Long working hours are inversely related to sick leave in the following three months: A four-year registry study.

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ABSTRACT

Purpose The aim of this study was to investigate the effects of long working hours (≥12 hour shifts) on sick leave using objective records of shift work exposure and of sick leave.

Methods A total of 1,538 nurses (mean age: 42.5, *SD*: 12.0; response rate 42%) participated. Payroll and archival sick leave data over a four-year period were retrieved from employers' records and aggregated over every third calendar month. A multilevel negative binomial model was used to investigate the effects of exposure to long working hours, on subsequent sick leave rates the following three months. Covariates included prior sick leave, number of shifts worked, night and evening shifts, personality, and demographic characteristics.

Results Exposure to long working hours was associated with fewer sick leave days in the subsequent three months [adjusted model, incidence rate ratio (IRR)=0.946, 95%CI=0.919-0.973, $p<0.001$]. The interaction long working hours by a number of work days showed that sick leave days the subsequent three months was higher by long shifts when number of shifts was high compared to when number of shifts was low [adjusted model, IRR=1.002, 95%CI=1.000-1.004, $p<0.05$].

Discussion Long working hours was associated with fewer sick leave days. The restorative effects of extra days off with long working hours are discussed as possible explanations to this relationship.

Key words: Long working hours, Extended daily working hours, Long shifts, Sick leave, Sickness absence

INTRODUCTION

Shift work is particularly common in the healthcare sector where about one third of the employees are working shifts (Parent-Thirion et al. 2007). The consequences of shift work have been widely investigated over the last decades, with results showing that shift work increases the risk of morbidity, and conceivably also mortality (Knutsson 2017). Consequently, attempts have been made to reduce the negative consequences of shift work, either by changing the length of working hours, changing from fixed to rotating schedules (or vice versa), or altering the speed and direction of rotations, and so forth. However, there does not seem to exist one optimal shift system that preserves the health and accommodate all individuals. Instead, most shift work systems have their pros and cons.

One controversy relates to the topic of the optimal daily length of working hours. Long working hours generally refer to shifts that are longer than 8 hours, which across studies can be 9, 10, 11, or 12-hour shifts. In a comprehensive review of 105 studies, Knauth (2007) provided an overview of the consequences of extended daily working hours (also referred to as long shifts/long working hours). One main concern is the negative impact on fatigue and safety, as most reports have indicated that long working hours are associated with increased risk of accidents (Knauth 2007). One study showed that, compared to 8-hour shifts, the risk of accidents increased by 13% when working 10-hour shifts, and by 27% when working 12-hour shifts (Folkard et al. 2005). Performance and alertness appear to be particularly impaired during the last hours of long shifts (Rosa and Bonnet 1993). Most reports suggest that long working hours lead to reduced duration and quality of sleep, although a considerable number of studies also show the opposite pattern, that long shifts lead to improved sleep (Knauth 2007). Whether or not sleep is influenced by the length of shifts is likely dependent on other

factors related to the different schedules that are being compared, such as the start and end times of the shifts, and whether the shifts in question are day shifts or night shifts as well as placement of off work periods (Aguirre et al. 2000; Knauth 2007).

In terms of other measures of health, long working hours have been associated with diabetes (Bannai et al. 2016), stroke and coronary heart disease (Kivimäki et al. 2015), as well as the development of depression and anxiety symptoms (Virtanen et al. 2011). Although most studies seem to suggest more adverse health effects of 12-hour shifts than of 8-hour shifts (van der Hulst 2003), others fail to identify any differences between the two, and indeed others have even found better health among workers on 12-hour shifts (Knauth 2007). Methodological differences and shortcomings across studies may account for some of the contradictory findings. For example, the comparability of the reference groups used across studies has been brought into question (van der Hulst 2003). In addition, potential moderators are rarely included in the models. Demographics, work and domestic characteristics, and personality traits associated with tolerance to shift work should be included as covariates in the statistical models employed (van der Hulst 2003). Other shortcomings pertain to the fact that there are mainly cross-sectional studies on this topic. More studies using longitudinal designs to elucidate the effects of long working hours are thus called for. A potential limitation of previous longitudinal studies has been that they typically use subjective reports of work hours at baseline as a predictor of subsequent health assessed at a follow-up evaluation. By this, one neglect to take into account whether or not the workers have been exposed to long working hours in the time from the baseline assessment leading up to the follow-up assessment (van der Hulst 2003). Thus, methodological approaches that can provide a more accurate measure of the exposure to long working hours over time are needed.

Sick leave refers to absence from work that is attributed to sickness, and is often used as a global measure of health (Hensing et al. 1998). Although employees can sometimes go to work in spite of being sick, and at other times have absence without actually being sick (e.g. because they need to stay home and take care of an ill family member), sick leave is by most researchers accepted as a surrogate of physical and social functioning (Marmot et al. 1995). Results from studies investigating the relationship between long working hours and sick leave have tended to either indicate no relationship (Jozef 1990) or an inverse relationship between the two (Smith et al. 1998). For example, a longitudinal study of more than 2,800 individuals found that those who worked long hours were less likely to take long sick leave than those who did not work long hours (Magee et al. 2011). However, a cautionary note when interpreting results linking long working hours to reduced risk of sick leave is that workers who work long shifts (e.g. 12-hour shifts) also have fewer potential work absence days, compared to workers on 8-hour shifts. Previous findings on this topic may thus represent an artefact of this (Smith et al. 1998). It is therefore important that researchers adjust for differences the previous number of work days in their models.

Shortly summarised, results from previous studies are ambiguous regarding the consequences of long working hours in terms of sick leave, and there are obvious methodological shortcomings in many of the previous conducted studies. On that account, the aim of the present study was to employ a more rigorous methodological approach to investigate whether long working hours are associated with future sick leave, using a sample of nurses and nurses' assistants.

METHODS

Subjects and procedure

This study was based on data from the Registry study of Working hour, Health and Sickness absence (RWHS) at the University of Bergen, Norway. Nurses and nurses' assistants (89.2% and 10.8%, respectively; hereinafter referred to as 'nurses') employed in a 50% position or more (>18h/week) at Haukeland University Hospital in Bergen (*N*=3,706) were asked to participate. A total of 1,538 nurses (response rate = 42%) agreed, where 991 responded via an e-mail invitation sent to their work e-mail, and another 547 responded to reminders that were sent out by letters to their home address. Non-responders were sent up till two reminders by e-mail, followed by up till two reminders by letters (including a pre-paid return envelope). The nurses were sent the first invitation to participate by e-mail in May 2013. The last completed questionnaires were returned in February 2014.

Participation required nurses to respond to a questionnaire assessing demographics and personality characteristics. In the invitation letter, the nurses were informed that by participating they implicitly gave their consent to the retrieval of their payroll and archival sick leave data from the employers' records (i.e. Haukeland University Hospital in Bergen), and that their questionnaire data could be linked with their payroll and sick leave records for purpose of the present study.

Registry data

Information about date, start and stop times for every shift the nurses had completed from the year 2010 throughout 2013 (four years) was retrieved from the local records at Haukeland University Hospital in Bergen. Long shifts were defined as shifts lasting 12 hours or more. The long shifts started and ended at various times throughout the 24-hour day, and no distinctions were made between long shifts that could be characterised as day, evening, or night shifts. Night shifts were defined as working 3 hours or more between 23:00 and 5:00 hours. Evening shifts were defined as working 3 hours or more from 18:00 hours or later.

Night and evening shifts were identified hierarchically, where shifts that overlapped the two definitions were characterised as night shifts based on the assumption that night shifts are more disadvantageous than evening shifts. These definitions of night and evening shifts have also been used in other studies (e.g. Vedaa et al. 2017). Archival sick leave records were also retrieved from the employers' records, and included information about the date of every full day of absence due to sickness from 2010 throughout 2013. Thus, these data included both short and long term sick leave. Absence from work to care for sick children was not counted as sick leave in the present study. Furthermore, a distinction was made between the number of sick leave days and the number of sick leave spells (periods of absence) during the four-year period.

Questionnaire data

Nurses provided information on demographic characteristics such as sex, age, marital status and having children living at home (Table 1). In addition, since the registry data only tracked back to 2010, the questionnaire also asked for the total number of years the nurses had been engaged in shift work (i.e. their shift work experience). Standardised questionnaires measuring the personality traits morningness (the Diurnal Scale, DS) (Torsvall and Åkerstedt 1980), flexibility and languidity (the revised Circadian Type Inventory, CTI) (Di Milia et al. 2005) were also included.

The morningness personality trait comprises a continuum ranging from those who prefer to rise early and go to bed early (morning types), and those who prefer to rise late and stay awake late(evening types) and was assessed by the Diurnal Scale (DS) (Torsvall and Åkerstedt 1980). The DS is a seven-item instrument where higher scores reflect a tendency towards morning type, and lower scores reflect a tendency toward evening type. Furthermore, this scale was specifically developed to assess the morningness-eveningness dimension in a

shift working population, where the items are designed to reflect individual preferences of bedtime, rise time, and time for activity during the day regardless of irregular working hours (Torsvall and Åkerstedt 1980). The DS has shown adequate convergent validity compared to other self-report scales measuring the morningness personality dimension (Thun et al. 2012). Cronbach's alpha of the DS in the present study was .60.

The revised Circadian Type Inventory (rCTI) is an eleven-item instrument measuring the personality traits flexibility and languidity (Di Milia et al. 2005). Five items measure flexibility, where high scores reflect better ability to sleep and work at odd times. Six items measure languidity, where higher scores reflect more difficulties overcoming drowsiness and feelings of lethargy upon losing sleep. The psychometric properties of the rCTI have been established showing good reliability and validity of the scales in a working sample (Di Milia et al. 2005). Satisfactory Cronbach's alphas were also confirmed in the present sample, with .83 for flexibility and .72 for languidity, respectively.

Statistical approach

All statistical analyses were carried out using STATA/SE V.15.0 (StataCorp. Stata Statistical Software: Release 15. College Station, Texas: StataCorp LP, 2017). In preparation for our analyses, the number of exposures to long shifts, night shifts and evening shifts, as well as number of sick leave days and sick leave spells as outcome measures, were aggregated over every third calendar month from the year 2010 throughout 2013. Number of exposures to the different shifts over a three-month period was then examined as predictors to number sick leave days and sick leave spells the subsequent three month period. Each individual could thus contribute with up to 15 pairs of prospective observations which could be studied in a multilevel model with observations clustered within individuals (e.g. Rabe-Hesketh and Skrondal 2012). The rationale for choosing to aggregate over every third calendar month

stemmed from the fact that long shifts were relatively infrequent events among these nurses, and time brackets of three months were deemed necessary as a reasonable accumulation of exposure to have an impact on sick leave.

A multilevel negative binomial analysis (Stata command: menbreg) gave the best model fit for sick leave as outcome measure and was therefore used in the present study. Number of long shifts over a three-month period was used as an independent variable, whereas number of sick leave days and spells in the subsequent three months comprised the dependent variables in two separate analyses. Covariates included prior sick leave (days and spells, respectively) during the three-month exposure periods, total number of shifts worked during the three-month exposure periods, and number of night shifts as well as number of evening shifts during the three-month exposure periods. Covariates also included scores on the personality characteristics morningness (DS), languidity (rCTI), flexibility (rCTI), and the total number of years the nurses had been working shift (self-report), as well as demographic characteristics such as sex, age, cohabitation, and whether the nurses had children living at home. The analyses were performed in three steps: (1) A minimally adjusted model including number of long shifts over a three-month period, sex and age as predictor variables; (2) a fully adjusted model including number of long shifts over a three-month period and all the above mentioned covariates; and (3) the fully adjusted model from step 2, that also included interaction effects (see Table 2). The interaction effects were modelled by product terms where we multiplied the number of long shifts over a three-month period with the demographic and background variables (sex, age, having children living at home, cohabitation, shift work experience, number of shifts worked during the three-month exposure periods, morningness, languidity, and flexibility, respectively). Continuous variables were centred for the interaction analysis. Significant interaction effects would be subjected to a post hoc probing procedure.

The separation between sick leave days and sick leave spells in the analyses was based on the reasoning that a high number of days absent may be a general reflection of how much the workers are set back by their reduced functioning and health problems. A high number of sick leave spells implies more fluctuations in and out of sick leave, where sick leave may be used more as a coping strategy to recuperate from the strains of working.

The default output of multilevel negative binomial analyses in STATA are log counts, which were converted into incidence rate ratios (IRR) and reported in the present study. An alpha level of .05 was set to signify statistical significance.

RESULTS

The majority of the nurses were female (88%), and the mean age was 42.5 years (*SD* = 12.0; age ranged from 22 to 73 years). Table 1 provides an overview of the demographic characteristics of the nurses and key characteristics of their shift work schedule. Eight hundred and fifty-one nurses (55%) had one or more long shift (≥ 12 hours) during the four-year period of records. The mean number of long shifts during a three-month period was 2.7 (*SD*=3.8), and the mean duration of the long shifts was 13.7 hours (*SD*=2.0). The majority of the long shifts were of 12.0-13.0 hours (60%), and few long shifts were of more than 16.0 hours (<10%). Furthermore, the nurses who worked the different shifts had a mean number of 23.1 (*SD*=14.4) day shifts, 12.0 (*SD*=6.5) evening shifts and 10.2 (*SD*=9.3) night shifts for every three-month period, and the nurses had a mean number of 2.6 (*SD*=6.3) sick leave days and 1.3 (*SD*=6.3) sick leave spells for every three-month period.

Shift work on sick leave

The results from the fully adjusted multilevel negative binomial model (Table 2) showed that having a higher number of long shifts during a three-month period was associated

with fewer sick leave days (incidence rate ratio, IRR=0.946, 95% CI=0.919-0.973) and sick leave spells (IRR=0.952, 95% CI=0.928-0.978) in the subsequent three month period. The mean number of long shifts over three-months were 2.7, which based on these results corresponds to 14% lower total number of sick leave days the subsequent three months, compared to those who had no long shifts. The number of shifts the nurses had during the three-month periods of exposure was associated with a higher number of sick leave days (IRR=1.012, 95% CI=1.008-1.015) and sick leave spells (IRR=1.006, 95% CI=1.003-1.009) during the subsequent three months. The number of years with shift work experience reported by the nurses was unrelated to sick leave.

Exposure to night shifts during three-months was not associated with sick leave the subsequent three months. However, being exposed to evening shifts during three-months was associated with a higher number of sick leave days (IRR=1.009, 95% CI=1.002-1.016) and sick leave spells (IRR=1.011, 95% CI=1.005-1.017) in the subsequent three months. The mean number of evening shifts during three months was 9.6 (*SD*=7.6), which corresponds to an expected IRR of 1.087, i.e. 9% higher number of sick leave days the subsequent three months, compared to those who had no evening shifts.

Interaction effects

Analyses of interaction effects indicated that the product term of number of shifts over three months by number of long shifts over three months was associated with a higher total number of sick leave days during the subsequent three months (IRR=1.002, 95% CI=1.000-1.004). This association was not significant when looking at number of sick leave spells as outcome (IRR=1.002, 95% CI=1.000-1.004). None of the other interaction terms examined showed any significant association to neither number of sick leave days nor spells (see Table 2). The significant interaction effect between total number of shifts and number of long shifts

were further explored in a post hoc probing procedure, where the association between number of long shifts and sick leave days was examined at low (-1SD), medium (mean), and high (+1SD) total number of shifts. A simple slope test showed a significant association between number of long shifts and sick leave days at low (β=-.269, 95% CI=-.425 to -.113, *p*=.001), medium (β=-.224, 95% CI=-.347 to -.101, *p*<.001), and high (β=-.155, 95% CI=-.277 to -.032, *p*=.013) total number of shifts (Figure 1).

Personality, prior sick leave, demographics and sick leave

The results from the fully adjusted model showed that scoring high on the personality characteristic languidity was associated with a higher total number of sick leave days (IRR=1.032, 95% CI=1.015-1.048) and sick leave spells (IRR=1.030, 95% CI=1.016-1.045). None of the other personality characteristics were related to sick leave. The results also showed that age was positively associated with a higher total number of sick leave days (IRR=1.006, 95% CI=1.000-1.011), but not sick leave spells (IRR=1.003, 95% CI=0.998-1.008). The other demographic characteristics; including sex, children living at home, and cohabitation were unrelated to sick leave. Sick leave days and sick leave spells during the three month exposure period were associated with a higher total number of sick leave days (IRR=1.054, 95% CI=1.049-1.059) and sick leave spells (IRR=1.107, 95% CI=1.097-1.117), respectively, during the subsequent three months.

Additional analyses

The analyses described above were also conducted without including prior sick leave as a covariate, where the results were similar to those described above with slightly stronger effects. Similarly, the analyses were repeated on female subjects only, where the results were

similar to the entire sample, with only slight differences in effect estimates. The results from these additional analyses are not reported in this study.

DISCUSSION

The primary objective of the present study was to examine whether exposure to long working hours was related to subsequent sick leave in a sample of nurses. The result showed that being exposed to a higher number of long shifts (≥12 hours) during a three-month period was associated with a significantly reduced total number of sick leave days and spells in the subsequent three months. Exposure to night shifts and evening shifts were controlled for in the analyses. The results regarding these variables showed that being exposed to night shifts was unrelated to sick leave during the subsequent three months, while being exposed to evening shifts was associated with a higher total number of sick leave days and spells during the subsequent three months.

Long working hours have also previously been associated with a reduced risk of sick leave (Bernstrøm and Houkes 2018), and the present study lend further support to these observations by confirming the findings by using a more stringent methodological approach. In particular, the present study is unique as it investigated long working hours and sick leave by utilising objective assessments of both the exposure and outcome variables, together with the fact that the analyses controlled for previous sick leave, the number of work shifts the workers had, and shift work tolerance personality characteristics, among other relevant covariates. Also, sick leave was registered from the first day of absence, which is rare in sick leave research that uses registry data. Indeed, the results showed that previous sick leave, number of work days, and a higher score on the personality characteristic languidity, were all significantly associated with more subsequent sick leave. This emphasises the importance of including these variables as covariates when investigating the relationship between shift work

and sick leave. Notably, the fact that the present study controlled for the number of shifts the nurses had, helped reduce the potential artefact in terms of number of work days. All things considered, the present study provides strong evidence that long working hours are associated with reduced total number of sick leave days and spells over a three month period.

In general, the number of work days per year for a worker on a 12-hour shift system is two-thirds of that to a worker on an 8-hour schedule (Knauth 2007). It is possible that having more days off bring about restorative effects that prevent workers on a 12-hour system from getting sick as often as workers on 8-hour schedules. This was also supported by the interaction analysis in the present study, where having long working hours in combination with a higher total number of shifts, was associated with more subsequent sick leave days in the following three months, compared to having long working hours in combination with fewer total number of shifts. Furthermore, there are also reports to suggest that healthcare workers experience less stress and more satisfaction with long working hours compared to 8-hour schedules (Dwyer et al. 2007; Kalisch et al. 2008; Knauth 2007; Stone et al. 2006), and that long shifts permit more time to plan, prioritise and execute the work tasks (Ingstad and Amble 2015; Richardson et al. 2007). Another possible explanation to the reduced sick leave among these workers is that they may possess characteristics that facilitate adaptation to long working hours. Characteristics that constitute tolerance to shift work may include sex, age, and personality, as summarised by Saksvik and colleagues (2011). These were among the characteristics that were controlled for in the present investigation, in addition to marital status, children living at home, and shift work experience. Therefore, to the extent that individual characteristics are the reasons behind the lower number of sick leave days among workers on long working hours, other characteristics than the ones controlled for in the present study need to be explored. However, the presence of any such characteristics among workers on long working hours rest on the assumption that there is a selection of workers into

(or out of) these shifts. Indeed, considering that scheduled long shifts are unconventional among healthcare workers in Norway, where a substantial proportion of the long working hours in this study were unscheduled overtime, that were voluntarily or involuntarily imposed on the workers, the presence of some form of selecting factor is plausible. For example, tolerant individuals may be more likely to say yes to working overtime, in addition, the mere opportunity to agree to work overtime is likely to influence the negative effects of demanding shifts. One study suggested that high control over one's working hours reduced the effects of long working hours on workers sick leave rates (Ala-Mursula et al. 2006). Furthermore, agreeing to work unscheduled overtime also comes with a considerable increase in the hourly pay, which may ameliorate some of the negative impacts these types of long working hours may have.

Another proposed explanation to the lower number of sick leave days associated with working long hours is that these workers may have a higher degree of presenteeism (working while sick) than regular day workers – for example due to a greater colleague solidarity and a higher threshold for calling in sick on short notice (Costa 1996; Estryn-Béhar and Van der Heijden 2012). It has also been suggested that shift workers, as opposed to day workers, more often view benign symptoms of impaired health as constituents of their work schedule, and not necessarily as something that justifies calling in sick (Thierry and Jansen 1998). However, the degree to which these factors explain the association between long working hours and fewer sick leave days remains unclear. As yet, the overall evidence seems to suggest beneficial effects of long working hours (≥12-hour shifts) in terms of sick leave rates as an outcome (Bernstrøm and Houkes 2018). It should also be noted that the present study examined the accumulative effects of long shifts without distinguishing between those who worked long shifts due to unscheduled overtime, those who only worked long shifts occasionally, or those who worked long shifts on a permanent basis. According to Ingstad and

Amble (2015), the full range of benefits of long working hours – that eventually lead workers to experience reduced stress and 'a newfound peace' at work – are only obtained once the whole department remits to a long shift schedule (e.g. due to better continuity and more freedom to prioritise the work tasks).

A systematic review of the effects of different shift schedules on sick leave maintained that there was no conclusive association between night work and sick leave, while fixed evening work appeared to be associated with an increased risk of sick leave (Merkus et al. 2012). The results from the present study support these observations, and further suggest that evening work in a rotating schedule is associated with a higher sick leave rate. It is not yet clear why night work would be unrelated to sick leave, considering the vast evidence of the detrimental health effects of night work. Certainly, the factors discussed in relation to long working hours, such as a higher degree of presenteeism, and a higher degree of selection of healthier and more tolerant individuals into such shifts ("the healthy shift worker effect"), may be applicable to workers on night shifts as well. It can be speculated that these factors mainly contribute as far as to equalise the initial difference between night workers and those not enrolled in night work when it comes to the relationship with sick leave as an outcome. Exposure to evening shifts contrasts with the other shifts in that the former consistently appears to lead to an increased risk of sick leave. The major cause of this may be the social consequences of evening work, and in particular the asynchrony with family life that accompany evening work, which in many respect can be worse than that of the social consequences of working during nights (Karhula et al. 2018; Presser 2006). In addition, evening shifts are sometimes followed by a rapid changeover to a day shift the next day, leaving workers with less than 11 hours of rest between the shifts – denoted as quick returns. Quick returns have been associated with increased sick leave rates in one previous study (Vedaa et al. 2017).

Notably, higher scores on the personality characteristic languidity were associated with a higher number of sick leave days. Languid individuals are believed to have a lower amplitude of their circadian rhythm, which makes them vulnerable to sleep loss in terms of difficulties overcoming drowsiness, as compared to individuals who score low on languidity (i.e. vigorous individuals) (Di Milia et al. 2005). Previous studies have shown that languid individuals have more difficulties maintaining alertness during shifts (Di Milia et al. 2005; Smith et al. 1999), and when working night shifts, they tend to report more psychosomatic problems, and more social and domestic difficulties (Ognianova et al. 1998; Smith et al. 1999). As far as we know, the present study is the first to demonstrate an association between languidity and higher sick leave rates among individuals engaged in shift work.

Prior sick leave was associated with later sick leave in this study, which has been shown by others as well (Koopmans et al. 2008; Roelen et al. 2011; van Drongelen et al. 2017; Vedaa et al. 2017). In addition, a higher age was associated with more sick leave days, but not sick leave spells. The distinction between sick leave days and sick leave spells in the present study was made based on the assumption that the two may reflect different patterns of impaired health. In particular, it can be reasoned that a high number of days absent is a general reflection of how much the workers are set back by their condition; whereas a high number of sick leave spells implies more fluctuations in and out of sick leave, where sick leave may be used more as a coping strategy to recuperate from the strains of working. Insofar as the rational for this distinction is accurate, our findings may suggest that sick leave rates are higher with increasing age due to a general decline in health (i.e. more continuous absence), and not because sick leave is being used as a coping strategy. The other demographic characteristics including sex, cohabitation, and having children living at home were unrelated to sick leave in the present study. Female gender, marital status as single/divorced/widowed, and having children living at home have typically been associated

with higher sick leave rates (Allebeck and Mastekaasa 2004), and lack of significant findings regarding these variables in the present study may be due to the relatively short time interval that was investigated (i.e. three months). It is also possible that any associations between sex and sick leave rates may have gone undetected in the present study due to the female preponderance in the sample.

Some limitations with the present study should be noted. Firstly, even though the present study was primarily based on already existing registry data, consent to use this information had to be obtained from the nurses which led to a response rate of 42%. This is lower than the preferred minimum of 50-60% response rate and imply a higher risk for non-response bias (Kerlinger 1986). No analysis were permitted on registry data from participants that did not consent to participate, which precluded non-responder analysis based on the sick leave data. Concerning representativeness, it should also be noted that the high female preponderance, and the fact that all were employed nurses or nurses' assistants, limits our ability to generalise the results to other occupations and gender distributions. Another limitation pertains to the self-report assessments in this study, where, in particular, the assessment of number of years with shift work experience is a measure that can be sensitive to recall bias. Self-report measures can involve measurement errors, which together with the fact that some potential confounders in the relationship between long shifts and sick leave were not measured in this study, can contribute to a residual confounding bias. Most self-report measures in this study were based on standardised questionnaires assessing personality characteristics that are subjective by their very nature. The reliability analyses showed that the Cronbach's alpha for the Diurnal Scale (morningness) was somewhat low, which may be owing to the low number of items in the scale. However, the mean inter-item correlation was .19 for the Diurnal Scale, which is within the recommended range of .15 to .50 and suggests that the scale still has adequate internal consistency (Clark and Watson 1995). It should also

be noted that some important variables that may affect both sick leave rates and shift work characteristics, such as socio-economic status, work demands (e.g. physical strains) and leadership, were not measured. Future studies should consider including such variables. A final point worth noting as a proviso with this study is the way we decided to organise the data for the analyses. The time-brackets chosen influence the results; where for example, exposure to evening shifts was associated with sick leave when time-brackets of three months were studied (i.e. in the present study), but not when time-brackets of one month were studied (Vedaa et al. 2017). This should therefore be taken into consideration when interpreting the results of the present study.

In conclusion, the present study investigated the association between long working hours and sick leave the subsequent three-month periods by using objective assessments of both the exposure and outcome measures, while controlling for important covariates, and thus provides strong evidence of long working hours (≥12 hour shifts) being associated with less sick leave short-term. Exposure to evening work was associated with higher sick leave rates the subsequent three-month periods, while exposure to night work was unrelated with sick leave. Although the impact of the different shift characteristics on sick leave shown in the present study were small and potentially negligible at the individual level, it may have substantial implication from a socio-economic perspective in terms of sick leave compensation. The potential benefits of long working hours, and the potential detriments of evening shifts, should be further explored in naturalistic intervention studies where objective records of the work schedule and sick leave are being used. Further studies should also aim at identifying the underlying cause of the beneficial and disadvantageous effects of long working hours and evening shifts, respectively. This is the first study to show that languid individuals engaged in shift work have a higher risk of short-term sick leave.

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Compliance with Ethical Standards: The study was approved by the Regional Committee for Medical and Health Research Ethics, Northern Norway (number 2013/526/REK nor) and by the Norwegian Data Inspectorate (13/00569-2/CGN).

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Table 1. Demographics and general shift work characteristics of the nurses (*N* = 1,538)

Demographics	
Sex (females)	87.7%
Age	42.5 years (*SD*=12.0)
Living with partner (cohabitants)	71.6%
Having children living at home	50.8%
Occupational groups	
Registered nurses	89.2%
Nurses assistants	10.8%
Shift work characteristics	**Mean (*SD*)**
Shift work experience (years)	15.5 (10.6)
Shifts during the three-month periods	38.5 (13.6)
Day shifts during the three-month periods	23.1 (14.8)
Evening shifts during the three-month periods	9.6 (7.6)
Night shifts during the three-month periods	5.9 (8.7)
Long shifts (≥12h) during the three-month periods[a]	2.7 (3.8)

[a]Refers to the mean number of long shifts (≥12h) among those nurses who had long shifts during the three-month periods from 2010 throughout 2013.

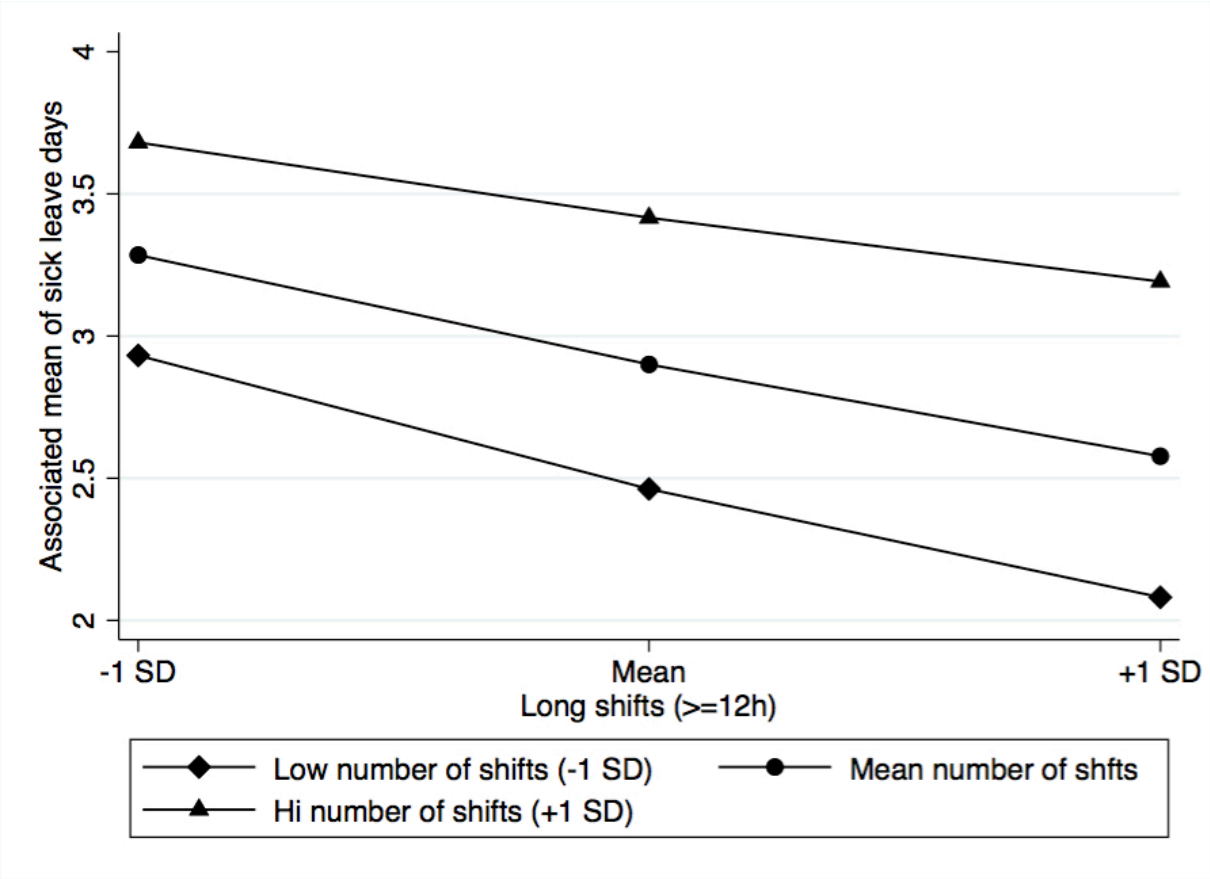

Figure 1. The associated mean of sick leave days over three months at low (-1SD), medium (mean), and high (+1SD) number of long shift and total number of shifts the previous three months.

Table 2. Results from the multilevel negative binomial model of exposure to shift characteristics during three months on sick leave the subsequent three months for the period 2010 throughout 2013 (*N*=1,538).

	Sick leave days the following three months, adjusted model			Sick leave spells the following three months, adjusted model		
	Incident rate ratio (IRR)	*p*	95% Conf. Interval	Incident rate ratio (IRR)	*p*	95% Conf. Interval
Step 1: Minimally adjusted model						
Female	1.117	0.305	0.904 to 1.381	1.122	0.242	0.925 to 1.362
Age (years)	1.003	0.256	0.998 to 1.008	1.000	0.894	0.995 to 1.005
Number of long shifts (≥12h)	0.942	<0.001	0.914 to 0.971	0.945	<0.001	0.919 to 0.972
Step 2: Adjusted model						
Sick leave at baseline[a]	1.054	<0.001	1.049 to 1.059	1.107	<0.001	1.097 to 1.117
Female	1.093	0.362	0.902 to 1.325	1.105	0.257	0.930 to 1.313
Age (years)	1.006	0.039	1.000 to 1.011	1.003	0.185	0.998 to 1.008
No children living at home	0.966	0.425	0.889 to 1.051	0.952	0.198	0.883 to 1.026
No cohabitant	0.925	0.160	0.829 to 1.031	0.957	0.378	0.867 to 1.056
Shift work experience (years)	1.000	0.981	0.999 to 1.001	1.000	0.819	0.999 to 1.001
Morningness (DS)	0.990	0.298	0.971 to 1.009	0.990	0.236	0.973 to 1.007

Languidity (rCTI)	1.032	<0.001	1.015 to 1.048	1.030	<0.001	1.016 to 1.045
Flexibility (rCTI)	0.999	0.908	0.985 to 1.014	0.996	0.592	0.984 to 1.009
Number of shifts worked[b]	1.012	<0.001	1.008 to 1.015	1.006	<0.001	1.003 to 1.009
Number of night shifts	0.996	0.150	0.990 to 1.002	0.998	0.410	0.993 to 1.003
Number of evening shifts	1.009	0.012	1.002 to 1.016	1.011	<0.001	1.005 to 1.017
Number of long shifts (≥12h)	0.946	<0.001	0.919 to 0.973	0.952	<0.001	0.928 to 0.978
Step 3: Adjusted model w/ interaction effects[c]						
Long shifts by Female	1.010	0.800	0.936 to 1.090	1.028	0.437	0.960 to 1.100
Long shifts by Age	1.000	0.885	0.996 to 1.004	1.000	0.809	0.996 to 1.003
Long shifts by No children living at home	0.996	0.936	0.912 to 1.088	0.996	0.926	0.924 to 1.075
Long shifts by No cohabitant	1.030	0.543	0.936 to 1.133	1.009	0.837	0.929 to 1.096
Long shifts by Shift work experience	1.000	0.640	0.999 to 1.001	1.000	0.588	0.999 to 1.001
Long shifts by Num. of shifts worked[b]	1.002	0.031	1.000 to 1.004	1.002	0.093	0.910 to 1.004
Long shifts by Morningness	0.993	0.253	0.980 to 1.005	0.995	0.370	0.984 to 1.006
Long shifts by Languidity	1.002	0.720	0.992 to 1.012	1.002	0.684	0.993 to 1.011

Long shifts by Flexibility	1.004	0.425	0.994 to 1.013	1.004	0.300	0.996 to 1.013

[a] Sick leave at baseline refers to the number of days/spells the nurses was on sick leave during the three months of exposure to the different shift characteristics.

[b] Number of shifts worked refers to the total number shifts the nurses worked during the three months of exposure to the different shift characteristics.

SE=Standard Error; DS=Diurnal Scale; rCTI=revised Circadian Type Inventory.

[c] The interaction effects were modelled by product terms where we multiplied the number of long shifts over a three-month period with the demographic and background variables.