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ORIGINAL ARTICLE

Pain complaints are associated with quick returns and insomnia among Norwegian nurses, but do not differ between shift workers and day only workers

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Abstract

Purpose To determine whether common work schedule characteristics among Norwegian nurses were associated with subjective pain complaints.

Methods A cross-sectional study in a sample of 1585 nurses, part of the longitudinal questionnaire-based cohort project 'Survey of Shift work, Sleep and Health' (SUSSH). Pain from six regions were assessed: 'headache', 'neck/shoulder/upper back', 'upper extremities', 'lower back', 'lower extremities', and 'abdomen'. Logistic and negative binomial regression (adjusted for age, sex, percentage of full-time equivalent, marital status and children living at home) were conducted where work schedule, number of night shifts last year, number of quick returns (QR) last year (< 11 h between shifts) and insomnia were predictors of localized pain, widespread pain and number of pain sites.

Results Localized pain, widespread pain and number of pain sites were associated with insomnia (OR 2.06, 95% CI 1.66–2.55, OR 2.14, 95% CI 1.47–3.09, IRR 1.70, 95% CI 1.51–1.91, respectively). Work schedule and number of night shifts worked last year were not associated with any of the three pain measures. Number of QRs worked last year tended to be associated with number of pain sites.

Conclusion The study did not support the hypothesis that non-daytime work schedules are associated with pain complaints. Neither was there support for the hypothesis linking number of night shifts, or the number of QRs, to pain complaints. Future studies should aim to determine the association between QRs and pain in more detail. Pain complaints were associated with insomnia.

Keywords Shiftwork · Night work · Insomnia · Quick returns · Pain complaints · Musculoskeletal

Introduction

Work-related musculoskeletal pain complaints are common. Twenty-five percent of the Norwegian working population reports work-related neck and shoulder pain, whereas 15% reports low-back pain (Statistics Norway 2016). A challenge in terms of preventing musculoskeletal complaints is its multifactorial origin. Shift work is one of several factors associated with musculoskeletal pain. Approximately one in four Norwegian adults between 18 and 66 years old are shift workers, and 12% work at night.

Few studies have adequately examined the relationship of work schedules and musculoskeletal pain. A potential challenge to the field is that parametrization of working hours is not straightforward. Previous cross-sectional studies have shown that working any time other than day shift

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are associated with an increased risk of reporting musculoskeletal pain complaints in one or more body sites (Attarchi et al. 2014; Lipscomb et al. 2002). A longitudinal study supports the same conclusion (Zhao et al. 2012). However, dichotomization into shift work and non-shift work may be too simplistic. An interesting question is therefore whether particular shift schedules among Norwegian nurses (e.g. night work only, two-shift rotation including day and evening work, three-shift rotation including day, evening and night work) are more strongly associated with pain complaints than day shift.

Two other shift-work factors with well-documented impact on health are the number of consecutive night shifts (Jensen et al. 2016), and the length of the restitution period between shifts (Vedaa et al. 2015). Night shifts disturb the diurnal rhythm (Jensen et al. 2016) and has been associated with pain complaints in micro-longitudinal studies (Katsifaraki et al. 2018), findings supported by experimental studies (Matre et al. 2017; Pieh et al. 2018). Quick returns (QRs), defined as < 11 h off between shifts, disturb sleep (Vedaa et al. 2015). A longitudinal study found that QRs increased the risk of developing musculoskeletal complaints in the neck, shoulder and back (Trinkoff et al. 2006). Confirmation of these findings is warranted.

An association between shift work and pain complaints may be mediated by disturbed sleep or insomnia (Akerstedt et al. 2010; Boardman et al. 2006; Uhlig et al. 2018). However, it is not known to what extent insomnia using a clinical definition is associated with pain among shift-workers.

The present study aims to determine whether common work schedule characteristics among Norwegian nurses are associated with subjective pain complaints, when splitting non-daytime shifts into more detailed shift categories, and whether number of night shifts or number of QRs were associated with pain complaints. A final aim was to determine whether workers with clinically defined insomnia disorder experienced more pain complaints than workers without insomnia disorder. Four hypotheses were investigated: An increased risk for reporting pain complaints is associated with (i) having a work schedule other than regular daytime, (ii) number of night shifts worked last year, (iii) number of QRs last year, and (iv) suffering from insomnia disorder.

Methods

Design and study population

In 2008/2009, the longitudinal questionnaire-based project 'Survey of Shift work, Sleep and Health' (SUSSH) was initiated based on a sample of Norwegian nurses. At startup (wave 1), a randomly selected population from the Norwegian Nurses Organisation's membership roll was invited to participate. A total of 38.1% completed the first wave. An additional sample of 906 newly educated nurses was recruited in 2009 (response rate 33.1%), making a total wave 1 sample of 2965 nurses (see details in Bjorvatn et al. 2015). Annual follow-ups of the cohort with postal questionnaires (pre-paid envelopes) have been conducted, including up to two reminders. All nurses participating took part in a lottery (25 individuals each won a gift card with value 500 NOK) at each wave. The present cross-sectional study included data from wave 6 in 2014 ($n = 1992$ participants, 69.4% response rate). Of these, 1585 participants were still working as a nurse and were thus included in the data analysis. Ethical approval was obtained from the Norwegian Regional Committee for Medical Research Ethics (Approval number 088.08).

Demographics

Age and sex were registered at wave 1, the remaining variables were registered at wave 6. The variables comprised percentage of full-time equivalent categorized as < 50%, 50–75%, 76–90% and > 90%, respectively, marital/cohabitating status (yes/no), and children living at home (yes/no).

Compliance with ethical standards

The authors declare no financial or non-financial conflicts of interest. All participants gave their informed consent to participate in the study, which was conducted in accordance with the Declaration of Helsinki.

Exposure variables

Participants were asked about current work schedule with the following six response alternatives: 'Only day time', 'Only evening time', 'Both day time and evening time', 'Only night time', 'Rotating shift work (three shift)', and 'Other schedule with both day and night shifts'. Fixed categorization of working hours is not necessarily meaningful, since nurses on a daytime schedule also take on night or evening shifts once in a while. Therefore, nurses were asked about the number of night shifts worked last year (subsequently categorized into 0, 1–20 nights and > 20 nights). The nurses were also asked about the number of QRs worked last year (subsequently categorized into 0, 1–20 nights and > 20 nights, respectively).

Insomnia symptoms were assessed by the Bergen Insomnia Scale (BIS), which assesses insomnia symptoms experienced the past month (Pallesen et al. 2008). The scale consists of six items, referring to sleep onset (sleep latency exceeding 30 min), wake after sleep onset (more than 30 min), early morning awakening (more than 30 min), non-restorative sleep, daytime impairment

and dissatisfaction with sleep. Each item is scored on an eight-point scale indicating the number of days per week for which a specific insomnia symptom is experienced (0–7 days). The scale was developed based on the diagnostic criteria for insomnia according to the fourth and revised version of the Diagnostic and Statistical Manual for Mental Disorders (DMS-IV-TR) (American Psychiatric Association 2000). In line with the ICSD-3 criteria (American Academy of Sleep Medicine 2014) insomnia disorder can be defined as reporting symptoms at least 3 days per week or more on at least one of the first three items as well as 3 days per week or more on at least one of the latter two items.

Dependent variables

Pain complaints were measured by assessing intensity and duration of symptoms or complaints during the last month prior to responding (Steingrimsdottir et al. 2004). Pain from six regions were assessed: 'headache', 'neck/shoulder/upper back', 'upper extremities' (arm, wrist, hand), 'lower back', 'lower extremities' (hip, knee, leg, foot), and 'abdomen'. Complaints were rated from 1 (not bothered by pain), 2 (a little bothered by pain), 3 (somewhat bothered by pain), to 4 (very bothered by pain). Complaint duration was rated in four categories: 1 (1–5 days), 2 (6–10 days), 3 (11–14 days) to 4 (15–28 days).

Data analysis

Multisite pain may have a greater impact on health than localized pain (Neupane et al. 2013), and may increase the likelihood for the pain to become chronic (Croft et al. 2006) and increases the risk of work disability (Miranda et al. 2010). Since currently it is not known whether shift work is associated with either localized pain or multisite pain, we used an explorative approach and included localized pain measures from each of the six body sites, in addition to two different metrics of multisite pain, widespread pain and number of pain sites (NPS) (Andrews et al. 2018; Nordstoga et al. 2017) as dependent variables.

Localized pain was defined as having pain of at least moderate intensity (response category 3) in at least one of the six regions. *Widespread pain* was defined as having pain in all four musculoskeletal pain regions ('neck/shoulder/upper back', 'upper extremities', 'lower back', and 'lower extremities'), with at least one region with moderate intensity pain. *Number of pain sites* (*NPS*) was operationalized as the number of pain regions endorsed having pain of moderate intensity, and could thus take a value between 0 and 6.

Statistical analyses

Our first hypothesis was that pain complaints would be associated with having a work schedule other than day only, which was treated as a reference. The binary pain variables (localized pain and widespread pain) were analyzed by logistic regression (not having localized or widespread pain as reference) and NPS was analyzed with negative binomial regression (treating increased NPS as increased severity). Work schedule comprised the independent variable and was treated as nominal in the analyses. Our second and third hypothesis treated the group as a whole (i.e., no stratification by work schedule) and investigated whether number of night shifts last year (no night shifts as reference), and number of QRs last year (no QR as reference), were associated with pain complaints. Finally, our fourth hypothesis investigated whether insomnia, was associated with pain complaints. In all analyses adjustments were made for age, sex, marital status, children living at home, and percentage of full-time equivalent position. Preliminary analyses were conducted to ensure no violation of the assumption of normality, linearity, multicollinearity and homoscedasticity. The statistical analyses were performed in Stata, version 15 (https://www.stata.com/).

Results

Work schedule and demographic variables

Four participants worked only evening time and were consequently excluded. Fifty-one participants responding with category "other schedule including night work" were included in the "three-shift" category. Twenty-three observations were missing, resulting in data from a total of 1558 nurses, divided into four work schedule groups. Table 1 presents the sizes of the work schedule groups and relevant descriptive statistics thereof, including statistical comparisons across work schedule groups by Chi square tests. Mean (SD) age was 32.5 (8.5) years (range 21–61 years). Nurses in the "day only" group were between 4.1 and 5.7 years older than the three other groups ($p < 0.001$). The male/female ratio was not different between groups ($p = 0.95$), neither was there any difference in terms of married/cohabiting status ($p = 0.24$). About three in four nurses in the "day only" group had children living at home, vs. 42.2%, 44.6%, and 54.0% in the other groups (all $p < 0.001$). More nurses in the "night only" group were working part time ($p < 0.001$). In the "day only" group, nine nurses worked 1–20 nights and eight worked > 20 nights. In the "two-shift" group, 119 nurses worked 1–20 nights and 78 worked > 20 nights. Still, the nurses were allocated to their initial group status in the analyses.

Table 1 Descriptive statistics on demographic and work related variables, by work schedule

	Day only (ref) ($n=80$)	Two-shift ($n=476$)	Night only ($n=129$)	Three-shift ($n=873$)
Age, mean (SD)	**37.4 (7.6)**	33.3 (9.4)	32.5 (7.8)	31.7 (7.9)
Sex (% female)	92.3	90.5	89.8	90.4
Married/cohabiting (% yes)	80.0	69.7	68.8	69.2
Children at home (% yes)	**74.4**	44.6	54.0	42.2
Percentage of full-time equivalent (%)				
< 50%	3.9	4.4	**6.5**	3.1
50–75%	14.3	18.6	**37.1**	19.3
76–90%	14.3	14.0	**20.2**	17.7
> 90%	67.5	63.1	**36.3**	60.0
Number of night shifts last year (%)				
0 nights	78.8	58.6	26.4	25.4
1–20 nights	11.3	25.0	17.1	28.0
> 20 nights	10.0	16.4	56.6	46.6
Number of quick returns last year (%)				
0 quick returns	67.5	21.0	38.0	14.7
1–20 quick returns	16.3	19.8	31.8	26.1
> 20 quick returns	16.3	59.2	30.2	59.2
Insomnia disorder (%)				
Not fulfilling criteria	37.5	52.4	34.4	52.8
Fulfilling criteria	62.5	47.6	65.6	47.2

Significant findings (Chi square test, $p < 0.001$) are in bold

Associations between pain complaints and work schedule

Localized pain was reported by 42.5% of the nurses in the "day only" group (Table 2). The proportion that reported pain did not differ from the three shift work groups (Tables 2, 4). The most prevalent pain region was neck/shoulder/upper back (reported by 67.7% of the nurses), followed by lower back (52.7%), headache (50.2%), lower extremities (45.7%), upper extremities (27.9%), and abdomen (23.6%).

Widespread pain was reported by 10.0% of the nurses in the "day only" group. The proportion that reported widespread pain did not differ from the three shift work groups (Tables 2, 4).

Of nurses in the "day only" group, 18.8% reported having pain in one region, 10.0% reported pain in two regions and 10.0% reported having pain in three regions (Fig. 1a, black bars). Less than 2.5% reported having pain in four regions or more. The proportion reporting pain in one or two regions was 4–5% points higher in the three non-daytime groups (Fig. 1a, red, green, and blue bars) than in the "day only" group. However, these group differences were not significant (Table 4).

Associations between pain complaints and night shifts, quick returns and insomnia

Localized pain of moderate intensity was experienced by slightly less than half of the nurses not working night shifts (Table 3). Adjusted logistic regression analyses showed that localized pain was not associated with the number of night shifts worked last year (Table 4). Of the nurses with no QRs last year, 42.9% experienced localized pain (Table 3), which was also not associated with the number of QRs last year (Table 4). The proportion of subjects with localized pain was 54.7% among those with insomnia and 36.7% among nurses without insomnia (Table 3). In the adjusted logistic regression analysis, localized pain was significantly associated with insomnia (OR 2.06, 95% CI 1.66–2.55) (Table 4).

Widespread pain was experienced by approximately one in ten nurses without night shifts (Table 3). Adjusted logistic

Table 2 Descriptive statistics on localized and widespread pain, by work schedule

	Day only (ref) ($n=80$)	Two-shift ($n=476$)	Night only ($n=129$)	Three-shift ($n=873$)
Localized pain (% yes)	42.5	48.5	46.5	44.4
Widespread pain (% yes)	10.0	9.7	13.2	9.3

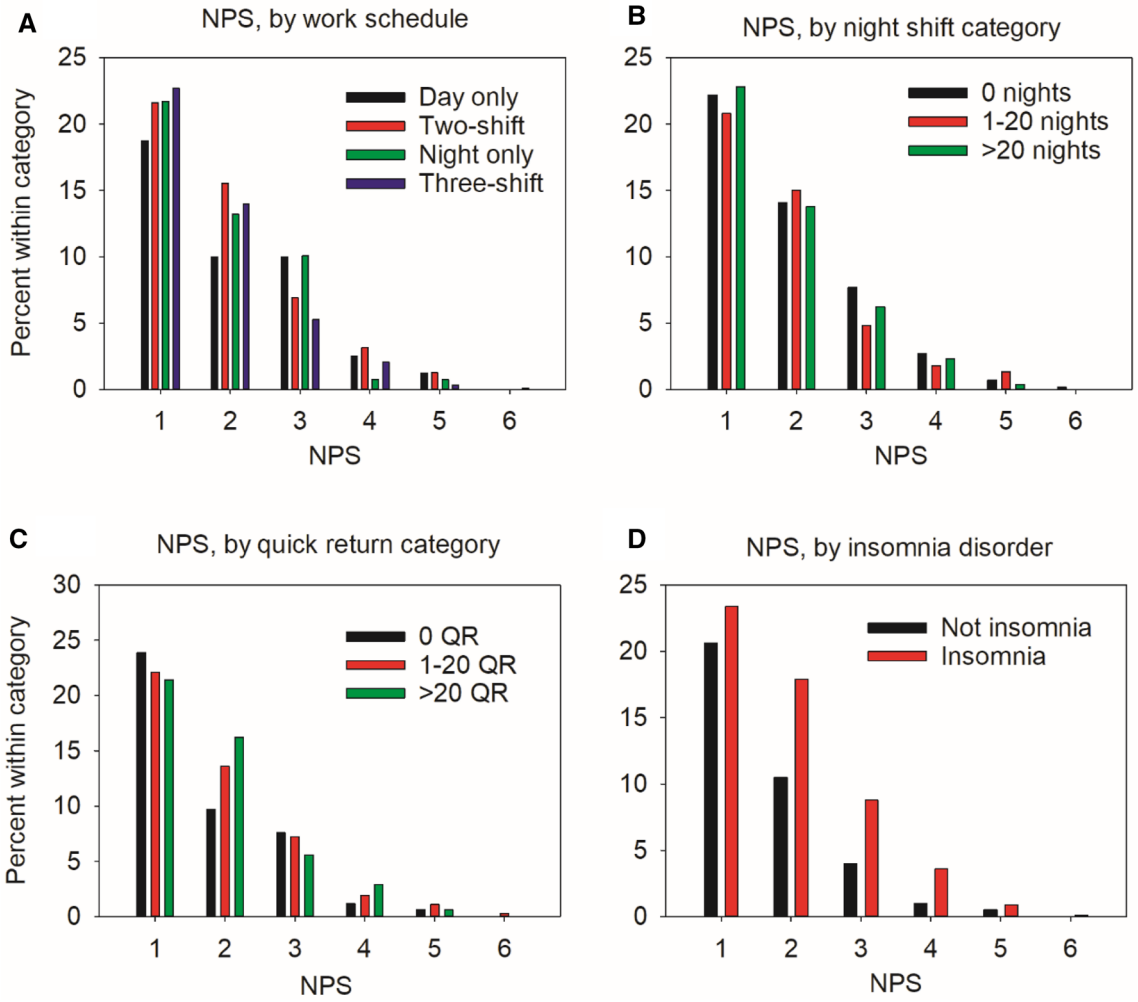

Fig. 1 Distribution of number of pain sites (NPS) by **a** work schedule, **b** night shift category, **c** QR category, and **d** insomnia disorder. Percentages are within category. Percentages of zero pain sites are omitted. *QR* quick returns

Table 3 Descriptive statistics on localized and widespread pain, by night shift category, quick return category and insomnia disorder

	Localized pain	Widespread pain
Number of night shifts last year (%)		
0 nights	47.5	10.7
1–20 nights	43.7	8.1
> 20 nights	45.4	9.9
Number of quick returns last year (%)		
0 quick returns	42.9	7.3
1–20 quick returns	46.0	10.6
> 20 quick returns	46.8	10.3
Insomnia disorder (%)		
Not fulfilling criteria	36.7	6.6
Fulfilling criteria	54.7	12.9

regression analyses showed that widespread pain was not associated with number of night shifts worked last year (Table 4). Of the nurses with no QRs last year, widespread pain was reported by 7.3% (Table 3). Widespread pain was also not associated with number of QRs worked last year (Table 4). The proportion of nurses with widespread pain was 12.9% among those with insomnia and 6.6% among those without insomnia. In the adjusted logistic regression analysis, widespread pain was significantly associated with insomnia (OR 2.14, 95% CI 1.47–3.09) (Table 4).

NPS did not vary significantly by the number of night shifts worked last year (Fig. 1b), as shown by adjusted negative binomial regression analysis (Table 4). NPS tended to be associated with number of QR worked last year, when contrasting the '> 20 QR' and '0 QR' categories (IRR 1.18 95% CI 0.98–1.43) (Table 4). According to Fig. 1c, the effect seemed to be driven by nurses with two pain sites. NPS were higher among nurses with insomnia than among nurses

Table 4 Separate adjusted logistic (localized and widespread pain) and negative binomial (NPS) regression analyses with three different pain measures as dependent variables

	Localized pain			Widespread pain			NPS		
	OR	95% CI		OR	95% CI		IRR	95% CI	
Work schedule									
Day only	1.00			1.00			1.00		
Two-shift	1.39	0.84	2.31	1.09	0.48	2.47	1.14	0.81	1.61
Night only	1.34	0.73	2.43	1.85	0.72	4.71	1.09	0.73	1.63
Three-shift	1.22	0.74	2.00	1.18	0.54	2.62	0.98	0.70	1.38
Number of night shifts last year									
0 nights	1.00			1.00			1.00		
1–20 nights	0.89	0.68	1.16	0.88	0.55	1.41	0.91	0.76	1.10
> 20 nights	0.92	0.72	1.17	1.08	0.72	1.63	0.90	0.76	1.06
Number of quick returns last year									
0 quick returns	1.00			1.00			1.00		
1–20 quick returns	1.10	0.81	1.04	1.46	0.84	2.53	1.13	0.91	1.40
> 20 quick returns	1.22	0.93	2.14	1.49	0.92	2.43	1.18	0.98	1.43
Insomnia disorder	**2.06**	**1.66**	**2.55**	**2.14**	**1.47**	**3.09**	**1.71**	**1.48**	**1.97**

Adjustment variables: age, sex, percentage of full-time equivalent, marital status, and children living at home

OR Odds ratio, *IRR* Incidence rate ratio, *NPS* Number of pain sites, Insomnia disorder

Significant findings are shown in bold

without insomnia (Fig. 1d). In the adjusted negative binomial regression analysis, NPS was significantly associated with insomnia (IRR 1.71 95% CI 1.48–1.97) (Table 4).

Associations between pain complaints and confounders

In terms of the confounders, only age and sex were significantly associated with any of the pain measures. Age was positively associated with all three pain measures (localized, widespread, and NPS), strongest with widespread pain (OR 1.07 95% CI 1.05–1.09). Being female was associated with localized pain (OR 1.51 95% CI 1.05–2.17), widespread pain (OR 2.68 95% CI 1.20–5.97), and with NPS (IRR 1.32 95% CI 1.02–1.71).

Discussion

The present study showed that pain complaints were not associated with shift work schedule, or with number of night shifts previous year, and weakly associated with number of quick returns previous year. Pain complaints were positively associated with having insomnia disorder.

Work schedule was not associated with pain complaints in the present study, which is in contrast to several other studies. At least two longitudinal studies support the hypothesis that shift workers are at higher risk for developing low back pain (Zhao et al. 2012), or for developing pain in the neck, shoulder or back (Trinkoff et al. 2006). Also cross-sectional studies of shift workers within the health sector (Attarchi et al. 2014; Lipscomb et al. 2002) and the transportation sector (Joksimovic et al. 2002) reported higher levels of pain complaints than non-shift workers, whereas a recent cross-sectional study, based on the same cohort as the present study, did not find any association between work schedule and different types of headaches (migraine, tension-type headache and medication-overuse headache) (Bjorvatn et al. 2018). Several explanations may contribute to the divergent findings between the present and the abovementioned studies. Firstly, the fact that more nurses were working part time in the present study's 'night only' group, could have contributed to this group being less afflicted by complaints than in the abovementioned studies. A second factor concerns the definition of pain. Participants in the present study were asked to what degree they had been 'somewhat bothered' or 'very bothered' by pain in six different regions. In the studies by Attarchi et al. (2014), Lipscomb et al. (2002), and Trinkoff et al. (2006), however, the pain definition was less specific, including terms as 'numbness, tingling and stiffness', which may have lowered the threshold for reporting complaints in these studies. A difference also relates to the distribution of pain, which in the present study was quantified as number of pain sites and widespread pain. Number of pain sites has shown a strong linear relationship with overall health (Kamaleri et al. 2008). Widespread pain, adapted from the 1990 criteria of the American College of Rheumatology, however, is stricter, requiring pain above and below the waist (Wolfe et al. 1990). A third factor that may partly explain the negative findings in the present study,

is the so-called 'healthy worker effect'. This assumes that shift workers have better health than those who both avoid and/or quit shift work (Knutsson 2004). Time from exposure to effect is a fourth factor that could have contributed to the present study's negative findings as pain following night shifts may be too short-lived to be detected by a study design, such as the present one. Indeed, when nurses are followed on a day-to-day basis, having worked the previous night increases pain complaints in several regions the following day (Katsifaraki et al. 2018).

Number of night shifts was not associated with pain complaints in the present study, which is in contrast to two other Norwegian studies. A longitudinal study on nurses' aides found that working night shifts 'sometimes' or 'very often' predicted low back pain-related sick leave exceeding 14 days (Eriksen et al. 2004). Possible explanations for the divergent findings may lie in different definitions of both shift work exposure and pain outcome. Number of night shifts was also associated with headache in a previous study based on the same cohort as the present study (Bjorvatn et al. 2018), a difference probably attributable to a more precise definition of headache (tension-type headache) than in the present study.

Having worked > 20 QRs the previous year tended to be associated with number of pain sites (OR 1.18, CI 0.98–1.43). A similar finding was reported by Trinkoff et al. (2006), who found that 'less than 10 h off between shifts' increased the risk for developing pain in the neck, shoulder and back. Given the detrimental effect of QRs on sleep (Vedaa et al. 2015), it is not surprising that QRs also increase pain risk. When the effect was not stronger in the present study, it is possible that the time course from exposure to effect plays a role, as suggested for night shift exposure. Future studies should look into whether short rest breaks between shifts increases the risk for reporting pain the following day(s).

Taken together, the majority of the abovementioned studies support an association between non-daytime work and an increased risk for musculoskeletal pain complaints, contradicting the present findings. Several differences exist between the studies, both in how work schedule exposure was defined and in how pain complaints were assessed, but also in terms of study design. As for work schedule exposure, it is most common to dichotomize cohorts based on whether they work regular daytime or shift work. If the group labeled 'shift work' is not properly defined, it may essentially be quite heterogeneous. This is exemplified with a question from a study simply asking the participants "What was your work schedule most often during the last year (day work or shift work)?" If no description is given of what 'shift work' entails, this leaves it to the worker to define whether he/she is a shift worker. In the present study, we gave the nurses the option to select between six relatively specific work schedule categories. Still, this may introduce noise in the material, which we identified two examples of in the present study. The first example was that a relatively large proportion of the 'day only' workers also worked nights (Table 1). Presumably this is because they once in a while take on extra work that could be night work. The second example was that a relatively large proportion of the 'night only' and 'three shift' workers reported working zero nights the previous year (Table 1). This is an odd combination of answers that does not have an obvious explanation. The fact that presumably mutually exclusive categories are misunderstood by the respondents, indicates a weakness with questionnaire data that may remain unsolved until register-based measures of actual working time patterns are in place (Härmä et al. 2015). To remedy the weaknesses with work schedule categories, one option is to assess other working time parameters with potential impact on the outcome of interest. This was done in the present study. Also the studies by Trinkoff et al. (2006) and by Lipscomb et al. (2002) are good examples of stratifying exposure into a range of dimensions, such as weekends per month, working more than 13 h, break frequency and time off between shifts.

We found a significant association between insomnia disorder and all three pain measures. An association between insomnia and pain is in accordance with several longitudinal studies (Boardman et al. 2006; Sivertsen et al. 2014; Uhlig et al. 2018), and supports the notion that a primary aim should be to design work schedules facilitating good sleep. Thus, when defining exposure items in futures studies, working time dimensions that are relevant for sleep length and sleep quality is warranted, since sleep disturbances may be one of the mediators between adverse working hours and pain. This dimension is scarcely studied, but a recent study found that elevated abdominal pain after night shifts most likely was mediated by short sleep duration (Katsifaraki et al. 2018). A review of 15 experimental studies points to reduced sleep duration as a highly likely mediator as this increases pain perception (Schrimpf et al. 2015) and sleep quality seems to affect next day's pain (Tang et al. 2012). Thus, elements of the work schedule that may affect sleep (duration, quality, awakenings, etc.) should be assessed, e.g., the possibility for taking a nap. Napping at day time reverses increased experimental pain sensitivity due to sleep restriction (Faraut et al. 2015). Napping during working hours has also been associated with reduced clinical pain among nursing home care workers working at night (Takahashi et al. 2009).

As for the measurements of pain complaints, most previous studies, including the present one, used variants of the Nordic Musculoskeletal Questionnaire, which by many is considered a standard tool in epidemiological studies evaluating musculoskeletal complaints. Since the literature on working hours and pain complaints is only in its infancy, we decided for an explorative approach when

defining pain. We investigated three definitions that have commonly been used, one measure of localized pain and two measures of multisite pain. Not having any a priori hypotheses on which pain measurement to use is a limitation. However, our consideration was that for the nurses, it is more important that we identify the work parameters associated with pain, than how it is conceptualized. Our analysis is based on an assumption that localized pain is a different entity than widespread pain, and not simply a graded severity. This is in line with treatment approaches in pain clinics, whereas central mechanisms and/or genetics are considered to be more important for widespread than localized pain (D'Agnelli et al. 2019; Nijs et al. 2010). However, we also included a graded measure of pain, i.e., number of pain sites, in order to be able to evaluate how shift work affect the severity of pain in a graded manner, acknowledging that increased distribution of pain also may be viewed as a measure of increased burden of pain.

A strength of the present study was that it was based on a relatively large and homogenous sample limiting the influence from possible specific confounding variables. The questions covered a broad range of work factors, demographics and health complaints. Thus, there is no reason to expect that the cohort was biased towards having more pain complaints than the general nursing population. We also consider the use of a validated and specific pain questionnaire a strength. Using three different measures of pain in the analysis is also considered a strength, although it may increase the risk of type II errors. With an explorative approach as in the present study, we would argue that focus on a strict significance threshold is limiting. Instead, one should allow paying attention to those tests that fell just below the significance threshold, where interesting ideas for futures studies may be picked up. A limitation of the present study is the uneven sex distribution across groups, taking into consideration that pain complaints are more prevalent in women (Bartley and Fillingim 2013). The response rate may also be considered low, especially in wave 1. Another limitation was that several work factors known to affect musculoskeletal pain complaints were not taken into account, such as psychosocial and mechanical factors (see, e.g., Andersen et al. 2013; Christensen and Knardahl 2010). A final limitation is that reverse causation cannot be excluded as pain experience may lead to shift selection.

In conclusion, the present data do not support the hypothesis that non-daytime work schedules are associated with pain complaints in nurses. Neither was there support for the hypothesis expecting a positive association between number of night shifts and pain complaints. We cannot exclude an association between quick returns and pain complaints, but further studies are needed to determine this association in more detail. Pain complaints were associated with insomnia. It's concluded that a primary aim in occupational settings should be to design work schedules facilitating good sleep.

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