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RESEARCH ARTICLE

Association of rotating shift work schedules and the use of prescribed sleep medication: A prospective cohort study

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Summary

We examined whether working rotating shifts, with or without night work, is associated with the purchase of prescribed sleep medication, and whether the association is dependent on age. Data were obtained from a longitudinal cohort study of Finnish public sector employees who responded to questions on work schedule and background characteristics in 2000, 2004 and 2008. The data were linked to national register data on redeemed prescriptions of hypnotic and sedative medications, with up to 11 years of follow-up. Age stratified Cox proportional hazard regression models were computed to examine incident use of medication comparing two groups of rotating shift workers (those working shifts that included night shifts and those whose schedules did not include night shifts) with day workers who worked in a similar range of occupations. Shift work with night shifts was associated with increased use of sleep medication in all age groups, after adjustments for sex, occupational status, marital status, alcohol consumption, smoking and physical activity levels (hazard ratio [HR], [95% confidence interval, CI] 1.14 [1.01–1.28] for age group ≤39 years; 1.33 [1.19–1.48] for age group 40–49 years; 1.28 [1.13–1.44] for age group ≥50 years). Shift work without nights was associated with medication use in the two older age groups (HR [95% CI] 1.14 [1.01–1.29] and 1.17 [1.05–1.31] for age groups 40–49 years and >50 years, respectively). These findings suggest that circadian disruption and older age puts rotating shift workers, and especially those who work nights, at increased risk of developing clinically significant levels of sleep problems.

KEYWORDS
age, circadian, hypnotics and sedatives, night work, work schedule

1 | INTRODUCTION

Shift work, and particularly night work, is commonly associated with acute sleep disruption. Night workers are required to sleep in opposition to their natural circadian rhythms and the normal sleep–wake cycle. They have to remain awake during the night when the sleep drive is high, while sleep opportunities occur during the day when circadian rhythms are promoting wakefulness. Hence, rotating shift workers often experience greater acute sleep disruption when they are working night shifts (Karhula et al., 2013; Sallinen et al., 2003). However, the cumulative sleep deficit over the entire shift cycle (e.g. the sequence of day shifts, nights shifts and rest days that defines a particular shift pattern) tends to be small (Folkard, 1992), at least when the shift pattern provides adequate recovery opportunities (Kecklund & Axelsson, 2016). This raises the question of whether night work as part of a rotating schedule is associated with clinically significant sleep problems.

A systematic review of published research up to 2012 (Linton et al., 2015) concluded that there is an association between shift work that may or may not include night work and sleep problems. However, the three studies in the review that focussed specifically on shift work involving night work found no significant associations (Akerstedt et al., 2010; Eriksen et al., 2008; Linton, 2004). Since that review, a longitudinal study of nurses (Waage et al, 2014) found that frequency of night shifts was prospectively associated with shift work disorder (a circadian rhythm sleep disorder characterised by excessive sleepiness and complaints of insomnia related to the work schedule; Schwartz & Roth, 2006). Another recent longitudinal study of healthcare workers found that changes in the frequency of working two consecutive nights was associated with parallel changes in difficulties falling asleep (Harma et al., 2018). However, two other recent prospective studies found little or no evidence that either night work (Thun et al., 2016) or shift work that may or may not involve night work (Akerstedt et al., 2015) is associated with sleep problems.

It is notable that, like the vast majority of research in this area, the above studies based their assessment of sleep problems on subjective self-reports. The reason for the lack of reports of disturbed sleep in many studies could be that shift workers do not consider their sleep to be disturbed because there is a clear external cause – the temporal displacement of sleep (Akerstedt et al., 2015). Indeed, evidence suggests that shift workers do not regard night work as very problematic, in comparison to other schedule characteristics (e.g. short notice of new work schedules, short inter-shift intervals and split shifts; Akerstedt & Kecklund, 2017). Thus, while it is evident that night work causes acute sleep disruption around the time that the night shifts are being worked (and in the days that immediately precede and follow the night shifts); it less clear whether night work affects sleep in a way that requires clinical treatment.

A useful objective index of clinically significant sleep problems is the purchase of prescribed sleep medication. Insomnia symptoms are associated with the prescription of psychotropic medication in a dose–response pattern (Haaramo et al., 2014). Only one study that we are aware of has examined the association between sleep medication use and work schedule, finding that shift work (loosely defined) predicted a 21% increased likelihood of redeeming prescriptions for sleep medication (Albertsen et al., 2020). No distinction was drawn between shift work that either included, or did not include, night work, thus leaving open the question of whether exposure to circadian disruption due to night work might account for the findings.

Variations between previous studies in the association of shift work with sleep disturbance may also reflect differences in the ages of the studied populations. It is well known that ageing is associated with earlier chronotype (Fischer et al., 2017) and increased risk of insomnia. Ageing shift workers have a higher need for recovery (Gommans et al., 2015) and tend to sleep less after night shifts (Harma et al., 1994; Hulsegge et al., 2018). On the other hand, the number of night shifts decreases in some shift worker populations with older age (Ropponen et al., 2020), possibly counterbalancing the age-related effects of shift work on sleep.

To address these limitations of previous research in this area, the present study examined associations between two forms of rotating shift work (shift work involving night work and shift work not involving night work) and the purchase of prescription sleep medication, a proxy for clinically significant sleep problems, and the extent to which these associations are dependent on age. In order to study the question of the possible age-related differences in the association of shift work with sleep, and to control for the possible selection effects, the analyses were stratified by age. It is likely that selection out of night work and shift work due to the development of sleep disorders or other health problems is most likely to occur among older shift workers. It was hypothesised that both types of shift work would be associated with greater use of prescribed sleep medication, after adjusting for potential confounds relating to demographic and economic background, and health behaviours. It was further anticipated that these effects would be greater for shift work that included night work than for shift work that did not include night work, due to the greater level of circadian disruption caused by night work. Lastly, it was hypothesised that associations would be most apparent in older age groups.

2 | METHOD

2.1 | Participants

Data were obtained from three waves of the Finnish Public Sector (FPS) study (2000, 2004, 2008; response rate 66%–68%). The FPS is comprised of two sub-studies: a study of local government employees in 10 towns (a mixture of healthcare workers and employees from other occupational sectors), the 10 Town Study; and a study conducted within 21 hospitals, the Finnish Hospital Personnel Study, referred to here as the Hospital Personnel Study.

Participants entered the present study at different points (i.e. either 2000, 2004 or 2008), depending on their self-reported work schedule status (for work schedule definitions, see *Shift work status* below). Participants who were classified as day workers kept their day worker status throughout the study period and their first survey response was considered as their study entry. Participants classified as shift workers entered the study in the first year when they reported working shifts. The follow-up for purchases of prescribed sleep medication began from the beginning of the year following the survey. The initial sample comprised a total of 66,892 men and women. Respondents who reported any type of work schedule other than day work, shift work without night shifts or shift work with night shifts were excluded. In order to reduce the discrepancy between the occupational profiles of day workers and shift workers, participants who were day workers were excluded if their occupation did not match the occupation of at least one of the participants classified as shift workers. We also excluded respondents who had purchased sleep medication during the 12 months preceding follow-up in order to be able to examine the association between exposure and change in the outcome, and to avoid confounding with the presence of pre-existing conditions. Lastly, we excluded those who reported at baseline ever having been diagnosed by a doctor with depression or another mental health problem. After exclusions, the analytic sample comprised 50,633 participants.

2.2 | Shift work status

Participants were classified as day workers, shift workers without night shifts or shift workers with night shifts. Classification was based on their survey response at baseline (see above for explanation of when participants entered the study).

In the 10 Town Study, participants in the 2000 and 2004 waves were asked: "Is your work regular day work?" Participants were classified as day workers if they answered "yes". The participants who responded "no" were further asked to indicate if their work included: (a) evening shifts, (b) night shifts or (c) weekend shifts. They were then classified as shift workers without night shifts if they answered no to the initial question and then indicated that their work included evening shifts but not night shifts; or as shift workers with night shifts if they answered no to the initial question and then indicated that their work included both evening shifts and night shifts.

In the Hospital Personnel Study and in the 2008 wave of the 10 Town Study, participants were classified according to whether they chose to describe their current work as either: (a) day work, (b) shift work without night shifts or (c) shift work with night shifts. Participants who chose the response options regular night work or other irregular work were excluded. These questionnaire items have previously been validated against an objective measure of shift work status based on payroll data (Harma et al., 2017).

2.3 | Use of prescription medicine

Data on the dates of purchases of prescription sleep medication [Anatomical Therapeutic Chemical (ATC) code N05C – hypnotics and sedatives) were retrieved from the Drug Reimbursement Register from 1 January 1999 to 31 December 2011. The date of the first purchased prescription after the survey response was used to determine incident use of prescribed sleep medication.

2.4 | Covariates

The covariates measured at baseline were sex; occupational status including four categories: upper white-collar [International Standard Classification of Occupations (ISCO) = 1–2), lower white-collar (ISCO = 3–4), skilled blue-collar (ISCO = 5), other blue-collar (ISCO = 6–9); marital status including four categories: unmarried, married or co-habiting, divorced, widower; alcohol consumption as a continuous measure: pure alcohol in g/week; current smoking status with two categories: no, yes; and physical activity as a continuous measure: metabolic equivalent in (MET) hr/week. All baseline data were obtained from the survey responses, except for occupational status, which was derived from employers' registers.

2.5 | Data analysis

Participants' survey responses were linked to data on redeemed prescriptions and death (for defining end of follow-up) obtained from the national registers using personal identification numbers and the linkage was successful for all respondents.

After confirming that the proportional hazards assumptions were not violated, associations between shift work status and incident purchase of sleep medication during follow-up were examined using Cox proportional hazard regression models. Two sets of analyses were conducted separately; one comparing shift workers without night shifts with day workers and the other comparing shift workers with night shifts with day workers. Follow-up for day workers began from the beginning of the first year (1 January in 2001, 2005 or 2009) after they responded to the survey. Follow-up of shift workers with/without out night shifts began from the beginning of the first year after they indicated that they were doing shift work with/without out night shifts. Follow-up time was calculated to the first date of purchase of medication, death or end of the follow-up (i.e. 31 December 2011), whichever came first. Each analysis was stratified by age (≤39, 40–49, and ≥50 years). We calculated hazard ratios (HRs) and their 95% confidence intervals (CIs) without adjustments (Model 0); with adjustments for sex, occupational status and marital status (Model 1); with adjustments in Model 1 plus adjustments for alcohol consumption, smoking and physical activity (Model 2). In order to account for the non-Gaussian distributions of the variables measuring alcohol consumption and physical activity, these variables were entered along with their squared terms.

Two sensitivity analyses were conducted. The first investigated the possibility that having former shift workers in the reference groups (day workers) could produce an under-estimation of the true impact of shift work. These analyses were only possible in the Hospital Personnel Study, where shift work history was reported. The sensitivity analyses involved analysing data from the Hospital Personnel Study as described above, but with the modification that day workers were excluded from the reference group if they reported having previously worked shifts for >1 year. The results were compared with an analysis of the Hospital Personnel Study data without the exclusion of former shift workers, to see whether the exclusion of former shift workers produced stronger effects. If they did, this would be taken as an indication that the main analyses may have underestimated the true impact of shift work, due to the 'contamination' of the control sample by former shift workers.

The second sensitivity analyses assessed the potential overestimation of the impact of shift work due to confounding with age, given that stratification by age in the main analysis is a crude means of controlling for age. The analysis examined whether there were effects of shift work in the unstratified sample, when age was included as a covariate. The same sample was used as in the main analysis, but instead of stratifying by age, the analysis incorporated age and $(\text{age})^2$ as additional covariates.

All statistical analyses were conducted with SAS, version 9.4, statistical software (SAS Institute, Inc.).

2.6 | Ethical approval

The FPS study has been approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa (HUS 1210/2016).

3 | RESULTS

The mean follow-up time was 7.7 years. The samples before exclusions (*N* = 66,892; 82.1% female; mean [*SD*] age 43.2 [10.0] years) and after exclusions (*N* = 50,633; 81.6% female; mean [*SD*] age 42.4 [10.0] years) did not differ substantially with respect to gender distribution or mean age.

Descriptive statistics of the final sample by work schedule are presented in Table 1. Age distributions were similar between day workers and shift workers without night shifts, but there were a higher proportion of younger shift workers with night shifts. Gender distributions were fairly similar between day workers and shift workers with night shifts, but there was a larger proportion of women shift workers without night shifts. The distribution of occupational status differed between the three work schedule groups, with the majority of day workers being in the upper two strata, shift workers

TABLE 1 Baseline descriptive statistics of the analytic sample, by work schedule

	Work schedule		
Variable	Day work (*n* = 33,014)	Shift work without nights (*n* = 7,557)	Shift work with nights (*n* = 10,062)
Age, years, *n* (%)			
≤39	12,074 (36.57)	2,625 (34.74)	5,281 (52.48)
40–49	11,100 (33.62)	2,394 (31.68)	2,973 (29.55)
≥50	9,840 (29.81)	2,538 (33.58)	1,808 (17.97)
Sex, *n* (%)			
Male	6,737 (20.41)	907 (12.00)	1,663 (16.53)
Female	26,277 (79.59)	6,650 (88.00)	8,399 (83.47)
Occupational status, *n* (%)			
Upper white-collar	14,019 (42.46)	1,065 (14.09)	197 (1.96)
Lower white-collar	9,555 (28.94)	2,358 (31.20)	6,189 (61.51)
Skilled blue-collar	5,243 (15.88)	2,062 (27.29)	3,331 (33.10)
Other blue-collar	4,197 (12.71)	2,072 (27.42)	345 (3.43)
Marital status, *n* (%)			
Unmarried	3,661 (11.09)	1,037 (13.72)	1,501 (14.92)
Married/co-habiting	26,030 (78.85)	5,526 (73.12)	7,639 (75.92)
Divorced	2,942 (8.91)	858 (11.35)	838 (8.33)
Widow(er)	381 (1.15)	136 (1.80)	84 (0.83)
Smoking status, *n* (%)			
No	27,960 (84.69)	5,980 (79.13)	8,225 (81.74)
Yes	5,054 (15.31)	1,577 (20.87)	1,837 (18.26)
Mean (*SD*)			
Alcohol consumption, g/week	63.7 (96.7)	53.1 (89.6)	52.9 (89.9)
Physical activity, MET hr/week	4.76 (4.18)	4.67 (4.26)	5.50 (4.71)

without night shifts being relatively evenly spread between the four strata and the majority of shift workers with nights being in the middle two strata. The distributions of marital status did not differ substantially between the three types of schedule, with the majority in each being co-habiting or married. Shift workers (both types) were somewhat more likely to be smokers, but they also tended to consume less alcohol than day workers. Shift workers with nights reported somewhat higher levels of physical activity.

Table 2 presents the unadjusted cumulative incident proportions for the use of sleep medication. Incident use tended to be highest among shift workers (both types), older individuals, females, divorcees, and smokers. There were no substantial differences between the four categories of occupational status.

Table 3 presents the results from the Cox regression analyses of associations between work schedule and any incident use of medication. In the fully adjusted models, there were significant positive associations among both groups of shift workers, across all age ranges, except for those in the youngest age group (≤39 years) who worked shifts without nights. The strongest associations, after full adjustment, were observed in those in the middle and older age ranges (40–49 and ≥50 years) who worked shifts with nights. Adjusting for covariates had only marginal effects on the strength of the observed associations.

TABLE 2 Sample size and unadjusted frequency of any incident use of sleep medication at follow-up, by predictor variable categories

Variable	*N*	*N* (%) new use of sleep medication
Work schedule		
Day	33,014	4,097 (12.4)
Shift work without nights	7,557	1,033 (13.7)
Shift work with nights	10,062	1,440 (14.3)
Age, years		
≤39	19,980	1,967 (9.8)
40–49	16,467	2,290 (13.9)
≥50	14,186	2,313 (16.3)
Sex		
Male	9,307	950 (10.2)
Female	41,326	5,620 (13.6)
Occupational status		
Upper white-collar	15,281	1,936 (12.7)
Lower white-collar	18,102	2,470 (13.6)
Skilled blue-collar	10,636	1,385 (13.0)
Other blue-collar	6,614	779 (11.9)
Marital status		
Unmarried	6,199	728 (11.7)
Married/co-habiting	39,195	4,969 (12.7)
Divorced	4,638	785 (16.9)
Widow(er)	601	88 (14.6)
Smoking		
No	42,165	5,325 (12.6)
Yes	8,468	1,245 (14.7)

In the first sensitivity analyses of the data from the Hospital Personnel Study, we found that excluding day workers who reported having previously worked for > 12 months in shift work (*N* = 468) made very little difference to the pattern of results obtained (data not shown).

In the second sensitivity analysis, medication use was positively associated with both shift work without nights (HR 1.10, 95% CI 1.02–1.17) and shift work with nights (HR 1.23, 95% CI 1.16–1.31) after adjustment for all covariates including age and $(age)^2$.

4 | DISCUSSION

The greater use of sleep medication by shift workers compared to day workers suggests an association between shift work and clinically significant levels of sleep disturbances. Consistent with our predictions, significant effects were observed irrespective of whether night work was present, although the effects were stronger among those working shifts that included night work and among shift workers aged ≥40 years.

One of the most frequently reported sleep problems among shift workers is 'difficulty falling asleep' (Tucker et al., 2011), a common indication for the prescription of hypnotics (Kilduff & Mendelson, 2015). Therefore, in seeking explanations of the link between work schedule and sleep medication use, the associations of shift work with difficulties falling asleep need further attention.

Both circadian and non-circadian factors are potential contributors to sleep initiation difficulties. The observation that associations were stronger among shift workers whose schedules included night work suggests that circadian disruption due to working nights plays an important role in the relationship between work schedule and use of sleep medication. Working at night and sleeping during the day requires the worker to sleep in opposition to their day-oriented body clock. As a consequence, workers may find themselves returning home from a night shift feeling extremely tired, having been awake the whole night and much of the preceding day, and yet have difficulty initiating and/or maintaining sleep. The present findings suggest that these problems are sufficiently persistent and severe among a significant proportion of workers that they are driven to seek medical treatment.

Circadian disruption may also play a role in sleep disturbances experienced by shift workers not working nights, but possibly to a lesser extent. Those workers will typically work combinations of morning and evening shifts. Early starting morning shifts have been linked to shorter, poorer quality sleeps, stemming from the difficulties shift workers have advancing their sleep on-set in the evenings in anticipation of an early start (Folkard & Barton, 1993; Tucker et al., 1998). These difficulties have been partly attributed to the influence of circadian rhythms that promote wakefulness in the early part of the evening (the "forbidden zone for sleep"; Lavie, 1986). The problem is often exacerbated by socio-environmental factors

TABLE 3 Hazard ratios (HRs) of incident use of sleep medication for shift work with and without night shifts compared to day work by age group

		Age group, years		
		≤39	40–49	≥50
	Model	HR (95% CI)	HR (95% CI)	HR (95% CI)
Shift work without nights	0	0.96 (0.84–1.10)	1.11 (0.99–1.25)	**1.16 (1.05–1.30)**
	1	1.01 (0.88–1.17)	**1.14 (1.01–1.28)**	**1.16 (1.04–1.30)**
	2	1.01 (0.88–1.16)	**1.14 (1.01–1.29)**	**1.17 (1.05–1.31)**
Shift work with nights	0	1.07 (0.96–1.18)	**1.30 (1.18–1.44)**	**1.30 (1.16–1.45)**
	1	**1.12 (1.00–1.26)**	**1.30 (1.17–1.45)**	**1.27 (1.13–1.44)**
	2	**1.14 (1.01–1.28)**	**1.33 (1.19–1.48)**	**1.28 (1.13–1.44)**

Model 0 = crude, Model 1 = adjusted for sex, occupational status and marital status; Model 2 = model 1 + alcohol consumption, (alcohol consumption)^2, smoking, physical activity and (physical activity)^2.
Statistically significant associations ($p < .05$) in bold.

that prevent or discourage early sleep onset in the evenings, e.g. the presence of children in the home and other domestic activities/obligations, engagement in social and cultural activities outside the home, and traffic noise (Halonen et al., 2012). The same socio-environmental factors may also affect the sleep of night workers trying to sleep in the day time between shifts.

Evening shifts may also be associated with sleep impairment, particularly when worked immediately prior to a morning shift. Such shift combinations (so called "quick returns") allow only a limited inter-shift interval for the shift worker to travel between work and home, eat, unwind from work and get sufficient sleep. Quick returns are thus commonly associated with truncated and poor quality sleeps, not only because of the limited time available for sleeping, but also because they limit opportunities for unwinding and psychologically detaching from thoughts about work before bedtime, leading to difficulties initiating sleep (Dahlgren et al., 2016; Eldevik et al., 2013; Harma et al., 2018; Kubo et al., 2018; Vedaa et al., 2017).

The findings with respect to age differences were partially consistent with our predictions. In both groups of shift workers, the strength of the associations increased from the youngest age range to the middle age range, but then remained relatively stable between the middle and older age ranges. Similar age-related patterns have been observed in shift workers' self-reported sleep problems (Parkes, 2002; Tucker et al., 2011). The initial increase may reflect accumulated exposure, as well as the early stages of age-related destabilisation of circadian rhythms that is exacerbated by shift work (Costa & Di Milia, 2008). The subsequent stabilisation from the middle to the older age range may be due to reduction in the frequency of night shifts (Ropponen et al., 2020) and to selection effects (the "healthy worker effect": Knutsson & Akerstedt, 1992). Older shift workers who experience severe sleep problems may transfer to day work, leaving a self-selected "survivor population" of older shift workers. Previous studies based on the FPS study have shown that workers who transfer from night work to day work experience reductions in sleep problems (Harma et al., 2018) and in common mental disorders, a correlate of sleep difficulties (Beltagy et al., 2018). In the latter study, a lack of association between night work and common mental disorders was found to be largely due to night workers with these disorders moving out of night work. However, in the present analyses selection through the healthy worker effect was not supported by the first sensitivity analysis. That said, interpretation was limited by the fact that the first sensitivity analysis could only be conducted for one of the cohorts. Moreover, it would only have been sensitive to the effects of workers transferring from shift work to day work within the same occupational setting, not to shift workers leaving the population (e.g. by changing employer or retiring early).

The present study benefits from the use of data from two large occupational cohorts (the 10 Town study and the Hospital Personnel study) with high participation rates, linked to high-quality national prescription register data. Using register data on redeemed prescriptions of sleep medicine helped us avoid inaccuracies and biases that are associated with subjective reports of medication use. However, we only had data on medication purchases, not whether the medicine was consumed or not. The detailed survey data made it possible to adjust for a wide range of potential confounders. The prospective design used in the present study is subject to less risk of error due to confounding or bias, as compared to retrospective designs (Rothman et al., 2015). The risk of major selection bias was reduced by recruiting all participants from the same cohorts. In differentiating between shift workers whose schedule either did, or did not, include nights shifts, the present study used more precise definitions of shift work than the previous study of associations between work schedule and sleep medication purchase (Albertsen et al., 2020). Nevertheless, the present study lacked detailed information regarding shift patterns (e.g. regularity of the schedule, intensity of night shifts), thereby limiting interpretation of the findings. We have previously shown in this population that assessment of work schedule status by self-report is reliable for day work and shift work with nights, but that it is less reliable for shift work without nights (Harma et al., 2017). This suggests a risk of misclassification of those working shifts without nights and a risk that their use of sleep medication could have been underestimated. Moreover, participants may have changed their work schedule during follow-up, which also increases the risk of work schedule misclassification and an underestimation of risk.

As noted above, our attempts to identify selection effects through the first sensitivity analysis were somewhat limited by the available data. Moreover, the first sensitivity analysis could only hope to detect selection bias *out of* shift work (i.e. bias resulting from individuals quitting shift work), but not selection bias *into* shift work (i.e. when individuals choose to avoid ever entering shift work due to pre-existing sleep problems). These kinds of selection effects could lead to the underestimation of the effects of shift work on sleep medication use.

Despite the large sample, effect sizes were rather small, with CIs bordering on unity in some instances. To put the effect sizes into context, we calculated the Attributable Risks (the proportion of a disease that could be prevented by elimination of a causal risk factor from a target population; Spiegelman et al., 2007) associated with the HRs observed in the middle age range for shift workers not working nights (1.14 in the fully adjusted model) and for shift workers working nights (1.33 in the fully adjusted model). These indicated that shift working accounted for 5% and 15% of sleep medication prescriptions in the respective populations. It could be argued that the statistical power of the present study design may have contributed to the finding of significant effects where previous study findings based on smaller samples have been equivocal.

The observed higher incidence of medication use by shift workers may not necessarily correspond with greater prevalence of sleep problems. The class of medication studied, hypnotics and sedatives, includes treatments for non-sleep problems such as anxiety. In an attempt to address this issue, we excluded participants who reported at baseline having ever being diagnosed by a doctor with psychological health problems. Nevertheless, it remains a possibility that the greater use of these medications by shift workers is at least partly due to higher levels of *undiagnosed* mental health problems or problems that developed after baseline. Another reason to be cautious about relying on hypnotics and sedative medication use as a proxy for medical diagnosis of a sleep disorder is that individuals presenting to their doctor with sleep problems may be prescribed alternative treatments other than this form of medication (e.g. behavioural therapy, or treatments for conditions that are comorbid with sleep disturbance). It remains to be determined whether doctors' decisions on diagnosis and treatment are affected by their patients' status as a shift worker. Lastly, reliance on prescription medication register data risks missing sleep problems that either go untreated (e.g. because treatment is not sought) or that are self-treated (e.g. using non-prescription medication).

A further caveat to the interpretation of the present results is that while the sample included employees from a range of occupational sectors, it was dominated by healthcare workers in the public sector. Thus, caution is needed when extrapolating from the present findings to other industries and sectors that employ shift workers.

In conclusion, rotating shift workers were more likely to purchase prescribed hypnotic and sedative medication than their day working counterparts, with the strongest effects observed among those whose work schedule included night work, and among middle-aged and older shift workers. This would appear to suggest that the greater levels of circadian disruption caused by night shift work and older age puts them at increased risk of developing clinically significant levels of sleep problems, and particularly difficulties initiating sleep.

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CONFLICT OF INTEREST

None to declare.

AUTHOR CONTRIBUTIONS

PT, MH and JV conceived the study. PS conducted preliminary analyses, while AO conducted the main analyses, overseen by PT and MH. MK, CL, TO, PS and JV advised on design of the analyses. PT drafted the initial manuscript. All authors contributed to the development of the final manuscript and accepted the final version to be submitted.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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