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Original Article

Employees with shift work disorder experience excessive sleepiness also on non-work days: a cross-sectional survey linked to working hours register in Finnish hospitals

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Abstract: A considerable proportion of shift workers have work schedule-related insomnia and/or excessive sleepiness, a phenomenon described as shift work disorder (SWD). There is yet a lack of evidence on whether or not employees recover from symptoms of SWD between work shifts. We studied whether SWD and its subtypes are associated with insomnia and excessive sleepiness during weekly non-work days and with 24-h sleep time. Hospital employees answered a survey on SWD, insomnia and excessive sleepiness on weekly non-work days, and 24-h sleep. To identify shift workers with night shifts (n=2,900, 18% with SWD) and SWD, we linked survey responses to employers' register on working hours. SWD included three subtypes: insomnia only (SWD-I, 4%, n=102), excessive sleepiness only (SWD-Es, 8%, n=244), and both insomnia and excessive sleepiness (SWD-IEs, 6%, n=183). Based on regression analyses, SWD was associated with excessive sleepiness on non-work days (OR: 1.42, 95% CI: 1.07–1.88) and with insomnia on non-work days (0.53, 0.31–0.91). SWD-I was associated with excessive sleepiness on non-work days (2.25, 1.31–3.87) and with shorter sleep (7–7.5 h: 1.96, 1.06–3.63; ≤6.5h: 2.39, 1.24–4.59; reference: ≥8 h). The results suggest that especially employees with SWD-I may need longer time to overcome excessive sleepiness than allowed by their roster.

Key words: Circadian rhythm sleep-wake disorder, Epidemiology, Health care, Insomnia, International Classification of Sleep Disorders, Nurses, Registry, Shift work sleep disorder

Introduction

Non-work days support employees' health by enhancing recovery from work. Employees generally sleep more and better on non-work days than on workdays[1)]. Successful recovery on non-work days is particularly important in shift workers, since they often lack opportunities to recover[2)] due to work shifts that hinder sleep[3)]. We recently discovered that shift work may induce long sleep, an indication of increased need for recovery[4)]. In addition to compensatory sleep, increased need for recovery from shift work manifests as sleepiness and fatigue[5, 6)], and these can spill over to non-work days. Typically, one night's recovery sleep reduces sleepiness, and most indi-

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viduals recover in two nights[7, 8]. However, depending on the severity and chronicity of sleep loss, recovery can take up to seven nights[7, 9].

We have recently found that up to 18% of hospital employees whose work include night shifts find shift working hours difficult and develop shift work disorder (SWD)[10]. SWD is characterized by shift work-related insomnia and/or excessive sleepiness based on the second edition of the International Classification of Sleep Disorders (ICSD-2) criteria[11], and it is referred to as circadian rhythm sleep-wake disorder (shift work type) in the 11th revision of the International Classification of Diseases (ICD-11)[12]. SWD can be classified into three subtypes based on the manifestation of its shift-related primary symptoms; insomnia only (SWD-I), excessive sleepiness only (SWD-Es), and both insomnia and excessive sleepiness (SWD-IEs)[13]. However, prevalence of the SWD-I or SWD-Es has not been explored to the best of our knowledge.

In line with the criteria, previous studies have found that employees with SWD fall asleep slower[13, 14], have more sleep problems[15], and show greater sleepiness[14, 16] and excessive sleepiness[16] than shift workers without SWD in connection to several shift types. SWD has been associated with decreased sleep quality[14, 15, 17, 18] and sleep efficiency[13, 14]. In addition, shift workers with SWD appear to sleep less than shift workers without SWD in relation to different work shifts[14, 16, 17]. This is consistent with the ICD-11 criteria mentioning that sleep typically reduces in SWD, and also with the ICSD-3 criteria[19] stating that reduction of sleep must supplement the primary symptoms of SWD (that is insomnia and/or excessive sleepiness).

SWD's primary symptoms likely reduce after a longer recovery period, such as a holiday[14, 15]. Little attention has been paid to weekly recovery in SWD, although shift workers often have increased sleepiness on non-work days[9] and SWD is commonly defined via absence of its symptoms on non-work days[20, 21]. Our findings in a field setting among 31 ground staff members of an airport-suggest that SWD could be associated with decreased ability to recover during non-work days[14]. However, it is not known whether hospital employees with different subtypes of SWD recover from insomnia and sleepiness between work shifts and whether the different subtypes are associated with shorter daily sleep time.

Therefore, we used a large sample of hospital employees from the Finnish Public Sector study to examine whether or not non-work days mitigate the symptoms of insomnia or excessive sleepiness in SWD. We used objective registry data on working hours, and survey data on symptoms of SWD. We had two main hypotheses. Firstly, that SWD is not associated with frequent insomnia on non-work days, since based on the criteria of SWD, insomnia should stem from shifts which are absent on non-work days. Secondly, we hypothesised that SWD is positively associated with frequent excessive sleepiness on non-work days, since shift work induces sleepiness on leisure time[9] and SWD has been related to limited compensatory sleep during non-work days[14]. We also wanted to characterise sleep time in the subtypes of SWD, since SWD is associated with reduced total sleep time based on diagnostic coding manuals.

Subjects and Methods

Study design

Using a cross-sectional design, 11,274 hospital employees answered the Finnish Public Sector survey (response rate 69%). The survey was linked to a registry of objective working hours based on a payroll shift scheduling software Titania®, CGI Finland[22]. The ethics committee of the Hospital District of Helsinki and Uusimaa approved the current study as part of the Finnish Public Sector study (HUS 1210/2016). The study followed the requirements of the Helsinki Declaration.

Participants

The study included those employees who based on the registry data of working hours had worked on at least 31 d during the 91 d preceding the survey in 2015 (n=9,246) (Fig. 1). We excluded all physicians because of missing data for on call duty (n=609). To focus on fluctuating circadian disturbance, we excluded permanent day workers (n=3,207), shift workers without night shifts (n=2,227), and permanent night workers (n=106), since they had less than three types of shifts. We excluded employees who did not answer the questions that were used to define SWD cases (n=171), and employees who had less than three non-day shifts (work outside 06:00–18:00 h) per month (n=26)[10]. The final sample included 2,900 shift workers who had at least three non-day shifts per month including at least one night shift (at least three h of work during 23:00–06:00) per month in accordance with our recent result on a minimum cut-off for the occurrence of SWD symptoms[10].

SWD, insomnia, and excessive sleepiness

SWD was defined using shift and free time-specific questions on insomnia and excessive sleepiness (Table 1)[10]. Shift workers who reported at least one pri-

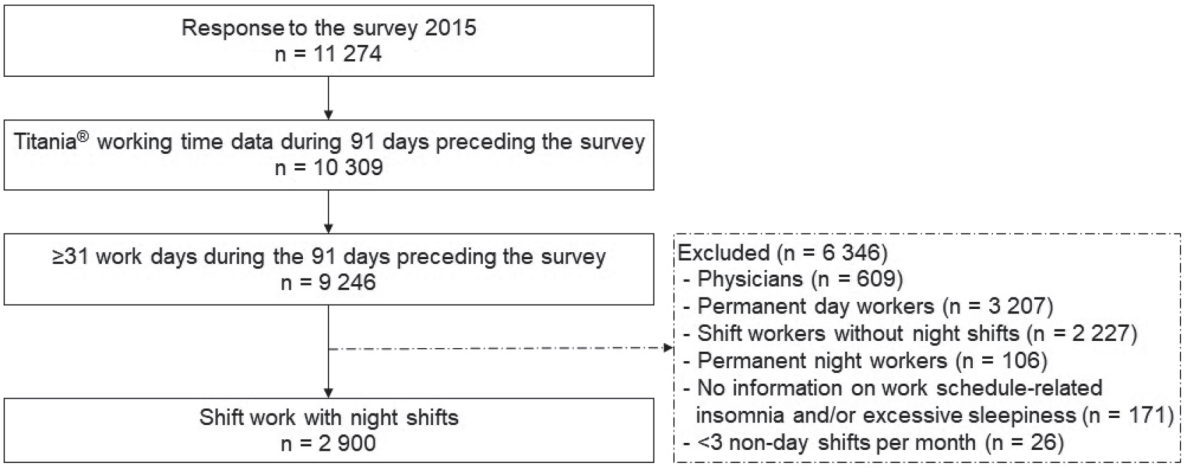

Fig. 1. Description of the sample.

Table 1. Shift and free time-specific questions on insomnia and excessive sleepiness

	Never	Rarely	Sometimes	Often	Always	Not applicable
1. How often during the last three months have you experienced insomnia? By insomnia we mean difficulties in initiating sleep, recurrent awakenings during sleep period, or difficulties in staying asleep.						
In connection to morning shifts	( )	( )	( )	( )	( )	( )
In connection to evening shifts	( )	( )	( )	( )	( )	( )
In connection to night shifts	( )	( )	( )	( )	( )	( )
On weekly non-work days	( )	( )	( )	( )	( )	-
While on holiday over two weeks	( )	( )	( )	( )	( )	-
2. How often during the last three months have you experienced excessive sleepiness?						
During morning shifts	( )	( )	( )	( )	( )	( )
During evening shifts	( )	( )	( )	( )	( )	( )
During night shifts	( )	( )	( )	( )	( )	( )
On weekly non-work days	( )	( )	( )	( )	( )	-
While on holiday over two weeks	( )	( )	( )	( )	( )	-

mary symptom of SWD (insomnia and/or excessive sleepiness) 'never' or 'rarely' in relation to over two weeks on holiday and reported the same symptom 'often' or 'always' in connection to morning, evening, and/or night shift (i.e. SWD-related shifts) were potential SWD cases. All potential SWD cases whose payroll registry data included at least three SWD-related shifts per month were assigned as having SWD (18.2%, n=529)[10] consistent with the ICSD-2 and the ICD-11 criteria. Of the 529 unclassified SWD cases, 19.3% (n=102) had SWD-I, 46.1% (n=244) had SWD-Es, and 34.6% (n=183) had SWD-IEs.

Insomnia on non-work days and excessive sleepiness on non-work days were rated using the weekly non-work day-specific sub-questions in Table 1. The answers were dichotomized to 'no' (never, rarely, or sometimes) and 'yes' (often or always).

Other variables

Employees responded to items on living with at least one child (0–18 yr, yes/no)[23, 24] and shift work experience (yr)[25]. Employees rated their chronotype based on the single question from the Morningness-Eveningness Questionnaire by Horne and Östberg (1976)[26] as follows: 'There are so-called "morning types of people" (morning spry, evening sleepy) and "evening types of people" (morning sleepy, evening spry). Which group do you belong to (definitely a morning type, more a morning than evening type, more an evening than morning type, definitely an evening type)?' The answers were dichotomized to morning/evening type[10]. Employees also answered the questions 'Has a physician ever told you that you have/you have had a sleep apnoea (yes/no), restless legs syndrome (yes/no), or depression (yes/no)?'[10, 23] and 'How many hours

do you normally sleep during 24 h'[23] (from 5 h or less to 10 h or more in 30-min intervals)? The latter, 24-h sleep time, was classified into 6.5 h or less, 7–7.5 h, and 8 h or more. Age (yr) and sex (man/woman) were obtained from employers' register as part of the survey study. Job titles were obtained from the payroll registry.

Statistical analyses

We used IBM SPSS Statistics 25.0 (Armonk, NY, USA) for the statistical analyses. To look at the recovery during typical non-work days and ability to sleep, we conducted crude and adjusted logistic regression analyses, using insomnia on non-work days, excessive sleepiness on non-work days, and 24-h sleep time (8 h or more as reference class) as dependent variables. In crude analyses, we used unclassified SWD (all subtypes of SWD together versus non-SWD), SWD-I (versus non-SWD), SWD-Es (versus non-SWD), and SWD-IEs (versus non-SWD) as predictor variables in separate analyses. In adjusted analyses, we included also age, sex, living with children, sleep apnoea, restless legs syndrome, and depression in the statistical models.

Table 2. Characteristics of the study population

	Mean	(SD)
Age, yr (n=2,900)	40.5	(11.3)
Shift work experience, yr (n=2,867)	13.5	(9.9)
	%	(n)
Sex		
Women	88.8	(2,575)
Men	11.2	(325)
Chronotype		
Evening type	65.9	(1,900)
Morning type	34.1	(981)
Living with children (0–18 yr)		
Yes	46.5	(1,213)
No	53.5	(1,397)
Sleep apnoea		
Yes	1.1	(31)
No	98.9	(2,775)
Restless legs syndrome		
Yes	3.1	(86)
No	96.9	(2,720)
Depression		
Yes	8.8	(247)
No	91.2	(2,559)

Results

The study population's (mean age 40.5 yr, SD 11.3 yr; 88.8% women; 94.8% healthcare professionals) most common job titles were registered nurse (63.0%, n=1,826), practical nurse (13.1%, n=381), midwife (6.2%, n=179), and psychiatric nurse (4.0%, n=116). Table 2 presents the characteristics of the study population. Table 3 presents their working hour characteristics according to Härmä *et al*[22].

Based on our criteria for SWD, 3.5% (n=102) of the hospital shift workers had SWD-I, 8.4% (n=244) had SWD-Es, and 6.3% (n=183) had SWD-IEs. Table 4 shows that 3.2% (n=17) of shift workers with SWD, and 6.5% (n=154) of shift workers without SWD reported insomnia on non-work days, and 15.5% (n=82) and 11.9% (n=281), respectively, reported excessive sleepiness on non-work days. Further, 26.5% (n=140) of shift workers with SWD, and 26.0% (n=616) of shift workers without SWD reported sleeping 6.5 h or less per day; 44.4% (n=235) and 44.1% (n=1,045), respectively, reported sleeping 7–7.5 h per day; and 28.9% (n=153) and 29.2% (n=692), respectively, reported sleeping 8 h or more per day. In addition, Table 4 presents prevalence rates of insomnia and excessive sleepiness on non-work days and 24-h sleep time among the three subtypes of SWD in the current sample.

Results of logistic regression analyses (Table 5) show that SWD was negatively associated with the risk of insomnia on non-work days (OR 0.53, 95% CI 0.31–0.91), positively associated with the risk of excessive sleepiness on non-work days (OR 1.42, 95% CI 1.07–1.88), and was not associated with 24-h sleep time in adjusted analyses. When investigating the risks induced by different subtypes of SWD (Table 6), no significant associations were found between the subtypes and insomnia on non-work days. SWD-I was significantly associated with increased risk of excessive sleepiness on non-work days (OR 2.25, 95% CI 1.31–3.87) in adjusted analysis. In addition, SWD-I was significantly associated with 24-h sleep of 7–7.5 h (OR 1.96, 95% CI 1.06–3.63) and 6.5 h or less (OR 2.39, 95% CI 1.24–4.59) compared to 24-h sleep of 8 h or more in adjusted analyses. SWD-Es and SWD-IEs were not significantly associated with excessive sleepiness on non-work days or 24-h sleep time in any of the analyses.

Discussion

Prior to the current study among Finnish hospital shift workers, recovery from excessive sleepiness on weekly non-work days has not been studied in SWD, although shift work typically increases need for recovery[2, 9]. In this study, we found that SWD was associated with exces-

Table 3. Characteristics of working hours during the past 91 d preceding the survey

	Mean	(SD)
Number of workdays	41.0	(7.6)
Time of the day		
Morning shifts of all shifts (%)	38	(16)
Day shifts (between 08:00 and 18:00 h) of all shifts (%)	2	(4)
Evening shifts of all shifts (%)	34	(12)
Night shifts of all shifts (%)	26	(15)
Non-day (evening and night) shifts of all shifts (%)	60	(17)
Length of working hours		
Length of work shifts (h)	8.9	(0.8)
≥12-h shifts of all shifts (%)	8	(17)
Length of night shifts (h)	10.6	(0.8)
Weekly working hours (h)	35.4	(3.4)
>40-h working weeks of all working weeks (%)	30	(15)
>48-h working weeks of all working weeks (%)	6	(9)
Shift intensity		
Number of consecutive shifts	3.8	(0.6)
Number of consecutive night shifts	3.3	(0.7)
Quick returns (<11-h) of all <48-h shift intervals (%)	18	(11)
<28-h recovery periods after the last night shift [a] (%)	4	(11)
Social aspects of working hours		
Weekend (Sat and/or Sun) work of all weekends (%)	46	(15)
Single non-work days of all non-work periods (%)	20	(11)

[a]Of all recovery periods after the last night shift. SD: standard deviation.

Table 4. Insomnia and excessive sleepiness on non-work days and 24-h sleep time among those without SWD and those with SWD, also including subtypes of SWD

	Non-SWD (n=2,371)		SWD							
			Any (all subtypes) (n=529)		SWD-I (n=102)		SWD-Es (n=244)		SWD-IEs (n=183)	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Insomnia on non-work days	6.5	(154)	3.2	(17)	2.9	(3)	3.7	(9)	2.8	(5)
Excessive sleepiness on non-work days	11.9	(281)	15.5	(82)	20.6	(21)	13.6	(33)	15.3	(28)
24-h sleep time, h										
6.5 or less	26	(616)	26.5	(140)	36.3	(37)	21.3	(52)	27.9	(51)
7–7.5	44.1	(1,045)	44.4	(235)	46.1	(47)	44.7	(109)	43.2	(79)
8 or more	29.2	(692)	28.9	(153)	17.6	(18)	34	(83)	28.4	(52)

SWD: shift work disorder; -I: only symptoms of insomnia; -Es: only symptoms of excessive sleepiness; -IEs: symptoms of insomnia and excessive sleepiness.

sive sleepiness on weekly non-work days, but not with insomnia on non-work days. This is also the first study to explore the three main subtypes of SWD in an epidemiological study design. We found that SWD-I, that was characterised by insomnia only, was associated with excessive sleepiness on weekly non-work days and with shorter 24-h sleep time, indicating poor recovery in this group.

We estimated the prevalence of SWD subtypes among hospital shift workers of the current sample. Previous research has found slightly greater 9–15% prevalence of SWD-IEs in occupations with male majority[21, 27] than the current study (6%) with female majority. In addition to SWD, prevalence of general level insomnia and daytime sleepiness, not specifically relating to shifts, has been explored: Compared to the current study, Drake *et al.*[28] found greater prevalence rates of insomnia without sleepi-

Table 5. Crude and adjusted logistic regression analyses with insomnia and excessive sleepiness on non-work days and 24-h sleep time as dependent variables

	Crude								Adjusted[a]							
	Insomnia on non-work days		Excessive sleepiness on non-work days		24-h sleep time (reference: 8 h or more)				Insomnia on non-work days		Excessive sleepiness on non-work days		24-h sleep time (reference: 8 h or more)			
					7–7.5 h		6.5 h or less						7–7.5 h		6.5 h or less	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
SWD	0.48	0.29, 0.80	1.36	1.04, 1.77	1.02	0.81, 1.24	1.03	0.80, 1.33	0.53	0.31, 0.91	1.42	1.07, 1.88	1.06	0.84, 1.35	1.06	0.81, 1.40

SWD: shift work disorder; OR: odds ratio; CI: confidence interval.

[a]Adjusted for age, sex, living with children, sleep apnoea, restless legs syndrome, and depression.

Table 6. Crude and adjusted logistic regression analyses with insomnia and excessive sleepiness on non-work days and 24-h sleep time as dependent variables

	Crude								Adjusted[a]							
	Insomnia on non-work days		Excessive sleepiness on non-work days		24-h sleep time (reference: 8 h or more)				Insomnia on non-work days		Excessive sleepiness on non-work days		24-h sleep time (reference: 8 h or more)			
					7–7.5 h		6.5 h or less						7–7.5 h		6.5 h or less	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
SWD-I	0.43	0.14, 1.38	1.94	1.17, 3.14	1.73	0.10, 3.00	2.31	1.30, 4.10	0.54	0.17, 1.75	2.25	1.31, 3.87	1.96	1.06, 3.63	2.39	1.24, 4.59
SWD-Es	0.55	0.28, 1.09	1.16	0.79, 1.71	0.87	0.64, 1.18	0.7	0.49, 1.01	0.6	0.29, 1.26	1.16	0.77, 1.76	0.92	0.67, 1.27	0.79	0.53, 1.17
SWD-IEs	0.41	0.17, 1.00	1.33	0.88, 2.03	1.01	0.70, 1.45	1.1	0.74, 1.65	0.44	0.18, 1.10	1.39	0.89, 2.16	1	0.69, 1.46	1.06	0.70, 1.63

SWD: shift work disorder; -I: only symptoms of insomnia; -Es: only symptoms of excessive sleepiness; -IEs: symptoms of insomnia and excessive sleepiness; OR: odds ratio; CI: confidence interval.

[a]Adjusted for age, sex, living with children, sleep apnoea, restless legs syndrome, and depression.

ness (10%) and sleepiness without insomnia (16%), and similar prevalence of both insomnia and sleepiness (6%) in rotating shift workers. Our findings add to the literature by showing the prevalence of the three different subtypes of SWD in hospital shift workers of the current sample, also SWD-I and SWD-Es.

Contrary to our first hypothesis, SWD that was not categorised into subtypes was associated with insomnia on non-work days, and the association was negative. The finding implies that the used SWD criteria has the capacity to separate SWD-related insomnia from other types of insomnia, as intended. When investigating the separate SWD subtypes, SWD was no longer significantly associated with insomnia on non-work days in the current study. This is in line with field studies in which employees have reported similar amounts of awakenings during sleep period on non-work days regardless of their SWD status[13, 14]. Although SWD has been associated with poorer capacity to sleep[13, 14], only SWD-I has been associated with pathologically significant sleep latency on weekly non-work days[13]. Gumenyuk *et al.*[13] concluded that SWD-I is potentially a work schedule induced primary insomnia syndrome. However, their findings also reflected the applied inclusion criteria that accepted insomnia on non-work days as an SWD criterion, while our criteria qualified as SWD cases only those whose shift-related symptoms did not occur on over two weeks holiday. The current results imply that insomnia rarely affects recovery during non-work days in SWD.

Supporting our second hypothesis, SWD was associated positively with excessive sleepiness on non-work days on a general level, but not among those whose SWD was characterised by excessive sleepiness (SWD-Es and SWD-IEs). Thus, it seems, that non-work days could mitigate shift work-related symptoms of excessive sleepiness among the latter. Similarly as SWD-Es and SWD-IEs cases (with shift-related excessive sleepiness), also many SWD-I cases (with shift-related insomnia) were likely to have excessive sleepiness on workdays. However, their excessive sleepiness resulted probably from other conditions than shift working hours, since it did not decrease on a longer recovery period. This can partially explain why SWD-I seemed to leave many shift workers excessively sleepy on weekly non-work days. Previous research has pointed daytime sleepiness on a general level as a predictor of SWD[29]. The current study adds to the literature by

indicating signs of recovery on non-work days in SWD-Es and SWD-IEs, and uncomplete recovery on non-work days in SWD-I particularly relating to excessive sleepiness.

We have recently shown that non-day shifts are associated with increased fatigue on non-work days and long 24-h sleep[30], which probably enhances recovery from shift work. In addition, short 24-h sleep has been associated with SWD[31], indicating poorer ability to recover from work shifts. While many shift types are associated with shorter sleep in SWD[14, 16, 17], the reduction of sleep does not necessarily take place on non-work period[13, 15], although one study has found reduced night-time sleep on weekend among those with SWD[17]. Instead of evaluating 24-h sleep time, e.g., during non-work days, weekends, or workdays in the current study, the participants evaluated the amount of sleep that they normally got during 24 h: We found no associations between SWD and 24-h sleep time; however, SWD-I was associated with shorter 24-h sleep time. This implies that those whose SWD relates specifically to insomnia, may lack healthy compensatory responses that shift workers typically show; for example, due to less flexible sleeping habits[14, 32]. In contrast to our finding, Gumenyuk *et al.*[13] did not find a difference in sleep time on non-work days when comparing those with and without SWD-I. However, the current finding is in line with our recent observational field study showing limited compensatory sleep during non-work days among those with SWD[14]. The current findings imply that hospital employees' typical sleep time is not enough to compensate shift work-related lack of sleep, and to overcome excessive sleepiness among those with SWD-I.

Although shift work has been associated with reduced sleep quality even in retirement[33] and some bodily functions, such as circadian rhythm[34], can recover slowly, work shift-related insomnia and sleepiness have shown to reduce faster[9, 35]. Studies by Åkerstedt *et al.*[9] have indicated that sleepiness reduces to normal levels during two to four non-work days, at the latest, after typical shift work. Although recovery can include many psychological or physiological components, for the purpose of the current study, we concentrated on aspects of recovery that are central to SWD, that is, insomnia, excessive sleepiness, and sleep. It is important to differentiate between symptoms specifically related to shift work (SWD) and symptoms due to other conditions[19, 28, 36]. Our definition of SWD is in line with the ICSD criteria[11, 19] requiring that SWD symptoms should be associated with working hours that overlap the habitual sleep time. Our definition likely reduced misclassification of the participants as having SWD due to conditions with persistent insomnia or sleepiness.

The current study has strengths, including the investigation of all three main subtypes of SWD for the first time and studying aspects of the little examined recovery profile of SWD in an epidemiological setting. Another strength is the use of objective data for example to verify sufficient exposure to shift work (at least three non-day shifts per month) and occurrence of symptoms of SWD (at least three days with SWD symptoms per month) when defining the study population and SWD cases, respectively[10]. We chose to use the ICSD-2 criteria of SWD, that do not require reduced sleep time; Firstly, since the latest ICD criteria mention—but do not require—reduction of sleep time in its definition of SWD. Secondly, to be able to explore how the different subtypes of SWD are associated with 24-h sleep time.

The study also has limitations. SWD was not classified by a clinical interview that could have verified our classification of SWD. We used one set of questions to define SWD, insomnia on weekly non-work days, and excessive sleepiness on weekly non-work days. Using one questionnaire enabled the participants to evaluate insomnia and excessive sleepiness on a shorter recovery period and on a longer recovery period (that was used to define SWD) without confusing the two. Further, the current study included some single-item measures. Although validated questionnaires on chronotype[26, 37] and register data on diagnosed disorders[38] would be more optimal, previous research indicates that the single-item scales on chronotype[37] and diagnosed disorders[38] can be usable. The current study design was cross-sectional and we could not examine causal interactions. We included employees with disorders such as sleep apnoea, restless legs syndrome, and depression that may induce insomnia or excessive sleepiness or may affect sleep, but we considered these in our adjusted analyses. However, one should also bear in mind that sleep disorders, and for example depression, can occur simultaneously[39, 40]. The statistical power may be limited—and thus the probability of making type II errors may be increased—in analyses regarding SWD subtypes. Caution should also be used when generalizing the results to populations with male majority or other vocational branches.

To conclude, hospital employees with SWD seemed not to have recovered from excessive sleepiness on non-work days as often as those without SWD on a general level. SWD-I was associated with shorter 24-h sleep time. Thus, sleep on non-work days seems not to be enough to

compensate the non-day shift-related lack of sleep, and to overcome excessive sleepiness among shift workers with SWD-I. Non-work days give shift workers possibility to rest when they want. However, the current study shows, that especially those with SWD-I seem not to recover as well as those with the other SWD subtypes. Thus, employees with SWD-I could benefit from longer recovery periods than allowed by their rosters. It has been suggested that SWD is associated with errors in patient care[41], which emphasises significance of finding ways to alleviate the symptoms of the disorder. Frequent night shifts and quick returns, extended night shifts, and missing of nap opportunities in night shifts have been associated with SWD. Influencing on these has been suggested as an approach to manage SWD[41]. Future studies could explore whether ergonomic or individualised shift scheduling could enhance recovery of employees with SWD-I.

Conflict of Interest

None.

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