

Shift work and sickness absence at a Norwegian hospital: a longitudinal multilevel study

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Objective Shift work is known to be related to several negative health consequences and sickness absence. Research results regarding the relationship between types of shift schedules and sickness absence and whether and how individual factors moderate this relationship, are mixed though. The present paper aims to provide more insight in these relationships.

Methods We used registry data from a large Norwegian hospital gathered for the years 2012 to 2016, for more than 17 000 employees. With random effects at the individual and unit levels, we analyzed the relationship between shift schedule worked and sickness absence in the same year.

Results The results showed increased risk of short-term sickness absence for two- and three-shift rotations, as well as fixed night shifts compared to fixed day shifts. We also found an increased number of absence periods for two-shift rotations without nights and three-shift rotations. Results for long-term sickness absence were mixed, with increased odds for two-shift rotations without nights, but reduced odds for three-shift rotations. We found partial support for a moderating influence of age, gender and parental status.

Conclusions There is a clear relationship between working shifts and increased risk of short-term sickness absence. The relationship persist across gender, age-group and parental status. The relationship between shift work and long-term sickness absence appears to be schedule and population specific. . These findings may have implications for HR policies and the organization of shift work in healthcare organizations.

Key words: "Shift Work Schedule", "Absenteeism", "Occupational Health", "Longitudinal Studies", "Effect Modifier, Epidemiologic"

Key messages

1. What is already known about this subject?
 - Shift work has been linked to increased sickness absence. Previous research suggested the relationship is potentially schedule and population specific.
2. What are the new findings?
 - For both men and women, shift work is related to increased short-term sickness absence. In particular, two- and three-shift rotations, and fixed night shifts are related to increased absence.
 - The relationship between shift rotations and increased sickness absence is generally stronger for older employees. The results show that older employees experience more adverse absence consequences of shift work.
3. How might this impact on policy or clinical practice in the foreseeable future?
 - The results indicate that shift-related absence could be reduced by HR policies tailoring shift work to employee life phases and needs.

Introduction

Numerous studies have linked shift work to negative consequences, such as reduced sleep,^{1 2} cancer,³⁻⁵ diabetes,⁶ hypertension,⁷ and cardiovascular disease⁸. Consequently, shift work has also been linked to increased risk of sickness absence.⁹ Yet for industries such as the healthcare sector where 24/7 staffing is required, shift work is unavoidable. Sickness absence is a particularly relevant consequence of shift work as an objectively recorded indicator of health,¹⁰ but also because of the impact on staffing. To organize shift work in an optimal way, it is necessary to know more about the adverse consequences of different shift schedules and potential individual moderators.

Shift work is defined as a working-time-arrangement where “workers succeed one another at the workplace so that operation hours exceed the hours of work of individual workers.”¹¹ This encompasses a specter of shift schedules, such as fixed evenings, fixed nights, early mornings, as well as employees who rotated between two or three time slots. In a systematic review of the relationship between shift work and sick leave Merkus et al.⁹ found strong support for a relationship between fixed evening shifts and long-term sick leave for female healthcare workers, but inconclusive findings regarding rotating shifts and night shifts. The authors concluded that there might be a schedule- and population-specific association between shift work and sickness absence.

There has, since the review, been increasing support for a negative relationship between different shift types and sickness absence, in particular for fixed night shifts,^{12 13} proportion of shifts worked at night,¹⁴ rotating two shifts (day and evening) and rotating three shifts (morning, evening and night),¹⁵ as well as shift work in general.^{17 18} However, some studies found no significant relationship between shift work and sickness absence,^{19 20} or found a relationship in the opposite direction.²¹ Few studies include more than one or two shift schedules.

To our knowledge, no studies have directly tested the moderating effect of individual demographic differences on the relationship between shift work and sickness absence. Knowledge about which factors moderate this relationship could help guide directed interventions, and tailor shift work to fit employees' life phases. Prior research have supported a moderating effect of age,^{22 23} gender²⁴, and parental status²⁵ for the relationship between shift work and other health consequences.

The aim of the present paper is therefore (1) to describe what shift-work arrangements exist at a large Norwegian hospital, (2) to investigate how these shift schedule relate to employees' sickness absence, and (3) to investigate how individual differences in age, gender and parental status moderate the relationship between shift work and sickness absence.

Method

Design

This was a longitudinal cohort study. All data were collected from the hospital's personnel records for the years 2012 to 2016.

Population

We utilized data from a large Norwegian hospital employing more than 20,000 employees, across multiple location. The hospital was established in 2009 following the merger of all three state-owned university hospitals in the capital city.

The sample consisted of 51,086 unique employee numbers. The sample was restricted to employees who worked full-time ($\geq 80\%$), who logged hours and who had worked at the hospital for 12 months the year in question.. Furthermore, because changes in shift schedules are often due to health reasons, we restricted the sample to employees who did not change shifts during the study period.

This left 14,132 unique employee numbers.

Measures

We utilized three datasets from the hospitals HR-registries. A registry of all employee absence, a registry of all shifts worked and a registry of employment contracts. The two first registries are continuously recorded by managers at the work unit. The third registry is recorded when employees are hired or their contract changed.

Sickness absence

The first registry contains information all absences, with start and end dates. We aggregated the data to comprise whether each employee began a short period of sickness absence (1–8 days), or a long period of sickness absence (>9 days), and the number of absence periods (irrespective of length) each year. Overlapping and consecutive periods were merged. We distinguish between short and long spells of absence because shorter spells are, to a greater extent than longer spells, also influenced by factors other than health.^{10 26} Shorter absences were operationalized as 1–8 days, because a medical certificate is necessary only for sick leaves lasting 9 days or more.

Shift work

In the second registry each shift worked by each employee is recorded with the start and end time, and the organizational-unit. The records are used to calculate salaries, and therefore, are expected to be relatively accurate.

We aggregated the data distinguishing four types of shifts: day, evening, night and early morning. A shift was coded as a day shift if it started at 07:00 or later, and ended no later than 18:00 the same day. A shift that started between 05:00 and 07:00 in the morning was coded as an early morning shift, and a shift that ended between 18:00 and 24:00 was coded as an evening shift. If some part of the shift occurred between 24:00 and 05:00 in the morning, it was coded as a night shift.

We coded the employees' shift combination based on when 90% of their shifts occurred. If 90% of all shifts worked during a year were day shifts, then the employee was coded as fixed day. An employee

was coded as working a two-shift rotation with days and evenings, if 90% of the employee's shifts were days or evenings, and >10% of the shifts were days and >10% shifts were evenings. Similarly, an employee was coded as working a three-shift rotation if 90% of the employee's shifts were days, evenings or nights, and >10% of the shifts were days, >10% of the shifts were evenings and >10% of the shifts were nights.

The focus of this paper was active shifts (i.e., shifts when employees are at work, not on-call shifts). However, 8% of the included shifts were combination shifts, shifts that were partially active and partially on-call. Because the shifts were partially active, we treated them as active shifts.

Demographic variables

The third registry contains employment contract and demographic information, including salary, age, gender, country of origin, position and nature of contract (i.e., temporary or permanent). Some employees had more than one employment contract. Contract information was summarized when possible (e.g., total salary), and it was based on the contract with the highest percentage of a full-time equivalent for variables where summarizing across positions was not possible-. A dummy variable indicates if the employee holds more than 1 contract.

To detect whether an individual had a child at home, we used a proxy based on the absence registry. The employee was coded as having children if they had an absence due to parental leave or care benefit days (i.e. paid absent from work if their child, or the person who usually looks after their child, is ill). In Norway, employed parents are entitled to 10 days of care benefit each up to and including the calendar year the youngest child in the household turns 12 (or your child turns 18 when you have a chronically ill or disabled child).²⁷ Because we had data over a long time span, this would likely include most parents with young children. We did likely not include parents with children old enough to stay home alone when they were ill or when a third party took care of the sick child.

Analyses

We analyzed the employees' shift schedules each year compared to their sickness absences the same year. We used a random effects regression model with a random intercept at the individual and work-unit levels. Fixed day was used as the reference group. We conducted both unadjusted analyses, and adjusted analyses also controlling for gender, having children, age, work hours a week, salary, temporary contract, multiple contract, nationality, and position. We expect each of these control variables to potentially impact which shifts employees work and their level of absence. For example older employees are more likely to be exempt from working night and have larger health issues and more long-term absence.

We used linear probability models (LPM) to analyze the dichotomous outcome variables (short and long-term absence), which implies using linear regression with binary outcomes²⁸. In LPM the coefficients are comparable to average marginal effects for logistic regression²⁸. In this manner we are able to compare absolute changes in probability, rather than relative.²⁹ Finally we also used Poisson regression to analyze number of sickness absence periods (irrespective of length).

Results

Shift-work arrangements at a large Norwegian hospital

Table 1 shows work and demographic characteristics of the study population. The most common shift schedules were fixed days, two-shift rotations without nights, and three-shift rotation with nights. Notably, two-shift rotations that involved night work were generally longer shifts, so that two-shifts could cover 24 hours. Or the rotations included day shifts and long combinations shifts where part of the shift was on-call.

Physicians most often worked two-shift rotations with nights, nurses most often worked three-shift rotations with nights, and administrative personnel most often worked fixed days. The

oldest employees were overrepresented on fixed night shifts, but underrepresented on rotation shifts with night. Men were overrepresented on 2 shift-rotations with night.

Shift-work arrangements and employees' sickness absence

The results for the relationship between each type of shift work and absence are presented in table 2. Compared to day workers, we found more short-term sickness absences among employees who worked two-shift schedules with days and evenings, two-shift schedules with evenings and nights, three-shift schedules with days, evenings and nights, and employees who worked fixed nights. The effect sizes in the linear probability models can be read as marginal effects. For example there is a 70% probability of short-term absence for employees working fixed-day, and 82% (+0.12) for employees working two-shift rotations of day and evening. No statistically significant difference was found for employees working two-shift schedules with days and night, or early morning shifts. Fewer employees worked these shift schedules, making it harder to find statistically significant differences.

Employees working two-shift schedules with days and evenings and three-shift schedules also had a significant higher number of sickness absence periods. For long-term absences, the results were more mixed. Employees working two-shift schedules with days and evenings had statistically significant more long-term absences than day workers. Employees working three-shift schedules with days, evenings and nights had statistically significantly fewer absences. No other statistically significant relationships between shift work and long-term absence were identified.

Moderating individual differences

For the moderating individual differences, we focused on two-shift workers without night (day and evening) and three-shift workers (day, evening and night) compared to day workers, the three most common shift schedules at the hospital. For each combination of shift work and absence a separate interaction-analysis was performed. The control variables remained the same as in table 2. The results of the analyses for moderating individual differences are presented in table 3. Moreover, the

predicted probability of absence (based on the results presented in table 3) are presented in table 4 and 5.

We found a moderating effect of age. The negative relationship between two-shift rotation and short-term sickness absence increases with age. The negative relationship between two- and three-shift rotation and number of absence periods also increases with age. Moreover, three-shift rotation was related to increased long-term sickness absence among the older age groups. A thirty year-old employee working a three-shift rotation had 2 percentage points higher probability of long-term absence compared to fixed-day. In comparison, a 60 year-old employee working a three-shift rotation had a 8 percentage points higher probability of long-term absence compared to fixed-day.

We found no moderating effect of gender on shift work and short-term absences or number of periods of absence. For long-term absences, the relationship for two-shift rotations was stronger for women, but no significant difference for three-shift rotations. While women working two-shift rotations had a 7 percentage points higher probability of long-term absence compared to fixed-day workers, men working two-shift rotations without night had approximately the same probability of long-term absence as men working fixed-day shifts.

We found a statistically significantly weaker relationship for parents between two-shift work and short-term absences, as well as number of periods of absence. However, we also found a significant stronger relationship between three-shift work and long-term absence.

As the variable for parental status was a proxy constructed based on the absence registry (i.e. absence due to parental leave or a sick child) it warrants further inspection. Thirty-one percent of the men and 35% of the women were registered as having children. The majority (84%) were in their 30s or 40s. In total, 61% of the employees in their 30s were registered as having children. Men were overrepresented among the older parents (12% of men and 5% of women at >49 years were registered as having children). These figures support our assumption that the proxy variable captures most parents with young children.

Discussion

The results showed a complex structure of several different shift schedules co-existing within the hospital. Fixed days and several types of rotating shifts were most common. Generally, employees who worked shifts had more short-term absences and more absence periods than employees who worked fixed day schedules. It can be concluded that all type of work other than fixed day are associated with an increased risk of short-term absence (though the association was not significant for early morning and day/night shifts). The results are in agreement with our expectations, and previous literature supporting a relationship between shift work and increased short-term sickness absence.^{9 12 13 15 16} The increased absence could be explained by several negative consequences of shift work, such as reduced sleep, disrupted cardiac rhythm and increased work-family conflict impairing employees' health and ability to attend work.³⁰⁻³⁶

Some substantial differences between the unadjusted and adjusted effect sizes reflect that there are also important demographic and work differences between employees working different shift types, and that these differences impact employee absence levels.

For employees working two-shift schedules with day and nights, or early mornings, the difference in absences from day workers was not statistically significant. However, we cannot conclude that these shift schedules are not related to short term-absences. Instead, the lack of statistically significant differences might also suggest that the sample was too small to identify a statistically significant relationship (as these shift types were less common in the hospital).

The results were more mixed for long-term absences. While employees working rotating two-shift schedules of days and evenings had more long-term sickness absences, employees working rotating three-shift solutions had fewer long-term sickness absences. It is unlikely that working three-shift rotations with nights is beneficial for employee health. However, this study is not the first to also find a negative relationship between shift work and sickness absence.²¹ A probable explanation for this difference is a selection effect, with unhealthy employees changing from three-shift rotations with

nights to two-shift rotations without nights. As employees who develop more severe health challenges are exempt from working night shifts, a selection effect would likely be particularly relevant for long-term absences.

Moderating individual variables

In line with previous literature, we found a moderating effect of age as the negative relationship between shift work and sickness absences increases with age.^{22 23} The present results supported that older employees had a larger increase in short-term absence when working two-shift rotations and in long-term absence when working three-shift rotations. They also had higher number of sickness absence periods when working two- or three-shift schedules. It is plausible to expect that the body's resilience to shift work and disruptions of the circadian rhythm, in particular, changes with age. This does not imply that shift work is not harmful for younger employees. For example, some studies have suggested that the increased risk of cancer associated with shift work is particularly pronounced for younger employees.³⁷ The results suggest that older employees are more prone to sickness absences (and the health problems likely to dominate the sickness absence statistics), as a result of shift work.

The results suggested that shift work is related to more short-term sickness absences for both women and men. Gender did not moderate the relation between shift work and short-term sickness absence, nor between shift work and number of sickness absence periods. For long-term absences, the moderating effect of gender was more in line with Merkus et al.⁹ finding. In particular, we found a statistically significant positive relationship only between working two-shifts and long-term absences for women, and no relationship for men. It is possible that the difference occurred because women have a more severe reaction to shift work than men (e.g. due to biological or social differences, or gender differences in the type of job held). However, as the difference was present only for long-term absences and two-shift work, it might also represent a gender difference in the selection effect (i.e., in which employees with health challenges are exempt from working nights). This would be the case if

men with health challenges largely changed employment out of the hospital, while women changed from three-shift work with nights, to two-shift work without nights.

In contrast to what we expected, we found mixed results for the moderating effect of having children. Employees with children had a weaker relationship between two-shift work and short-term absences, and number of episodes of sickness absence. However, they had a stronger relationship between three-shift work and long-term absence. While the latter result is in line with what we expected, the former result is surprising because work-family conflict is an important consequence of shift work,^{36 38} and likely an important mediator between shift work and health outcomes.^{17 39} It is natural to expect increased work-home conflict to be stronger for employees with children. It is possible, however, that for some employees, shift work might also be a strategy to balance work and private life. Working at different times than one's partner will increase the amount of time at least one partner is free and available to take care of the children. Some nurses have reported that an advantage of working nights is more flexibility for family activity.⁴⁰ Having children is a variable we created based on the employee absence registry (i.e., have employees ever been absent due to sick children or parental leave). It is important to recognize this limitation when interpreting the results. The variable for having children in the dataset most likely encompasses only parents with children who were too young to stay home alone while ill, and where parental leave and care for ill children were not delegated to a third party. Nonetheless, it is still interesting that we did not find, in precisely this group of parents, extra strain manifested as increased short-term absences connected to shift work.

Strengths and limitations

The study utilized a large and longitudinal dataset with objectively recorded data in an HR registry. The data provided a unique opportunity to study shift work in more detail—differentiating between different shift work arrangements, eliminating recall bias and utilizing the strengths of employees being measured repeatedly over multiple years. We could not control for selection effects that happened before the start of the project, however.

Another limitation of the present study is that the data was collected from a single hospital, possibly limiting the generalizability of the findings. The latter is a large hospital though, comprising multiple geographical locations with employees organized in a variety of different shift schedules. Nevertheless, it is still possible that specific characteristics of this hospital have influenced the results. It is also important to note that Norway has a relatively high level of sickness absence,⁴¹ and a generous sickness absence system.⁴² It is therefore possible that employees to a greater extent respond to shift-related distress and health impairments with increased absence in Norway, compared to countries with lower absence rates and different social security systems. The study population represents a heterogeneous group in terms of age and education. However, the sample is predominantly female. While we have investigated the gender differences specifically, we cannot exclude that the results would have been different in a male-dominated sector. Furthermore, we have limited the sample to full-time employees, as a consequence we have also excluded shift-schedules predominantly worked by part-time employees (in particular fixed evening shifts). The relationship between part-time work and sickness absence is complicated,⁴³ and could have complicated the interpretation of the results. However, it is important to recognize that the findings might not be generalizable to employees working shorter hours and different shifts. Nonetheless, the general congruence between the present study and prior research indicates that the findings are generalizable.

Conclusions

In conclusion, we found that several shift work arrangements (with and without nights) were related to increased odds for short-term absences. The difference was present for men and women. However, the relationship seemed to be most pronounced for older workers. The results suggest that absences could be reduced by HR policies tailoring shift work to employee life phases.

Contributors

VHB initiated the study. VHB and IH planned the study, VHB prepared the data and executed the statistical analyses, VHB and IH interpreted the results, drafted and revised the manuscript. Both authors read and approved the final manuscript.

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Competing interest

None declared.

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Table 1 Characteristics of the study population*

	Total subjects N (%)	Subjects with short-term absence N (%) [†]		Subjects with long-term absence N (%) [†]		Fixed Day		Rotating day and evening		Rotating day, evening, and night		Fixed night [†]		Rotating day and night		Rotating evening and night		Rotating morning and day		Other shift schedules	
		N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Total	14132	11961	6720	7941	2301	2626	185	841	74	43	121										
Gender																					
Male	3731 (26)	2797 (23)	1407 (21)	2047 (26)	546 (24)	526 (20)	92 (50)	405 (48)	43 (58)	19 (44)	53 (44)										
Female	10401 (74)	9164 (77)	5313 (79)	5894 (74)	1755 (76)	2100 (80)	93 (50)	436 (52)	31 (42)	24 (56)	68 (56)										
Age																					
Mean±SD	43 (12)	42 (12)	44 (12)	45 (11)	43 (12)	35 (10)	50 (9)	42 (10)	36 (11)	42 (10)	41 (10)										
< 30	2117 (15)	1884 (16)	770 (11)	647 (8)	341 (15)	1034 (39)	3 (2)	46 (5)	30 (41)	5 (12)	11 (9)										
30-39	3964 (28)	3365 (28)	1806 (27)	2050 (26)	617 (27)	810 (31)	21 (11)	387 (46)	19 (26)	13 (30)	47 (39)										
40-49	3272 (23)	2747 (23)	1543 (23)	2070 (26)	483 (21)	405 (15)	50 (27)	203 (24)	14 (19)	13 (30)	34 (28)										
50-59	3197 (23)	2705 (23)	1791 (27)	2049 (26)	594 (26)	297 (11)	71 (38)	146 (17)	8 (11)	11 (26)	21 (17)										
> 59	1582 (11)	1260 (11)	810 (12)	1125 (14)	266 (12)	80 (3)	40 (22)	59 (7)	3 (4)	1 (2)	8 (7)										
Have (young) children																					

No	9272 (66)	7589 (63)	4136 (62)	5147 (65)	1533 (67)	1836 (70)	128 (69)	469 (56)	56 (76)	32 (74)	71 (59)
Yes	4860 (34)	4372 (37)	2584 (38)	2794 (35)	768 (33)	790 (30)	57 (31)	372 (44)	18 (24)	11 (26)	50 (41)

Sickness absence (Mean±SD)

Yearly probability of short-term absence	0.74 (0.4)	0.87 (0.2)	0.84 (0.3)	0.68 (0.4)	0.85 (0.3)	0.87 (0.3)	0.84 (0.3)	0.57 (0.4)	0.86 (0.3)	0.84 (0.3)	0.74 (0.4)
Yearly probability of long-term absence	0.30 (0.4)	0.33 (0.4)	0.62 (0.3)	0.29 (0.4)	0.37 (0.4)	0.28 (0.4)	0.32 (0.4)	0.15 (0.3)	0.32 (0.4)	0.35 (0.4)	0.27 (0.4)
Average number of absence periods per year	3.12 (3.1)	3.65 (3.1)	4.48 (3.3)	2.85 (3.1)	4.02 (3.3)	3.61 (2.9)	3.15 (2.2)	1.61 (2.1)	4.00 (3.3)	3.54 (3.1)	2.83 (2.7)

Temporary contract

No	10523 (74)	9188 (77)	5556 (83)	6268 (79)	1891 (82)	1657 (63)	175 (95)	359 (43)	59 (80)	37 (86)	77 (64)
Yes	3609 (26)	2773 (23)	1164 (17)	1673 (21)	410 (18)	969 (37)	10 (5)	482 (57)	15 (20)	6 (14)	44 (36)

Multiple contracts

No	13604 (96)	11530 (96)	6490 (97)	7693 (97)	2208 (96)	2489 (95)	174 (94)	811 (96)	69 (93)	42 (98)	118 (98)
Yes	528 (4)	431 (4)	230 (3)	248 (3)	93 (4)	137 (5)	11 (6)	30 (4)	5 (7)	1 (2)	3 (2)

Nationality

Norwegian	13111 (93)	11140 (93)	6311 (94)	7363 (93)	2154 (94)	2448 (93)	160 (86)	767 (91)	69 (93)	42 (98)	108 (89)
Other Nordic countries	490 (3)	440 (4)	211 (3)	214 (3)	94 (4)	122 (5)	18 (10)	35 (4)	1 (1)	0 (0)	6 (5)
Other Western countries	296 (2)	206 (2)	99 (1)	199 (3)	23 (1)	35 (1)	7 (4)	24 (3)	2 (3)	1 (2)	5 (4)
Non-Western countries	235 (2)	175 (1)	99 (1)	165 (2)	30 (1)	21 (1)	0 (0)	15 (2)	2 (3)	0 (0)	2 (2)

Position

Nurse	4537 (32)	4237 (35)	2329 (35)	945 (12)	1247 (54)	2100 (80)	120 (65)	86 (10)	8 (11)	2 (5)	29 (24)
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Physician	1597 (11)	1084 (9)	426 (6)	686 (9)	168 (7)	48 (2)	0 (0)	648 (77)	0 (0)	1 (2)	46 (38)
Patient-focused other	3266 (23)	2990 (25)	1727 (26)	1998 (25)	725 (32)	347 (13)	59 (32)	57 (7)	64 (86)	1 (2)	15 (12)
Administration/management	2680 (19)	2166 (18)	1256 (19)	2524 (32)	58 (3)	21 (1)	2 (1)	32 (4)	2 (3)	24 (56)	17 (14)
Other operation/technical personnel	661 (5)	553 (5)	332 (5)	570 (7)	35 (2)	48 (2)	0 (0)	1 (0)	0 (0)	7 (16)	0 (0)
Kitchen/cleaning/orderly	638 (5)	607 (5)	480 (7)	498 (6)	57 (2)	58 (2)	4 (2)	0 (0)	0 (0)	8 (19)	13 (11)
Other	753 (5)	324 (3)	170 (3)	720 (9)	11 (0)	4 (0)	0 (0)	17 (2)	0 (0)	0 (0)	1 (1)
Work hours a week											
<41 hours	13807 (98)	11761 (98)	6670 (99)	7867 (99)	2281 (99)	2599 (99)	185 (100)	651 (77)	67 (91)	43 (100)	114 (94)
>41	325 (2)	200 (2)	50 (1)	74 (1)	20 (1)	27 (1)	0 (0)	190 (23)	7 (9)	0 (0)	7 (6)
Salary (in 100 000kr)											
Mean±SD	4.6545 (1.5)	4.4632 (1.2)	4.3816 (1.2)	4.8808 (1.6)	4.2326 (0.9)	3.9386 (0.6)	4.113 (0.5)	6.1588 (1.7)	3.4746 (0.4)	3.6838 (0.8)	4.8047 (1.2)

* Absence statistics are averages of employee averages. For all other characteristics that vary between years (e.g. salary) the first registered value is given.

The average shift duration was 8 hours (73%); otherwise, shifts tended to be 10 (7%), 9 (7%), 7 (6%), 4 (1%), 6 (1%) and 12 (1%) hours. A typical day shift can go from 08:00-15:30, evening shift from 15:00-22.30 and night shift from 22:00-08:00.

† The hospital has implemented a restrictive policy for permitting new fixed knight contracts, which is reflected in a skewed age distribution for this shift schedule.

Table 2: Results of the random effects regression models of the association between shiftwork and short and long-term sickness absence

	Short-terms sickness absence (LPM) [§]			Long-term sickness absence (LPM) [§]			Number of periods of sickness absence (Poisson) [¶]		
	Unadjusted model	Adjusted model		Unadjusted model	Adjusted model		Unadjusted model	Adjusted model	
	coef. (95% CI)	coef. (95% CI)		coef. (95% CI)	coef. (95% CI)		coef. (95% CI)	coef. (95% CI)	
Fixed day	Reference	Reference		Reference	Reference		Reference	Reference	
Rotating day and evening	0.12 (0.10- 0.14)	0.07 (0.05- 0.09)	0.09	0.07 (0.05- 0.09)	0.05 (0.03- 0.07)	0.07	0.36 (0.30- 0.42)	0.23 (0.18- 0.29)	
Rotating day, evening, and night	0.13 (0.10- 0.15)	0.06 (0.04- 0.09)	0.09	-0.03 (-0.05- -0.01)	-0.02 (-0.04- 0.00)	0.00	0.27 (0.21- 0.33)	0.11 (0.05- 0.17)	
Fixed night	0.09 (0.04- 0.13)	0.06 (0.01- 0.11)	0.11	0.00 (-0.05- 0.05)	-0.01 (-0.06- 0.04)	0.04	0.10 (-0.04- 0.24)	0.05 (-0.09- 0.18)	
Rotating day and night	-0.01 (-0.05- 0.02)	0.02 (-0.02- 0.05)	0.05	-0.11 (-0.15- -0.08)	-0.01 (-0.04- 0.02)	0.02	-0.21 (-0.32- -0.10)	-0.03 (-0.13- 0.08)	
Rotating evening and night	0.18 (0.08- 0.28)	0.11 (0.02- 0.20)	0.20	0.02 (-0.08- 0.11)	0.05 (-0.04- 0.14)	0.14	0.41 (0.14- 0.70)	0.25 (-0.00- 0.50)	
Rotating morning and day	0.07 (-0.06- 0.19)	0.06 (-0.06- 0.17)	0.17	0.04 (-0.08- 0.16)	0.01 (-0.10- 0.12)	0.12	0.04 (-0.32- 0.40)	0.06 (-0.25- 0.38)	
Other shift schedules	0.06 (-0.01- 0.12)	0.05 (-0.01- 0.11)	0.11	-0.03 (-0.10- 0.04)	0.00 (-0.07- 0.06)	0.06	0.09 (-0.11- 0.27)	0.13 (-0.04- 0.31)	
Gender									
Male		Reference			Reference			Reference	
Female		0.08 (0.06- 0.09)	0.09	0.09 (0.08- 0.11)	0.09 (0.08- 0.11)	0.11	0.29 (0.25- 0.33)	0.29 (0.25- 0.33)	
Age (in 10years)		-0.01 (-0.01- 0.00)	0.00	0.03 (0.02- 0.03)	0.03 (0.02- 0.03)	0.03	-0.01 (-0.02- 0.01)	-0.01 (-0.02- 0.01)	
Parental status									
No (small) children		Reference			Reference			Reference	
Have (small) children		0.08 (0.07- 0.09)	0.09	0.08 (0.07- 0.09)	0.08 (0.07- 0.09)	0.09	0.24 (0.21- 0.27)	0.24 (0.21- 0.27)	
Work hours a week									
<41 hours		Reference			Reference			Reference	
41–48 hours		-0.08 (-0.10- -0.05)	-0.05	-0.12 (-0.14- -0.09)	-0.12 (-0.14- -0.09)	-0.09	-0.39 (-0.47- -0.31)	-0.39 (-0.47- -0.31)	
>48 hours		-0.01 (-0.06- 0.03)	0.03	-0.06 (-0.11- -0.01)	-0.06 (-0.11- -0.01)	-0.01	-0.26 (-0.42- -0.10)	-0.26 (-0.42- -0.10)	
Salary (in 100 000 NOK)		-0.05 (-0.06- -0.05)	-0.05	-0.03 (-0.04- -0.03)	-0.03 (-0.04- -0.03)	-0.03	-0.18 (-0.19- -0.16)	-0.18 (-0.19- -0.16)	
Temporary contract									
No		Reference			Reference			Reference	
Yes		-0.04 (-0.05- -0.02)	-0.02	-0.06 (-0.08- -0.05)	-0.06 (-0.08- -0.05)	-0.05	-0.15 (-0.18- -0.12)	-0.15 (-0.18- -0.12)	
Multiple contracts									
No		Reference			Reference			Reference	
Yes		-0.05 (-0.07- -0.02)	-0.02	0.00 (-0.03- 0.03)	0.00 (-0.03- 0.03)	0.03	-0.08 (-0.13- -0.02)	-0.08 (-0.13- -0.02)	
Nationality									
Norwegian		Reference			Reference			Reference	
Other Nordic countries		0.04 (0.02- 0.07)	0.07	-0.02 (-0.05- 0.01)	-0.02 (-0.05- 0.01)	0.01	0.08 (-0.00- 0.16)	0.08 (-0.00- 0.16)	
Other Western countries		-0.02 (-0.05- 0.02)	0.02	-0.02 (-0.06- 0.02)	-0.02 (-0.06- 0.02)	0.02	-0.17 (-0.28- -0.05)	-0.17 (-0.28- -0.05)	
Non-Western countries		-0.02 (-0.07- 0.02)	0.02	0.01 (-0.04- 0.05)	0.01 (-0.04- 0.05)	0.05	-0.03 (-0.15- 0.09)	-0.03 (-0.15- 0.09)	
Position									
Nurse		Reference			Reference			Reference	
Physician		-0.10 (-0.13- -0.07)	-0.07	-0.03 (-0.05- 0.00)	-0.03 (-0.05- 0.00)	0.00	-0.31 (-0.40- -0.22)	-0.31 (-0.40- -0.22)	
Patient-focused other		-0.02 (-0.04- 0.00)	0.00	-0.01 (-0.03- 0.01)	-0.01 (-0.03- 0.01)	0.01	-0.05 (-0.10- 0.00)	-0.05 (-0.10- 0.00)	
Administration/management		-0.07 (-0.09- -0.05)	-0.05	-0.03 (-0.05- -0.01)	-0.03 (-0.05- -0.01)	-0.01	-0.22 (-0.27- -0.16)	-0.22 (-0.27- -0.16)	

Other operation/technical personnel †	-0.05	(-0.08-	-0.02)						0.00	(-0.03-	0.03)							-0.14	(-0.23-	-0.06)	
Kitchen/cleaning/orderly	0.07	(0.03-	0.11)						0.20	(0.17-	0.24)								0.38	(0.26-	0.50)
Other ‡	-0.33	(-0.37-	-0.30)						-0.07	(-0.10-	-0.04)								-0.95	(-1.05-	-0.84)
_cons	0.65	(0.64-	0.66)	0.93	(0.90-	0.96)	0.28	(0.27	0.29)	0.32	(0.29-	0.35)	0.46	(0.41	0.51)	1.36	(1.26-	1.46)			

† Other operation/technical personnel includes IT and engineers, among others.

‡Other includes research staff, summer temps, and unspecified positions.

§ coefficients/effect sizes should be read as marginal increases in the probability of short and long-term absence, a coefficient of 0.12 implies an estimated increase of 12 percentage points. The estimated probability in the reference group (fixed day, all non-shift variables set at mean) is 70% for short-term absence and 29% for long-term absence.

¶The estimated probability in the reference group (fixed day, all non-shift variables set at mean) is 2.5 episodes a year in the adjusted model (and 2.6 in the unadjusted model). Coefficients are Poisson coefficients and should be read as increases in the natural logarithm of the incidence rate. With a reference value of 2.6 (or $\exp(0.95)$); a coefficient of 0.36 implies an increase to ($\exp(0.95+0.36)$) 3.7 episodes a year, and an incident risk ratio of (3.7/2.6) 1.4.

N employees: 14,132; N work units: 1,316.

Table 3: Results of the random effects linear probability models of the interaction between shiftwork and gender, age and parental status for the association with short and long-term sickness absence

		Short-term sickness absence		Long-term sickness absence		Number of periods of sickness absence	
		coef. (95%. CI)		coef. (95%. CI)		coef. (95%. CI)	
Gender							
Shift:	Fixed day	Reference		Reference		Reference	
	Rotating day and evening	0.09	(0.06- 0.13)	0.00	(-0.03- 0.03)	0.24	(0.15- 0.33)
Gender:	Male	Reference		Reference		Reference	
	Female	0.08	(0.07- 0.10)	0.08	(0.07- 0.10)	0.30	(0.25- 0.34)
Interaction:	Rotating day and evening × female	-0.03	(-0.06- 0.00)	0.07	(0.04- 0.11)	-0.01	(-0.10- 0.09)
Shift:	Fixed day	Reference		Reference		Reference	
	Rotating day, evening, and night	0.08	(0.05- 0.11)	-0.05	(-0.08- -0.01)	0.15	(0.05- 0.25)
Gender:	Male	Reference		Reference		Reference	
	Female	0.08	(0.07- 0.09)	0.09	(0.07- 0.10)	0.30	(0.26- 0.34)
Interaction:	Rotating day, evening, and night × female	-0.02	(-0.05- 0.01)	0.03	(-0.00- 0.07)	-0.05	(-0.14- 0.05)
Age (in 10 years, centered at 30 years)							
Shift:	Fixed day	Reference		Reference		Reference	
	Rotating day and evening	0.05	(0.02- 0.08)	0.04	(0.01- 0.07)	0.17	(0.10- 0.24)
Age:	Age	-0.01	(-0.02- 0.00)	0.03	(0.02- 0.03)	-0.02	(-0.04- -0.00)
Interaction:	Rotating day and evening × Age	0.01	(0.00- 0.03)	0.01	(-0.00- 0.02)	0.04	(0.01- 0.08)
Shift:	Fixed day	Reference		Reference		Reference	
	Rotating day, evening, and night	0.07	(0.05- 0.09)	-0.04	(-0.07- -0.02)	0.07	(-0.00- 0.14)
Age:	Age	-0.01	(-0.01- 0.00)	0.02	(0.02- 0.03)	-0.02	(-0.03- 0.00)
Interaction:	Rotating day, evening, and night × Age	-0.01	(-0.02- 0.01)	0.02	(0.01- 0.03)	0.05	(0.02- 0.09)
Parental status							
Shift:	Fixed day	Reference		Reference		Reference	
	Rotating day and evening	0.09	(0.07- 0.11)	0.05	(0.03- 0.07)	0.27	(0.20- 0.33)
Parental status:	No (young) children	Reference		Reference		Reference	
	Have (young) children	0.09	(0.08- 0.10)	0.08	(0.07- 0.09)	0.26	(0.22- 0.29)
Interaction:	Rotating day and evening × children	-0.05	(-0.08- -0.02)	0.00	(-0.03- 0.04)	-0.09	(-0.17- -0.01)
Shift:	Fixed day	Reference		Reference		Reference	
	Rotating day evening, and night	0.07	(0.04- 0.09)	-0.04	(-0.07- -0.02)	0.10	(0.03- 0.16)
Parental status:	No (young) children	Reference		Reference		Reference	
	Have (young) children	0.08	(0.07- 0.09)	0.07	(0.05- 0.08)	0.23	(0.19- 0.27)
Interaction:	Rotating day, evening, and night children	0.00	(-0.03- 0.03)	0.06	(0.03- 0.09)	0.05	(-0.03- 0.13)

Each analyses also contains the following control variables: shift schedule, gender, work hours a week, salary, temporary contract, multiple contract, age, parental status, nationality, and position. The predicted values for each employee group are presented in table 4 and 5.

N employees: 14,132; N work units: 1,316.

Table 4 predicted probabilities of absence for groups of employees working fixed day and day-evening rotations (2-shift rotation).

	Short-term absence			Long-term absence			Number of episodes		
	Fixed day	Day and evening	Difference	Fixed day	Day and evening	Difference	Fixed day	Day and evening	Difference
Male	64 %	74 %	9p.p.	23 %	23 %	0p.p.	2.1	2.6	0.6
Female	73 %	79 %	6p.p.	31 %	38 %	7p.p.	2.8	3.5	0.7
No (small) children	67 %	76 %	9p.p.	26 %	32 %	5p.p.	2.3	3.0	0.7
Have (small) children	76 %	80 %	4p.p.	34 %	40 %	6p.p.	3.0	3.6	0.6
20 years	70 %	78 %	8p.p.	30 %	36 %	6p.p.	2.5	3.3	0.7
30 years	69 %	78 %	9p.p.	33 %	40 %	7p.p.	2.5	3.4	0.9
40 years	68 %	79 %	11p.p.	36 %	43 %	8p.p.	2.4	3.4	1.0
50 years	67 %	79 %	12p.p.	38 %	47 %	8p.p.	2.4	3.5	1.1
60 years	66 %	80 %	14p.p.	41 %	50 %	9p.p.	2.3	3.6	1.3

p.p. percentage points

Table 5 predicted probabilities of absence for groups of employees working fixed day and day-evening-night rotations (3-shift rotation).

	Short-term absence			Long-term absence			Number of episodes		
	Fixed day	Day, evening and night	Difference	Fixed day	Day, evening and night	Difference	Fixed day	Day, evening and night	Difference
Male	65 %	73 %	8p.p.	23 %	18 %	-5p.p.	2.0	2.4	0.3
Female	73 %	79 %	6p.p.	31 %	30 %	-1p.p.	2.8	3.1	0.3
No (small) children	68 %	74 %	7p.p.	27 %	23 %	-4p.p.	2.4	2.6	0.2
Have (small) children	76 %	82 %	6p.p.	34 %	35 %	2p.p.	3.0	3.4	0.5
20 years	70 %	76 %	6p.p.	30 %	30 %	0p.p.	2.5	3.0	0.5
30 years	69 %	75 %	5p.p.	33 %	35 %	2p.p.	2.5	3.1	0.6
40 years	69 %	74 %	5p.p.	35 %	39 %	4p.p.	2.4	3.2	0.8
50 years	68 %	72 %	4p.p.	38 %	43 %	6p.p.	2.4	3.4	1.0
60 years	68 %	71 %	4p.p.	40 %	48 %	8p.p.	2.4	3.5	1.1

p.p. percentage points

