	1.01	1.00, 1.02
> 25% > 40 h weeks of all work weeks	1.25	1.12, 1.39	1.32	1.04, 1.68	0.86	0.57, 1.29	1.46	1.27, 1.69	1.19	0.96, 1.49	1.41	0.99, 2.02
> 48 h weeks of all work weeks (%)	1.00	1.00, 1.01	1.01	1.00, 1.02	0.99	0.98 1.01	1.01	1.00 1.01	1.01	1.00, 1.02	1.01	0.99, 1.02
> 25% > 48 h weeks of all work weeks	1.23	0.92, 1.65	1.23	0.59, 2.56	0.50	0.05, 5.51	1.15	0.75, 1.76	1.75	0.86, 3.56	1.14	0.41, 3.15
> 12 h shifts	1.01	1.00, 1.02	0.98	0.95, 1.01	0.96	0.92 1.01	1.00	0.98, 1.01	1.00	0.97, 1.03	0.97	0.93, 1.02
Time of day												
Morning shifts (%)	1.00	0.99, 1.00	0.99	0.98, 1.00	1.00	0.99, 1.00	0.99	0.98 0.99	0.99	0.98, 1.00	1.00	0.99, 1.01
Day shifts (%)	1.00	0.99, 1.01	0.99	0.98, 1.01	1.00	0.97, 1.02	1.00	0.98, 1.01	1.01	0.98, 1.04	1.01	0.97, 1.05
Evening shifts (%)	1.01	1.00, 1.02	0.98	0.97, 1.00	0.99	0.97, 1.01	0.99	0.99, 1.01	1.00	0.99, 1.02	1.00	0.97, 1.02
> 25% evening shifts of all shifts	0.98	0.80, 1.21	0.68	0.48, 0.96	0.39	0.22, 0.72	na	–	na	–	na	–
Night shifts (%)	1.01	1.00, 1.01	0.99	0.98, 1.01	0.97	0.95, 0.99	1.01	1.00, 1.01	1.00	0.98, 1.01	1.00	0.98, 1.02
> 25% night shifts of all shifts	0.86	0.68, 1.10	0.91	0.56, 1.48	0.92	0.42, 2.02	na	–	na	–	na	–
Shift intensity												
Quick returns	1.01	1.01, 1.02	1.01	1.00, 1.01	1.00	0.99, 1.01	1.01	1.01, 1.02	1.00	1.00, 1.01	1.00	0.99, 1.02
> 25% quick returns of all shift intervals	1.28	1.16, 1.42	1.02	0.83, 1.24	1.04	0.81, 1.33	1.34	1.18, 1.53	1.01	0.84, 1.23	0.93	0.67, 1.27
0–1 quick returns/4 weeks	0.39	0.30, 0.52	0.44	0.29, 0.68	0.63	0.38, 1.05	0.29	0.21, 0.40	0.33	0.20, 0.55	0.42	0.15, 1.18
2–3 quick returns/4 weeks	0.55	0.46, 0.65	0.59	0.43, 0.81	0.65	0.44, 0.95	0.60	0.49, 0.73	0.50	0.36, 0.68	0.54	0.33, 0.88
4 quick returns/4 weeks	0.68	0.57, 0.82	0.70	0.49, 0.98	0.63	0.40, 0.99	0.63	0.50, 0.80	0.75	0.53, 1.06	0.53	0.31, 0.90
≥ 5 quick returns/4 weeks	2.09	1.04, .38	2.05	1.62, 2.60	1.77	1.33 2.35	2.29	1.95, 2.68	2.31	1.80, 2.97	2.05	1.43, 2.93
Number of consecutive shifts	1.03	0.97, 1.08	0.94	0.84, 1.05	1.02	0.87, 1.19	1.03	0.96, 1.11	0.97	0.86, 1.08	1.05	0.89, 1.22
Number of consecutive evening shifts ≥ 4 shifts	1.02	0.85, 1.22	na	–	0.87	0.62, 1.22	na	–	na	–	na	–
Number of consecutive evening shifts ≥ 2 shifts	1.10	1.02, 1.19	1.16	1.01, 1.32	1.05	0.91, 1.22	na	–	na	–	na	–
Number of consecutive night shifts ≥ 4 shifts	1.07	0.99, 1.16	1.04	0.91, 1.18	0.90	0.57, 1.40	na	–	na	–	na	–
Number of consecutive night shifts ≥ 2 shifts	1.07	1.01, 1.12	1.08	0.96, 1.21	1.13	0.92 1.39	na	–	na	–	na	–

na = not able to be assessed due to small number of employees.

Table A2
Conditional logistic regression (odds ratios, OR, with 95% Confidence intervals, CI) for associations between working-hour characteristics (28 days exposure and 28 days control windows) **in day work** and first incidence of short sickness absence stratified by five hospital districts and one division of social and health care services (unit 1–6) in a municipality among female hospital workers.

Working-hour characteristics	Day work contract											
	Unit 1 (n = 3141)		Unit 2 (n = 585)		Unit 3 (n = 402)		Unit 4 (n = 1427)		Unit 5 (n = 207)		Unit 6 (n = 265)	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Length of working hours												
Daily working hours (h)	0.94	0.78, 1.12	1.04	0.77, 1.41	1.14	0.80, 1.62	0.91	0.72, 1.16	0.91	0.43, 1.93	0.76	0.36, 1.60
Weekly working hours (h)	1.02	1.01, 1.03	0.99	0.97, 1.01	1.00	0.98, 1.02	1.02	1.01, 1.03	1.02	0.99, 1.05	1.02	1.00, 1.05
> 40 h weeks of all work weeks (%)	1.00	1.00, 1.01	1.00	0.99, 1.01	1.00	0.99, 1.02	1.01	1.00, 1.01	1.01	1.00, 1.02	1.01	1.00, 1.02
> 25% > 40 h weeks of all work weeks	1.17	0.97, 1.42	0.82	0.49, 1.36	1.20	0.60, 2.38	1.51	1.15, 1.99	1.12	0.70, 1.83	1.67	0.81, 3.41
> 48 h weeks of all work weeks (%)	1.01	0.99, 1.02	0.99	0.96, 1.02	1.01	0.98, 1.03	1.01	1.00, 1.03	0.99	0.96, 1.03	1.01	0.97, 1.06
> 25% > 48 h weeks of all work weeks	2.33	0.60, 9.02	2.00	0.18, 22.06	2.00	0.57, 3.44	1.00	0.32, 3.10	1.00	0.06 15.99	1.41	0.25, 5.98
> 12 h shifts	0.97	0.93, 1.01	0.97	0.88, 1.06	0.97	0.88, 1.07	1.02	0.97, 1.07	0.94	0.82, 1.08	0.84	0.70, 1.01
Time of day												
Morning shifts (%)	1.00	1.00, 1.01	0.99	0.98, 1.00	1.00	0.98, 1.01	1.00	0.99, 1.00	1.00	0.98, 1.01	1.01	0.98, 1.04
Day shifts (%)	1.01	1.00, 1.02	0.98	0.96, 1.00	1.00	0.95, 1.05	1.00	0.99, 1.02	1.01	0.97, 1.05	1.05	1.00, 1.11
Evening shifts (%)	1.00	0.95, 1.05	0.98	0.86, 1.11	1.00	0.89, 1.12	1.00	0.97, 1.04	0.92	0.80, 1.07	1.06	0.91, 1.22
> 25% evening shifts of all shifts	1.00	0.14, 7.10	1.00	0.06, 15.99	na	–	na		na	–	na	–
Night shifts (%)	1.00	0.98, 1.02	0.98	0.93, 1.05	0.91	0.81, 1.02	1.00	0.98, 1.03	0.94	0.73, 1.20	1.09	0.90, 1.31
> 25% night shifts of all shifts	0.76	0.37, 1.57	na	–	na	–	na	–	na	–	na	–
Shift intensity												
Quick returns	1.03	1.03, 1.04	1.00	0.99, 1.02	1.01	1.00, 1.03	1.03	1.02, 1.04	1.02	0.99, 1.05	1.01	0.99, 1.04
> 25% quick returns of all shift intervals	0.56	0.50, 0.64	0.48	0.36, 0.64	0.50	0.35,0.72	0.59	0.50, 0.70	0.67	0.43, 1.05	0.58	0.39, 0.87
0–1 quick returns/4 weeks	0.32	0.21, 0.48	0.88	0.44, 1.77	0.40	0.13, 1.28	0.26	0.15, 0.46	0.13	0.02, 1.00	0.43	0.11, 1.66
2–3 quick returns/4 weeks	0.46	0.37, .57	0.43	0.25, 0.72	0.70	0.35, 1.39	0.33	0.23, 0.47	0.35	0.14, 0.90	0.46	0.22, 0.94
4 quick returns/4 weeks	0.70	0.53, 0.92	0.46	0.23, 0.91	0.54	0.33, 0.75	0.50	0.33, 0.75	0.32	0.13, 0.79	0.90	0.37, 2.21
≥ 5 quick returns/4 weeks	2.37	1.98, 2.83	2.05	1.41, 2.98	1.95	1.12, 3.39	3.32	2.52, 4.37	3.82	1.97, 7.42	2.06	1.15, 3.67
Number of consecutive shifts	1.08	1.01, 1.16	0.88	0.76, 1.02	0.96	0.79, 1.18	1.06	0.96, 1.16	0.99	0.76 1.27	1.17	0.94, 1.46
Number of consecutive evening shifts ≥ 4 shifts	1.00	0.68, 1.48	na	–	na	–	na	–	na	–	na	–
Number of consecutive evening shifts ≥ 2 shifts	1.21	0.80, 1.81	na	–	na	–	na	–	na	–	na	–
Number of consecutive night shifts ≥ 4 shifts	0.95	0.68, 1.31	na	–	na	–	na	–	na	–	na	–
Number of consecutive night shifts ≥ 2 shifts	1.00	0.76, 1.32	na	–	na	–	na	–	na	–	na	–

na = not able to be assessed due to small number of employees.

Table A3
Conditional logistic regression (odds ratios, OR, with 95% Confidence intervals, CI) for associations between working-hour characteristics (28 days exposure and 28 days control windows) and first incidence of short sickness absence stratified **by main groups of job titles** among female hospital workers.

Working-hour characteristics	Shift work contract						Day work contract					
	Nurses (n = 6741)		Nursing assistants (n = 2827)		Others (n = 2588)		Nurses (n = 2055)		Nursing assistants (n = 527)		Others (n = 3643)	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Length of working hours												
Daily working hours (h)	1.02	0.96, 1.09	0.97	0.87, 1.08	0.96	0.86, 1.08	0.93	0.78, 1.10	1.01	0.62, 1.63	0.98	0.82, 1.17
Weekly working hours (h)	1.01	1.01, 1.02	1.02	1.01, 1.03	1.02	1.01, 1.03	1.01	1.01, 1.02	1.01	0.99, 1.03	1.02	1.01, 1.02
> 40 h weeks of all work weeks (%)	1.01	1.00, 1.01	1.01	1.01, 1.01	1.01	1.00, 1.01	1.01	1.00, 1.01	1.01	1.00, 1.02	1.00	1.00, 1.01
> 25% > 40 h weeks of all work weeks	1.28	1.16, 1.40	1.45	1.22, 1.71	1.20	1.01, 1.42	1.27	1.04, 1.55	2.00	0.97, 4.12	1.15	0.94, 1.40
> 48 h weeks of all work weeks (%)	1.00	1.00, 1.01	1.01	1.00, 1.02	1.00	1.00, 1.01	1.00	0.99, 1.02	1.02	0.98, 1.06	1.01	1.00, 1.02
> 25% > 48 h weeks of all work weeks	1.08	0.83, 1.40	1.72	0.96, 3.08	1.57	0.98, 2.52	0.75	0.26, 2.16	2.02	0.78, 3.12	2.60	0.93, 7.29
> 12 h shifts	1.00	0.99, 1.01	0.99	0.97, 1.01	0.99	0.97, 1.02	1.00	0.97, 1.04	0.95	0.86, 1.06	0.95	0.91, 0.99
Time of day												
Morning shifts (%)	0.99	0.99, 1.00	0.99	0.99, 1.00	1.00	0.99, 1.00	1.00	1.00, 1.01	1.00	0.98, 1.01	1.00	1.00, 1.00
Day shifts (%)	0.99	0.99, 1.00	1.00	0.99, 1.01	1.00	0.99, 1.01	1.00	0.99, 1.02	0.99	0.97, 1.00	1.01	1.00, 1.02
Evening shifts (%)	1.00	0.99, 1.01	1.00	0.99, 1.01	1.00	0.99, 1.01	1.02	0.98, 1.06	1.09	0.96, 1.24	0.95	0.92, 1.00
> 25% evening shifts of all shifts	0.87	0.76, 1.00	0.69	0.51, 0.93	0.62	0.45, 0.86	1.25	0.34, 4.65	–	na	0.40	0.08, 2.06
Night shifts (%)	1.00	1.00, 1.01	1.00	0.99, 1.01	0.99	0.98, 1.01	0.97	0.94, 1.01	1.01	0.99, 1.03	1.00	0.97, 1.04
> 25% night shifts of all shifts	1.05	0.88, 1.27	0.75	0.53, 1.08	0.72	0.50, 1.02	0.50	0.09, 2.73	0.80	0.37, 1.71	1.50	0.42, 5.31
Shift intensity												
Quick returns	1.01	1.01, 1.01	1.01	1.00, 1.02	1.02	1.01, 1.02	1.02	1.00, 1.04	1.02	1.01, 1.03	1.03	1.02, 1.04
> 25% quick returns of all shift intervals	1.21	1.12, 1.32	1.23	1.06, 1.41	1.12	0.97, 1.29	0.57	0.49, 0.67	0.55	0.40, 0.75	0.56	0.50, 0.63
0–1 quick returns/4 weeks	0.41	0.33, 0.50	0.32	0.22, 0.47	0.36	0.25, 0.53	0.33	0.20, 0.55	0.25	0.10, 0.61	0.38	0.27, 0.54
2–3 quick returns/4 weeks	0.62	0.55, 0.71	0.55	0.44, 0.69	0.43	0.34, 0.56	0.54	0.41, 0.72	0.61	0.38, 0.97	0.34	0.27, 0.43
4 quick returns/4 weeks	0.68	0.58, 0.78	0.67	0.52, 0.87	0.61	0.46, 0.81	0.55	0.39, 0.79	0.69	0.40, 1.18	0.59	0.46, 0.77
≥ 5 quick returns/4 weeks	2.04	1.83, 2.26	2.12	1.79, 2.51	2.42	2.01, 2.91	2.40	1.59, 3.59	2.19	1.76, 2.73	2.79	2.35, 3.31
Number of consecutive shifts	1.01	0.96, 1.06	1.03	0.95, 1.11	1.03	0.95, 1.11	1.07	0.98, 1.16	0.99	0.82, 1.19	1.04	0.98, 1.11
Number of consecutive evening shifts ≥ 4 shifts	1.63	0.67, 3.92	0.50	0.09, 2.73	1.13	0.43, 2.92	4.00	0.45, 35.79	1.00	0.06, 15.99	2.00	0.18, 22.06
Number of consecutive evening shifts ≥ 2 shifts	1.20	1.02, 1.41	1.01	0.78, 1.31	1.60	1.16, 2.21	0.78	0.29, 2.09	2.00	0.18, 22.06	0.50	0.17, 1.46
Number of consecutive night shifts ≥ 4 shifts	1.59	1.07, 2.37	1.56	0.67, 3.59	1.25	0.49, 3.17	–	na	–	na	–	na
Number of consecutive night shifts ≥ 2 shifts	1.29	1.14, 1.44	1.10	0.83, 1.47	1.14	0.81, 1.60	0.82	0.34, 1.97	–	na	2.67	0.71, 10.05

na = not able to be assessed due to small number of employees.

Acknowledgements

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