

ORIGINAL ARTICLE

Shift-related sleep problems vary according to work schedule

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Received 1 August 2012

Revised 8 November 2012

Accepted 24 November 2012

Published Online First

23 January 2013

ABSTRACT

Objectives Shift-related sleep and sleepiness problems may be due to characteristics of both shifts (ie, day, evening and night shifts) and work schedules (ie, permanent vs rotational schedules). The Bergen Shift Work Sleep Questionnaire (BSWSQ) was used to investigate associations between shift-related sleep problems and work schedules.

Methods 1586 nurses completed the BSWSQ. Participants who, in relation to a shift, 'often' or 'always' experienced both a sleep problem and a tiredness/sleepiness problem were defined as having shift-related insomnia (separate for day, evening and night shifts and rest-days). Logistic regression analyses were conducted for day, evening, night, and rest-day insomnia with participants on both permanent and rotational schedules.

Results Shift-related insomnia differed between the work schedules. The evening shift insomnia was more prevalent in the two-shift rotation schedule than the three-shift rotation schedule (29.8% and 19.8%, respectively). Night shift insomnia showed higher frequencies among three-shift rotation workers compared with permanent night workers (67.7% and 41.7%, respectively). Rest-day insomnia was more prevalent among permanent night workers compared with two- and three-shift rotations (11.4% compared with 4.2% and 3.6%, respectively).

Conclusions The prevalences of shift-related insomnia differed between the work schedules with higher frequencies for three-shift rotations and night shifts. However, sleep problems were present in all shifts and schedules. This suggests that both shifts and work schedules should be considered in the study of shift work-related sleep problems.

INTRODUCTION

Shift workers report more sleep problems than the general public.¹ There is ample evidence linking sleep disturbances to both somatic and psychological health problems.^{2–3} Sleep problems related to the work schedule may additionally mediate the relationship between shift work and other health issues.⁴ Shift work-related sleep problems may be associated with several types of shift (ie, day shift, evening shift and night shift) as well as with work schedules (ie, different shift rotations).⁵ Previous studies on shift workers have demonstrated that sleep problems vary according to different shifts.^{6–7} Sleep problems are related to working night shifts and to permanent day (especially with early

What this paper adds

- ▶ Different work schedules and shifts may produce different sleep and sleepiness problems, but studies rarely investigate the effect of different shifts and work scheduling on sleep and sleepiness. The present study is distinct in providing a detailed overview of sleep and sleepiness problems in day, evening and night shifts across different permanent and rotational schedules. In addition, seven different symptoms of sleep and sleepiness problems are assessed, giving a more nuanced picture of the varying problems in relation to specific shifts and schedules. To assess the most problematic schedules we have categorised the sleep and sleepiness problems according to severity.
- ▶ Night shifts and rotating schedules were particularly problematic in terms of insomnia.
- ▶ Our findings implicate that a systematic assessment of different symptoms related to both shifts and work schedules is necessary when studying sleep in shift workers.

morning start from 07:00 or earlier) and to two-shift rotation schedule (day and evening work).^{7–8} Currently, around a third of the US and European workforce have irregular work schedules.^{9–10} The public health consequences of shift-related sleep problems may be extensive.

Shift work scheduling including night shifts, evening shifts, early starting day shifts and the rotation between the aforementioned shifts disrupts the basic sleep regulation. Sleep is regulated by the homeostatic sleep pressure (ie, accumulated with hours awake) and by the circadian rhythm. While the homeostatic pressure affects the sleep depth (often corresponding to experienced sleep quality), the circadian rhythm influences the sleep length. Both the homeostatic and the circadian factors are reactant to external factors such as light and social expectations/activity.¹¹ Various aspects of shift work may affect one or both of these sleep regulating mechanisms differently, resulting in different sleep/sleepiness problems in different schedules. Studies have shown problems with excessive sleepiness during night shifts and premature awakenings from the following daytime sleep, short total sleep

To cite: Flo E, Pallesen S, Åkerstedt T, et al. *Occup Environ Med* 2013;**70**:238–245.

time and inadequate rest in early day shifts,¹² and sleep onset problems associated with evening shifts.¹³ In addition, transition between shifts may be problematic. Sufficient sleep may be more difficult to obtain when a day shift succeeds an evening shift, as part of a rotation. Shifts with less than 11 h in between have been related to increased problems with sleep and sleepiness in shift workers.¹⁴ This can be an issue in both two- and three-shift rotations (rotations between day and evening shifts, and among day, evening and night shifts, respectively). Rotations between shifts necessitate the shift worker to adapt and to readapt to different sleep–wake rhythms, which can disrupt the circadian rhythm.

Transitions between shifts as well as transitions between shifts and rest-days may affect sleep regulation. Sleep during rest-days is in general longer than sleep on workdays, indicating that sleep problems would be reduced during days off regardless of work schedule.¹⁵ Yet, those working night shifts (particularly permanent night shifts) may have to readjust their sleep–wake rhythm in order to meet social expectations during rest-days. Permanent night work could entail increased sleep problems during rest-days compared with other schedules.

A revisited issue in this field of research is that the term ‘shift work’ covers a wide range of work arrangements with varied directions and timing of the rotation, number of hours between succeeding shifts and distribution of rest-days.¹⁶ Across different studies, shift work-related sleep problems may be influenced by several different work scheduling factors.

Another challenge concerns the many definitions of ‘sleep problems’. Some shift workers may experience difficulties falling asleep when working evening shifts, but do not necessarily report sleep problems if questioned about their sleep in general. Also, it is necessary to distinguish ‘normal’ responses to shift work from more severe shift work-related sleep problems.

In light of the above mentioned challenges, the Bergen Shift Work Sleep Questionnaire (BSWSQ) was constructed aiming to assess problems with sleep and tiredness/sleepiness across different shifts and during rest-days.⁵ The items are based on insomnia symptoms: difficulties initiating or maintaining sleep, non-restorative sleep and tiredness/sleepiness. With clearly defined symptoms, this questionnaire will detect various sleep and sleepiness problems in different shift and work schedules. The overview of symptoms enables a systematic assessment of insomnia and sleepiness across shifts and work schedules. Reporting a high occurrence of sleep problems as well as reduced wake-time functioning would indicate severe and disruptive problems.¹⁷ This allows for a dichotomised severity threshold where participants who ‘often’ or ‘always’ experience sleep problems *and* wake-time symptoms in relation to shifts (day, evening or night) can be regarded as having shift-related insomnia. Hence, participants may show symptoms corresponding to ‘day shift insomnia’, ‘evening shift insomnia’, ‘night shift insomnia’ and/or ‘rest-day insomnia’. These categorisations enable a comprehensible assessment of how pervasive shift-related sleep/sleepiness problems are across different work schedules.

Work schedule characteristics may produce different shift-related sleep and tiredness/sleepiness problems.⁷ Hence, in the present study, we aimed to investigate the prevalence of *discrete insomnia symptoms* in different shifts in the following work schedules: permanent day, permanent night, two-shift rotation (between day and evening shifts) and three-shift rotation (between day, evening and night shifts). We additionally aimed to investigate the association between the abovementioned schedules and the four types of *shift-related insomnia*.

In terms of discrete symptoms, we expected descriptive analyses to show high problem prevalences in rotational schedules and schedules with night work. In terms of shift-related insomnia, we expected: (i) an increased risk of day shift insomnia in both the two- and three-shift rotation schedules compared with the permanent day schedule, (ii) a higher risk of night shift insomnia in the three-shift rotation schedule compared with the permanent night shift schedule and (iii) a higher risk of rest-day insomnia in permanent night shift workers than the permanent day, two-shift rotation and three-shift rotating workers (due to the issue of readaptation).

METHOD

Procedure and participants

The present study sample comprises nurses participating in the second wave of the longitudinal questionnaire study ‘The survey of shift work, sleep and health’ (SUSSH). The SUSSH study comprises Norwegian nurses drafted from the Norwegian Nursing Organisation’s membership registers. The questionnaire and a prepaid return envelope were sent per postal mail to the participating nurses’ home address. The response rate of the second wave was 80.9%, of which the invited nurses were those who participated in wave 1 (2059 participants, response rate of 38.1%). In the second wave, participants were asked to report their work schedules and fraction of full position according to predetermined categories. All participants worked at least 50% of full position (median >90%). The 1586 participants in the second wave worked one of the following schedules: ‘permanent day shifts’ (11.0%), ‘permanent evening shifts’ (0.3%), ‘permanent night shifts’ (8.2%), ‘two-shift rotation schedule’ (ie, day and evening shifts, 27.1%), ‘three-shift rotation schedule’ (day, evening and night shifts, 50.2%) and ‘other schedules including night shifts’ (3.2%). Due to a low number, as well as unclear work schedule characteristics, the participants working ‘permanent evening shifts’ and ‘other schedules including night shifts’ were excluded, leaving 1462 nurses for the analyses. The included participants had a mean age of 34.2 years and 91.2% were female subjects. The most common work hours for the Norwegian nursing population are 07:00 to 15:00 (day shifts), 14:30 to 22:00 (evening shifts) and 22:00 to 07:30 (night shifts). Nurses working in outpatient clinics or administratively may work 08:00 to 16:00. Permanent night and three-shift rotation workers in full position have a 35.5 h workweek, while day workers in full position have a 37.5 h workweek.

Measurements

The nurses answered numerous questions in this survey. Only the questions related to the present study will be described and reported here.

Demographic data were registered, including age, gender, work schedule, fraction of full position and number of shifts separated by less than 11 h worked the last year.

The Bergen Shift Work Sleep Questionnaire

The BSWSQ assesses insomnia symptoms, separately for day, evening and night shifts, as well as rest-days.⁵ The symptom questions are as follows: (i) How often has it taken you more than 30 min to fall asleep after the light is switched off; (ii) How often are you awake for more than 30 min within your main sleep period; (iii) How often have you woken up more than 30 min earlier than you wished, without being able to fall asleep again; (iv) How often have you not felt adequately rested following sleep; (v) How often have you been tired/sleepy at work; (vi) How often have you been tired/sleepy in your free

time (time out of work) on workdays; and (vii) How often have you been tired/sleepy on rest-days/on vacation. Symptoms are rated for the last 3 months. The response alternatives are 'never', 'rarely', 'sometimes', 'often' and 'always' (ranging from 0 to 4). Not applicable is also offered as a response alternative since not all participants work all three shifts (scored as missing). Importantly, each symptom was related to day, evening and night shift in addition to rest-days, when applicable.

Questions 1–4 concern sleep problems (sleep latency, wake after sleep onset (WASO), premature awakening and non-restorative sleep), while questions 5–7 address impaired wake-time functioning (tiredness/sleepiness during work, free periods on work days and during rest-days). If a participant 'often' or 'always' suffers from one sleep problem as well as 'often' or 'always' experiences one wake-time impairment, this could be argued to imply a clinically severe problem.¹⁷ Based on this assumption, we classified participants into not having or having shift-related insomnia for each shift. Participants scoring 'often' or 'always' on at least one of items 1–4 and on at least one of items 5–6 in relation to a specific shift (items 1–4 and 7, in relation to the rest-days) were consequently defined as having shift-related insomnia.

The BSWSQ questions are based on the insomnia inclusion criteria described by the International Classification of Sleep Disorders (ICSD-2),¹⁸ the Diagnostic and Statistical Manual of Mental Disorders-IV-TR (DSM-IV)¹⁹ and by the International Statistical Classification of Diseases and Related Health Problems (ICD-10).²⁰ In the present study the Cronbach's α was 0.89.

Statistical analyses

We used SPSS V.19 for all statistical analyses. Participants were excluded from analyses concerning shifts which were not a part of their work schedule (ie, data from permanent day workers were only included in analyses concerning day shifts and so on). This exclusion included the N/A answers already set to missing. Cross-tabulations were conducted looking at differences in symptoms (occurring 'often' or 'always') in each of the work schedules (ie, permanent day, permanent night, two-shift rotation and three-shift rotation schedules).

We investigated work schedule group differences in terms of age (analysis of variance), gender and fraction of full position (χ^2). We also investigated whether there were significant differences between two- and three-shift rotations in terms of number of shifts separated by less than 11 h worked per year (independent samples t test). Both age and fraction of full position differed across work schedules; therefore, these group differences were controlled for in further analyses.

Descriptive statistics were completed investigating the prevalence of shift-related insomnia (separate scores for day, evening and night shifts and rest-days) in relation to each work schedule category (permanent day, permanent night, two-shift rotations and three-shift rotations).

Crude and adjusted logistic regression analyses were conducted investigating the associations between the four shift-related insomnia categories (dependent variables) and different work schedules, as well as age, gender and fraction of full position. Fraction of full position and work schedule categories were dummy-coded. The three-shift rotation schedule was present in all analyses and was used as the contrast. Subsequently, the permanent night and permanent day schedules were set as contrasts to investigate the association between the four shift-related insomnia categories (dependent variables) and the different work schedules. The contrast was only changed in

the analyses with more than two work schedules to compare (ie, day shift insomnia and rest-day insomnia). Preliminary analyses were performed to dismiss the possibility of collinearity. The work schedules included in the adjusted analyses were different for day shift insomnia (n=1227), evening shift insomnia (n=1081), night shift insomnia (n=808) and rest-day insomnia (n=1433). Significance for all analyses was set to $p < 0.05$.

Ethical statement

This study was approved by the Regional Committee for Medical and Health Research Ethics, Health Region West (REK-Vest).

RESULTS

Prevalence rates for discrete symptoms

Sleep onset latency

As shown in table 1, few participants reported problems with sleep onset latency (defined as 'often' or 'always' using more than 30 min to fall asleep) in relation to day shifts and rest-days. With regard to evening shifts, more than 50% of two- and three-shift rotation workers reported problems with sleep onset latency.

Wake after sleep onset

Overall, there were low prevalence figures regarding problems with WASO occurring 'often' or 'always' (defined as being awake for more than 30 min within the main sleep period). All shifts and work schedules gave rates below 20%, except for three-shift rotation workers in relation to night shifts, of which 29% reported WASO (table 1).

Premature awakening

Problems with premature awakenings (defined as waking up more than 30 min earlier than wished, without falling asleep again) also showed prevalence rates below 20% in all shifts except for night shifts. In relation to night shifts, 39.3% of the three-shift rotation workers experienced premature awakenings 'often' or 'always' (table 1).

Not feeling adequately rested following sleep

All work schedules showed a prevalence of above 40% with regard to this problem (occurring 'often' or 'always'). Night shifts as part of a three-shift rotation schedule showed a prevalence of 63.5% (table 1). This problem was reported in relation to day shifts by 50.7% of the permanent day workers.

Experience of being tired/sleepy at work

With regard to problems with tiredness/sleepiness while at work, night shifts entailed high prevalence figures for both permanent night and three-shift rotation schedules (table 1). As many as 70.0% of the three-shift rotation workers and 41.7% of the permanent night shift workers reported being 'often' or 'always' tired/sleepy while working night shifts.

Experience of being tired/sleepy during free periods on workdays

In relation to the three-shift rotation schedules, 65.8% and 44.4% of these nurses were 'often' or 'always' tired/sleepy in the free time during workdays during night shifts and day shifts, respectively. Lowest were evening shift prevalence rates, both for two- and three-shift rotation schedules.

Table 1 Symptoms of sleep and sleepiness problems in relation to rest-days, and day-, evening - and night shifts

Work schedules	Work schedules				Total % (n)*
	Permanent day % (n)*	Two-shift (day-evening) rotation % (n)*	Permanent night % (n)*	Three-shift (day-evening-night) rotation % (n)*	
(1) Sleep onset latency (using more than 30 min to fall asleep)					
Day shift	11.6 (17)	17.0 (65)		11.9 (84)	13.5 (166)
Evening shift		54.3 (207)		55.2 (388)	54.9 (595)
Night shift			13.2 (15)	27.7 (193)	25.6 (208)
Rest-days	9.3 (13)	8.4 (33)	13.6 (16)	8.4 (62)	8.9 (124)
(2) Wake after sleep onset (bouts of wakefulness lasting more than 30 min within the main sleep period)					
Day shift	9.6 (14)	7.1 (27)		5.3 (37)	6.4 (78)
Evening shift		19.5 (74)		15.8 (111)	17.1 (185)
Night shift			18.3 (21)	29.0 (201)	27.4 (222)
Rest-days	6.6 (9)	3.0 (12)	9.4 (11)	3.5 (26)	4.2 (58)
(3) Premature awakening (waking more than 30 min earlier than wished, without falling asleep again)					
Day shift	11.0 (16)	14.9 (57)		8.3 (58)	10.7 (131)
Evening shift		17.8 (68)		11.1 (78)	13.5 (146)
Night shift			24.6 (28)	39.3 (273)	37.2 (301)
Rest-days	7.3 (10)	5.5 (22)	5.9 (7)	2.5 (18)	4.1 (57)
(4) Not feeling adequately rested following sleep					
Day shift	50.7 (75)	43.6 (167)		44.0 (310)	44.7 (552)
Evening shift		49.9 (190)		43.1 (304)	45.5 (494)
Night shift			41.7 (48)	63.5 (444)	60.4 (492)
Rest-days	14.2 (19)	9.7 (38)	13.6 (16)	9.5 (70)	10.4 (143)
(5) Experience of being tired/sleepy at work					
Day shift	16.9 (25)	29.8 (115)		23.8 (168)	24.8 (308)
Evening shift		22.4 (86)		10.8 (76)	14.9 (162)
Night shift			41.7 (48)	70.2 (493)	66.2 (541)
(6) Experience of being tired/sleepy during free periods on workdays					
Day shift	41.8 (61)	43.0 (166)		44.4 (313)	43.7 (540)
Evening shift		24.2 (93)		18.5 (131)	20.5 (224)
Night shift			42.9 (48)	65.8 (459)	62.6 (507)
(7) Experience of being tired/sleepy when not working/on vacation					
Rest-days	11.0 (18)	7.4 (30)	14.5 (18)	6.6 (50)	8.0 (116)

The percentage distribution refers to the nurses *within* each work schedule (permanent day, permanent night, two-shift and three-shift rotation) reporting to 'often' or 'always' experiencing the symptoms.

*Columns depict the percentage (%) and number (n) of nurses *within* a given work schedule who reported to 'often' or 'always' experience a specific shift-related symptom.

Experience of being tired/sleepy when not working/on vacation

In all, 14.5% of the permanent night workers reported 'often' or 'always' being tired/sleepy during rest-days, while only 6.6% of the three-shift rotation workers reported this symptom (table 1).

Differences between the work schedules

We found significant differences between the different work schedules in terms of age and fraction of full position (table 2). There were no gender differences between the work schedules. There were no differences between two- and three-shift rotations in terms of number of shifts separated by less than 11 h.

Differences in shift work-related insomnia

Day shift insomnia

The day shift insomnia showed no associations with any work schedules either in the crude or in the adjusted logistic regression analyses (table 3). Descriptive analyses showed similar prevalence rates for the permanent day (33.8%), two-shift rotation (37.2%) and three-shift rotation (35.6%). Using the permanent day schedule as a contrast in the adjusted analysis yielded no significant difference between the schedules. There was an association between different fractions of full position and the day shift insomnia, showing higher insomnia prevalence

Table 2 Percentage distribution of gender and fraction of full position and mean and SD for age according to work schedule in a sample of 1462 nurses, as well as number of shifts with less than 11 h in between in two- and three-shift rotational workers

	Permanent day		Two-shift rotation		Permanent night		Three-shift rotation	
	%	(n)	%	(n)	%	(n)	%	(n)
Gender								
Male	9.8	(16)	7.7	(31)	14.8	(18)	8.3	(63)
Female	90.2	(148)	92.3	(374)	85.2	(104)	91.7	(695)
Fraction of full position*								
50%–75%	9.6	(16)	24.4	(99)	68.5	(85)	26.2	(199)
76%–90%	14.5	(24)	15.8	(64)	16.1	(20)	15.3	(116)
>90%	75.9	(126)	59.9	(243)	15.3	(19)	58.6	(445)
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Age*	36.8	(8.3)	35.0	(9.5)	34.0	(7.4)	33.4	(7.6)
Shift >11 h between			50.5	(38.3)			48.4	(34.6)

*p<0.0005.

Table 3 Crude and adjusted logistic regression analyses showing associations among shift-related insomnia, age, gender, fraction of full position and work schedules

Day shift insomnia	Crude OR†	95% CI	Adjusted OR‡	95% CI
Age	0.99	(0.98 to 1.00)	0.99	(0.98 to 1.00)
Gender				
Male	1.00		1.00	
Female	1.02	(0.68 to 1.54)	1.11	(0.73 to 1.69)
Fraction of full position				
50%–75%	1.00		1.00	
76%–90%	0.91	(0.61 to 1.36)	0.94	(0.63 to 1.40)
>90%	1.45*	(1.06 to 1.88)	1.45*	(1.08 to 1.94)
Work schedule				
Three-shift rotation	1.00		1.00	
Permanent day	0.92	(0.63 to 1.35)	0.88	(0.59 to 1.29)
Two-shift rotation	1.08	(0.83 to 1.39)	1.07	(0.83 to 1.39)
Evening shift insomnia				
Age	1.02*	(1.00 to 1.03)	1.01	(1.00 to 1.03)
Gender				
Male	1.00		1.00	
Female	1.05	(0.63 to 1.75)	1.08	(0.64 to 1.82)
Fraction of full position				
50%–75%	1.00		1.00	
76%–90%	1.27	(0.81 to 2.00)	1.24	(0.78 to 1.96)
>90%	1.19	(0.84 to 1.67)	1.19	(0.84 to 1.68)
Work schedule				
Three-shift rotation	1.00		1.00	
Two-shift rotation	1.72**	(1.29 to 2.30)	1.68**	(1.26 to 2.24)
Night shift insomnia				
Age	1.00	(0.98 to 1.02)	1.00	(0.99 to 1.02)
Gender				
Male	1.00		1.00	
Female	1.32	(0.83 to 2.11)	1.15	(0.71 to 1.88)
Fraction of full position				
50%–75%	1.00		1.00	
76%–90%	0.87	(0.56 to 1.35)	0.68	(0.43 to 1.08)
>90%	1.01	(0.74 to 1.40)	0.73	(0.51 to 1.05)
Work schedule				
Three-shift rotation	1.00		1.00	
Permanent night	0.34**	(0.23 to 0.51)	0.30**	(0.19 to 0.47)
Rest-day insomnia				
Age	0.99	(0.97 to 1.02)	0.99	(0.96 to 1.03)
Gender				
Male	1.00		1.00	
Female	1.27	(0.50 to 3.21)	1.35	(0.52 to 3.51)
Fraction of full position				
50%–75%	1.00		1.00	
76%–90%	0.52	(0.23 to 1.18)	0.61	(0.26 to 1.39)
>90%	0.62	(0.37 to 1.05)	0.79	(0.43 to 1.44)
Work schedule				
Three-shift rotation	1.00		1.00	
Permanent day	1.98	(0.96 to 4.07)	2.14*	(1.02 to 4.48)
Two-shift rotation	1.19	(0.64 to 2.22)	1.21	(0.65 to 2.25)
Permanent night	3.46**	(1.76 to 6.81)	3.22**	(1.54 to 6.71)

*p<0.05; **p<0.001.
 †OR, variables entered separately.
 ‡OR, all variables included in the model.

rates in fractions of 90% or more compared with smaller fractions (table 3). Working close to a full position was associated with an increased risk of experiencing day shift insomnia.

Evening shift insomnia

The descriptive analyses yielded varying prevalence rates in two- and three-shift rotations with regard to evening shift insomnia

(29.8% compared with 19.8%, respectively). As shown in table 3, this difference was also significant in the crude and the adjusted logistic regression analyses in which two-shift rotations yielded a higher OR than three-shift rotations. Only these two work schedule categories were included in this analysis. Age showed a positive association with evening shift insomnia in the crude analysis, but not in the adjusted analysis.

Night shift insomnia

With regard to night shift insomnia, a higher prevalence rate in three-shift rotation work was found compared with permanent night work (67.7% compared with 41.7%, respectively). This difference was significant in the adjusted regression analysis, in which permanent night shifts had a lower risk compared with three-shift rotations (table 3).

Rest-day insomnia

The adjusted logistic regression analyses showed significant differences between work schedules in relation to rest-day-related insomnia (table 3). The highest prevalence rate was found among permanent night shift workers (11.4%) compared with permanent day shifts (6.8%), two-shift rotations (4.2%) and three-shift rotations (3.6%). The adjusted regression analyses showed that both the permanent day and permanent night schedules had significantly higher ORs compared with three-shift rotations. When the permanent night schedule was set as contrast in the adjusted analysis, two-shift rotations showed significantly lower risk (OR=0.38, 95% CI 0.17 to 0.83), but the permanent day schedule showed no significant association (OR=0.67, 95% CI 0.26 to 1.68). When the permanent day schedule was set as contrast, two-shift rotations showed no significant association (OR=0.56, 95% CI 0.26 to 1.25).

DISCUSSION

In the present study we showed elevated prevalence rates in symptoms occurring 'often' or 'always' in rotational schedules and schedules with night work. In terms of our hypotheses: (i) we did not find an increased risk of day shift insomnia in either the two- or three-shift rotation workers compared with the permanent day workers; (ii) we did confirm a higher risk of night shift insomnia in the three-shift rotation workers compared with the permanent night shift workers as well as (iii) a higher risk of rest-day insomnia in permanent night shift workers compared with two-shift rotation and three-shift rotation workers.

Day shift-related problems with sleep and tiredness/sleepiness

The hypothesis that rotational shift workers would show higher day shift insomnia prevalences than permanent day workers was not confirmed. The prevalence rates for day shift insomnia were moderate across all work schedules. Day shifts (starting 07:00 or earlier) have been related both to shortened sleep and to feelings of inadequate rest.⁷ There was higher day shift insomnia prevalence among those working a fraction of 90% or more. It is possible that individuals with health issues seek to work less than full position. These results may have been biased by a 'healthy worker effect'. Participants on a permanent day schedule may have left other schedules as a consequence of sleep and/or other health issues. This may have masked some of the work schedule effects on day shift-related problems with sleep and tiredness/sleepiness. Comparable with day shift insomnia, the discrete day shift-related sleep problems were equally present across all work schedules.

Evening shift-related problems with sleep and tiredness/sleepiness

We did not have a specific hypothesis related to the evening shift insomnia in two- and three-shift rotation schedules. Nevertheless, we did find that three-shift rotations yielded a lower prevalence rate than two-shift rotations. In some institutions, working in outpatient clinics (ie, permanent day work) may be reserved for senior nurses or for nurses with additional education. In effect, young nurses who do not cope well with night shifts may seek a two-shift rotation schedule. Yet, group differences between the work schedules were not present in the logistic regression analysis. We found no differences between the rotational schedules in terms of number of shifts with less than 11 h between. Schedule characteristics such as the organisation of rest-days could have influenced the difference in evening shift insomnia prevalences. Overall, fewer participants had evening shift insomnia than day and night shift insomnia, which is in line with previous studies.²¹

Night shift-related problems with sleep and tiredness/sleepiness

We expected the three-shift rotation schedule to show higher insomnia prevalence than permanent night shifts. This hypothesis was confirmed. Additionally, the three-shift rotation workers had generally higher prevalences of discrete symptoms than the permanent night workers, which further corresponded to our hypotheses.

Regarding premature awakenings, the three-shift rotation schedule showed a higher prevalence than the permanent night schedule. However compared with the other shifts (ie, day shift and evening shift) work schedules including night work (ie, three-shift rotation and permanent night) showed overall high problem frequencies. Working nights has previously been related to 2–4 h curtailed total sleep time.¹⁴ Prevalences for 'being tired while on work' were high in both the three-shift rotation and in permanent night workers. This was to be expected as night shifts entail being awake at the nadir of alertness/activity in the human circadian rhythm.²²

Permanent night workers are often exposed to stimuli at odds with their wake–sleep rhythm (ie, daylight). Only a small proportion of permanent night workers become entrained to the night schedule.²³ Our findings suggest that permanent night workers are affected by their schedule. Nevertheless, three-shift rotation workers have to adapt and readapt to different shifts more frequently, which affects sleep onset, WASO and premature awakening.⁷ Number of hours awake before a night shift, increasing the homeostatic sleep pressure, may have additionally contributed to the high levels of reported wake-time tiredness/sleepiness among three-shift rotation workers.¹⁴

Rest-day/vacation-related problems with sleep and tiredness/sleepiness

The symptom 'tiredness/sleepiness during rest-days/vacation' had low prevalences in all schedules and shifts. We expected that permanent night shifts would involve a higher risk of rest-day insomnia than permanent day shifts, two-shift rotation and three-shift rotation workers. This was confirmed concerning the rotational schedules but not the permanent day schedule. The permanent night workers more likely have to readapt to daytime during rest-days.

The three-shift rotation workers showed lower prevalences for rest-day insomnia than both permanent night and two-shift rotation workers. Two-shift workers showed a lower prevalence

than permanent night workers. The three-shift rotation workers may, as previously suggested, represent a group with initially less sleep and health problems than the other schedules (healthy worker effect). This may in part explain the three-shift rotation workers' low insomnia prevalence related to rest-days. The low problem rate also suggests that there was no negative response bias among the participants. However, since the three-shift rotation workers reported high levels of shift-related insomnia, these workers may have had a higher homeostatic sleep drive following work periods.

It is possible that the nurses reporting problems in relation to rest-days were individuals with general insomnia symptoms. Since the BSWSQ is not constructed as a global/general insomnia measure, we are precluded from providing estimates of the general insomnia prevalence. Data related to rest-day insomnia may be regarded as a proxy for general sleep and sleepiness status. It is worth noting that apart from the permanent night workers, the rest-day insomnia prevalence rates were below estimates of insomnia in the general population.²⁴ The differences between work schedules in terms of rest-day insomnia suggest a work-related phenomenon. The number of nurses who may have had the insomnia diagnosis remains a speculation.

Although the same symptoms are reported for day and night shifts alike, different mechanisms may be at play. For example, there were generally high prevalences of 'tiredness/sleepiness during the free period on work days' across the different work schedules and shifts. The free period in relation to night shifts is usually located before the work starts. Sleepiness/tiredness in relation to this free period may be due to sleep inertia and possibly also to sleep deprivation. Conversely, the free period in relation to day shifts is usually located after work. Here, tiredness/sleepiness may be due to a high homeostatic sleep pressure, general fatigue from a busy day and possibly truncated night sleep due to an early shift start.

Because of the large quantities of information regarding symptom frequencies in different work schedules, the data were compiled. The shift-related insomnia variables enabled a comparison between multiple groups. These variables illustrate the prevalence of sleep problems combined with tiredness/sleepiness with a tenacity indicating clinical severity. Yet, shift-related insomnia does not represent a diagnostic cut-off, but a way of assessing how severely the work shifts affect sleep and wake-time functioning. A nurse may report being severely affected by night work. Nonetheless, if the quantity of night shifts per month is low, the nurse may not experience being burdened by the work schedule in everyday life. Night shift insomnia would not necessarily correspond to either general insomnia or shift work disorder.

Strengths and limitations

In the present study, we used the validated BSWSQ to assess shift-related sleep/sleepiness problems.⁵ The shift-related insomnia as defined in this study incorporates different combinations of symptoms. This reduces the possibility that sleep problems are neglected; differences between schedules are detailed, yet comprehensible.

We found differences between the work schedules regarding age and fraction of full position. These variables were included in the adjusted analysis. Nevertheless, it is not possible to completely rule out effects from social or individual factors in relation to the differences between work schedules. It was not possible to identify and exclude nurses working from 08.00 to 16.00. Nevertheless, these are not the usual work hours and these nurses represent a minority in our sample.

The study sample was large and homogenous, reducing the influence from possible confounding variables. Nevertheless, this makes generalisation to other occupations more problematic. The initial response rate in wave 1 was lower than in subsequent waves. Low response rates represent an increasing problem in epidemiological research.²⁵ Although the mean age of the study sample was low, it does probably not represent a response bias. As the study was designed to be a cohort study with a 10-year time-frame, the initial recruitment deliberately addressed younger nurses to be included to avoid retirement dropout with time. Also, the majority of actively working nurses in Norway are between 25 and 44 years.²⁶ A low mean age would probably mask out some of the negative effect of shift work. The study sample had a skewed gender distribution, comprising about 90% female subjects. The results cannot be generalised to male subjects without reservations. However, a more even gender distribution would not reflect the general nursing population. In line with our sample, approximately 90% of the nursing populations in the USA, as well as in Norway, are female.^{26 27}

The differential responses between work and rest-days may suggest that there was no selection bias in terms of nurses with sleep problems seeking to participate. Since the present study was cross-sectional, it is not possible to make conclusions about causal directions.

In conclusion, this study corroborates earlier findings with regard to night shifts entailing high levels of problems with sleep and sleepiness.^{7 14} We found an association between work schedules and shift-related insomnia. Working night shifts and rotating schedules stood out as particularly problematic. We did not find any differences between work schedules regarding day shift insomnia. The three-shift rotation schedule was particularly related to higher night shift insomnia prevalence compared with the permanent night shift schedule. Our findings indicate that work shifts and the work scheduling must be considered with regard to problems with sleep and tiredness/sleepiness in shift workers.

Contributors All authors have made substantial contributions to the conception and development of this manuscript, drafting the article and/or critically revising it, as well as giving final approval of the current submitted version. No scientific writing assistance from agency/freelance writer has been employed in the drafting of this manuscript.

Funding The present study received a grant for practical administration and data collection from The Western Norway Regional Health Authority (grant number 911386, no personal payment/salary). Elisabeth Flo received a PhD grant from The Western Norway Regional Health Authority. The Norwegian Nurses Organisation gave economic support to cover expenses related to mailing of questionnaires (no personal payment/salary).

Competing interests None.

Ethics approval This study was approved by the Regional Committee for Medical and Health Research Ethics, Health Region West (REK-Vest, case number 088.08).

Provenance and peer review Not commissioned; externally peer reviewed.

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