ORIGINAL ARTICLE

Sleep-related problems in the US working population: prevalence and association with shiftwork status

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ABSTRACT

Objective To estimate the prevalence of a comprehensive set of self-reported sleep problems by job characteristics, including shiftwork status, among a representative sample of US workers.

Methods Data for 6338 workers aged ≥18 years were obtained from the National Health and Nutrition Examination Survey. Short sleep duration was defined as <7 hours per weekday/workday. Sleep quality was categorised as good, moderate and poor based on the frequency of 6 sleep-related symptoms. A sleep-related activities of daily living (ADL) score ≥2 was defined as impaired. Insomnia was defined as having poor sleep quality and impaired ADL. Shiftwork status was categorised as daytime, night, evening, rotating or another schedule. Prevalence rates were calculated and multivariate logistic regression analyses were used.

Results The prevalence of short sleep duration (37.6% overall) was highest among night shift workers (61.8%; p<0.001). The prevalence of poor sleep quality was 19.2% among all workers, with the highest prevalence among night shift workers (30.7%, p=0.004). The prevalence of impaired ADL score (24.8% overall) and insomnia (8.8% overall) was also highest for night shift workers (36.2%, p=0.001 and 18.5%, p=0.013, respectively). In multivariate analysis, night shift workers had the highest likelihood of these sleep problems.

Conclusions Self-reported short sleep duration, poor sleep quality, impaired ADL score and insomnia are common among US workers especially among night shift workers. Although these findings should be confirmed with objective sleep measures, they support the need for intervention programmes to improve sleep quantity and quality among night shift workers.

What this paper adds

- Little is known about the prevalence of sleep-related problems in the US working population.
- This is the first study to use a nationally representative sample of the US working population to examine the role of shiftwork on sleep quality, sleep-related activities of daily living (ADL) and insomnia.
- Short sleep duration, poor sleep quality, impaired sleep-related ADL and insomnia were common among US workers, especially among night shift workers.
- Work-based programmes and policies should be adopted to improve the quantity and quality of sleep among workers.

INTRODUCTION

Although sleep is essential to health and well-being, an estimated 50–70 million Americans suffer from a sleep disorder.[1] Short sleep duration (<7 hours/day) has been shown in some studies to be associated with many chronic health problems, including immune dysfunction, obesity, diabetes, hypertension, cardiovascular disease and all-cause mortality risk.[2–4] Sleepiness and fatigue, the consequences of short sleep duration, have been linked to undesirable job impacts, including productivity loss[5] and adverse safety outcomes.[6 7] Sleep deficiency is thus an important public health problem affecting a large proportion of the US population, and costs billions of dollars annually.[8]

Workers with irregular work schedules and those not working the 09:00 to 17:00 time frame are increasingly needed to meet the demands of globalisation and a 24-hour society. According to the Sleep in America Poll, 25% of the workers in the USA reported that their current work schedule does not permit sufficient sleep.[9] Shift workers are known to have more sleep-related problems than the general population, including difficulty falling asleep, not getting enough sleep and sleepiness on waking.[10 11]

To date, little is known about the prevalence of sleep-related problems in the US working population as the majority of studies are limited to selected occupational groups or geographic regions[12 13] with limited generalisability. Furthermore, most of the studies focused on a few specific problems, such as short sleep duration[14 15] or insomnia.[5] Therefore, using nationally representative data from National Health and Nutrition Examination Survey (NHANES), we (1) estimated the prevalence of a comprehensive set of self-reported sleep problems by job characteristics, including shiftwork status, selected sociodemographic characteristics, and health and lifestyle factors among US workers; and (2) performed an in-depth examination of the association between these sleep problems and shiftwork status, adjusted for sociodemographic characteristics and other potential confounders.

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METHODS

Study design and population

Data from NHANES, a continuous series of cross-sectional surveys conducted by the National Center of Health Statistics (NCHS) of the Centers for Disease Control and Prevention, were used. A detailed description of the recruitment, design and surveys is available online (http://www.cdc.gov/nchs/nhanes/about_nhanes.htm). Briefly, data were collected in 2-year cycles using a stratified multistage probability design to ensure a nationally representative sample of the non-institutionalised US civilian population. Participants were interviewed in their homes, followed by an invitation to undergo various examinations, provide a blood sample and complete additional questionnaires.

The current analysis was limited to the NHANES 2005–2006 and 2007–2008 cycles only. Detailed data on sleep habits and sleep-related problems were not collected before 2005 or after 2008. The unweighted response rates for the two cycles were 78.4% and 75.4%, respectively. Since the exposure of interest was shiftwork, we excluded participants who were unemployed in the past week. This left an analytical sample of 6338 adults aged ≥18 years. All participants gave written informed consent. The NHANES study protocol was approved by the NCHS Research Ethics Review Board.

Sleep-related variables

Study participants completed a sleep questionnaire that included items from previously validated instruments.[16]

Sleep duration

Sleep duration was determined from the question, 'How much sleep do you usually get at night on weekdays or workdays?' with responses recorded in whole hours and ≥12 hours coded as '12'. This question did not have a specific time component (eg, in the last week or month). Based on the National Sleep Foundation recommendation that adults should sleep 7–9 hours per night,[17] two categories of sleep duration were created: <7 (ie, short sleep duration) and ≥7 hours per weekday or workday.

Sleep disorders

Physician-diagnosed sleep disorders were first identified by a 'yes' response to the question, 'Have you ever been told by a doctor or other health professional that you have a sleep disorder?'. This was followed by questions to ascertain the specific type of diagnosed disorder: sleep apnoea; insomnia; restless leg syndrome; or 'other'. Self-reported sleep latency or time to sleep was categorised as <30 and ≥30 min based on the question, 'How long does it usually take you to fall asleep at bedtime?' (ie, without a time component). Frequent use of sleeping pills was defined as taking sleeping pills or other medication to help sleep five or more times in the preceding month.

Sleep quality

Self-reported trouble sleeping and ever having told a physician about trouble sleeping were assessed. Ever telling a physician about trouble sleeping was defined as answering 'yes' to 'Have you ever told a doctor or other health professional that you have trouble sleeping?'. Self-reported sleep symptoms in the past month was assessed by asking about the following six sleep symptoms: (1) trouble falling asleep; (2) waking up during the night and having trouble getting back to sleep; (3) waking up too early in the morning and being unable to get back to sleep; (4) feeling unrested during the day, no matter how many hours of sleep were obtained; (5) feeling excessively or overly sleepy during the day and (6) not getting enough sleep. Each self-reported sleep symptom was considered frequent if the response was five or more times a month. We also created a sleep quality index by combining the frequency of self-reported sleep symptoms.[18] Participants were categorised as having 'poor' sleep quality if the response to any of the six self-reported sleep symptoms was 16–30 times a month; else as having 'moderate' sleep quality if at least one response was 5–15 times a month; and all other participants were defined as having 'good' sleep quality.

Sleep-related activities of daily living impairment

Participants also completed a general productivity subscale of the Functional Outcomes of Sleep Questionnaire.[19] The following eight items assessed the difficulty in performing certain activities of daily living (ADL) generally (ie, without a time component) due to excessive sleepiness: (1) concentrating on things, (2) remembering things, (3) eating or finishing a meal, (4) working on a hobby, (5) getting things done because too sleepy to drive or take public transportation, (6) taking care of financial affairs and doing paperwork (eg, paying bills), (7) performing paid or volunteer work and (8) maintaining a telephone conversation. Responses to each item were assigned a score: 0=no difficulty, 1=a little difficulty, 2=moderate difficulty and 3=severe difficulty (all other responses, including 'do not do this activity', were set to missing). The scores for the completed eight items were summed and participants were dichotomised based on the sample mean of 2.[20] A score ≥2 suggests a greater amount of ADL impairment from sleep compared to those with a score <2.

Insomnia

Insomnia was loosely based on the definitions and criteria of the American Psychiatric Association (APA).[21] Participants were categorised as having insomnia if they met these two conditions: (1) had poor sleep quality as defined above and (2) an ADL score suggesting impaired function (ie, ADL score ≥2).

Job exposures/characteristics

Shiftwork status was determined by the question: 'Which best describes the hours you usually work?'. The response options were (1) regular daytime schedule ('work anytime between 06:00 and 18:00'), (2) regular evening shift ('work anytime between 14:00 and midnight'), (3) regular night shift ('work anytime between 17:00 and 08:00'), (4) rotating shift ('a work shift that changes periodically from days to evenings or nights') or (5) another schedule ('a split shift consisting of two distinct work periods each day, an irregular schedule arranged by the employer, or any other schedule'). We also assessed the effect of other job-related characteristics on sleep: duration of current main job (<10 vs ≥10 years), hours worked in all jobs in the preceding week (<48 vs ≥48 hours) and the occupation category for the main job (three categories: service, farm/blue collar and white collar).

Covariates

Several self-reported potential confounders were assessed: age, gender, race/ethnicity, marital status and education level. Socioeconomic status was assessed by the poverty income ratio (PIR), which was calculated as the ratio of self-reported family income to the poverty threshold level according to US Census Bureau poverty guidelines.[22] PIR was categorised as <1 (below

the poverty threshold), 1 to <3 and ≥3 (representing family income three or more times the poverty threshold). The health-related potential confounders included self-rated general health status dichotomised into two groups: excellent, very good or good health versus fair or poor health. Health insurance status was dichotomised as covered by any type of health insurance versus not insured. Prescription medication use was also dichotomised (yes vs no).

During the examination, weight and height were measured. Body mass index was calculated using these measurements and categorised as <25.0 (underweight/normal weight), 25.0–29.9 (overweight) and ≥30.0 (obese). Current smoking status was assessed using serum cotinine; those with levels >10 ng/mL were considered smokers and those with levels ≤10 ng/mL were considered non-smokers. Data were also collected on self-reported use of two substances that may affect sleep: alcohol and caffeine. Average daily caffeine intake (in mg) was calculated from fluid (coffee, tea and soda) and food sources (chocolate) reported in two 24-hour dietary recalls, and categorised into quartiles based on intake distribution.

Depression was assessed using a validated questionnaire.[23] Participants were asked about nine symptoms over the previous 2-week period (ie, little interest in doing things; feeling down, depressed or hopeless; trouble sleeping or sleeping too much; feeling tired or having little energy; poor appetite or overeating; feeling bad about yourself; trouble concentrating on things; moving or speaking slowly or too fast; and thinking it is preferable to be dead). The frequency of each symptom was assigned a score: 0=not at all, 1=several days, 2=more than half the days and 3=nearly every day. The symptom scores were summed, which ranged between 0 and 27. A summed score of ≥10 was defined as having symptomatic depression.[23]

Statistical analysis

All analyses were conducted using SAS V.9.3 (SAS Institute, Cary, North Carolina, USA) and SAS-callable SUDAAN V.11.0.0 (Research Triangle Institute, Research Triangle Park, North Carolina, USA) to account for the complex survey design. To obtain results that would be generalisable to the non-institutionalised US civilian population, all estimates were weighted to account for the unequal probabilities of selection, oversampling and non-response. The sample weights for the combined 4-year data were constructed by multiplying the provided 2-year mobile examination centre sample weights by one half.[24]

Prevalence (%) and 95% CIs for each of the sleep problems were estimated for all study participants combined and stratified by sociodemographic characteristics, health factors, lifestyle factors, job characteristics and certain sleep characteristics. Imputed values for missing components of the sleep quality index (n=10 participants), ADL score (n=200 participants) and depression score (n=16) were assigned using the method of Raaijmakers.[25] Imputation of missing items occurred only when at least one component was non-missing. If all components of the scale were missing, no imputation was performed (no imputation was performed for 13 participants on the ADL score and for 544 participants on the depression score; all participants had values for at least one component of the sleep quality index). Wald χ^2 tests were used to examine differences in the prevalence of sleep problems across the categories of shiftwork status and across several other covariates. Estimates with a relative SE (RSE) >30% but ≤50% are noted in the tables as they do not meet the NCHS standards of reliability/precision; however, no RSE was >50%. All comparisons reported in the Results section are statistically different at a significance level of 0.05; however, not all significant differences are reported in the Results section.

Logistic regression analysis was used to examine the relationship between shiftwork status (as the exposure variable) and the binary outcomes of sleep duration, sleep-related ADL score and insomnia. For the sleep quality index, a multinomial logistic regression analysis was used. Simple logistic regression was first performed to assess the relationship between each outcome and the independent variables to identify potential confounders. Multicollinearity was assessed by examining associations among all explanatory variables. A multivariate logistic regression model was fitted for each outcome and included the sociodemographic characteristics of age group, gender, race/ethnicity and education level as well as all other factors that had $p<0.05$ in the univariate analysis. A backwards elimination approach was next used. Since the models for each sleep outcome were similar with or without further adjustment for physician-diagnosed sleep disorder and frequent use of sleeping pills, only the results without such adjustment are presented. Results are reported using prevalence ratio (PR) and their 95% CI. A p value of <0.05 from the Wald test was considered statistically significant.

RESULTS

The study sample included 6338 non-institutionalised, US civilian adults (3418 men and 2920 women) who were employed in the week preceding interview. The majority of workers reported that they regularly worked in the daytime (72.1%), 4.4% worked the night shift (representing 6.3 million US workers) and 23.5% worked on another shift (6.0% evening shift, 9.0% rotating shift and 8.5% another schedule) with data missing for two workers. The distribution of demographic and continuous sleep variables (ie, sleep duration and sleep latency) is provided in table 1.

Prevalence of selected sleep-related problems

The prevalence of short sleep duration was 37.6% among all workers, representing 54.1 million US workers (table 2). The prevalence of short sleep duration was lower among daytime workers (35.9%) compared with night shift (61.8%) workers. Of the workers with physician-diagnosed sleep disorders, sleep apnoea had the highest prevalence (3.9%), followed by insomnia (0.9%), restless leg syndrome (0.3%) and 'other' types (1.0%) (data not shown). The prevalence of prolonged sleep-onset latency (≥30 min) was lower among the daytime workers (31.0%) compared with the night shift (46.2%), evening shift (43%) and rotating shift (42.1%) workers.

The overall prevalence of good, moderate and poor sleep quality among all workers was 53.5%, 27.3% and 19.2% (ie, representing 76.9, 39.4 and 27.6 million US workers), respectively. Night shift workers had the highest prevalence of poor sleep quality (30.7%) and workers on another schedule had the highest prevalence of moderate sleep quality (34.1%) (table 2). Among all workers combined, the prevalence of specific self-reported sleep symptoms varied from 14% to 27%. Night and evening shift workers compared with the daytime workers had a higher prevalence of frequent trouble falling asleep (21.7% and 21.2%, respectively, vs 12.7%, table 2). Night shift workers and those on another schedule also had a higher prevalence of not getting enough sleep (37.2% and 32.8%, respectively, vs 25.2% among daytime shift workers, table 2). Compared with the daytime workers, the night shift workers also had a higher prevalence of frequently feeling excessively or overly sleepy during the day (22.3% vs 16.2%).

Table 1 Distribution of sociodemographic characteristics, health/lifestyle factors, job characteristics and sleep characteristics among US workers (NHANES, 2005–2008)

	n*	Weighted n	% (95% CI)
Sociodemographic characteristics			
Age group (years)			
18–29	1807	35 542 634	24.7 (23.0 to 26.4)
30–39	1374	31 973 309	22.2 (20.3 to 24.2)
40–49	1316	35 275 123	24.5 (22.7 to 26.4)
50–59	1059	28 927 115	20.1 (18.5 to 21.7)
≥60	782	12 291 375	8.5 (7.6 to 9.5)
Gender			
Male	3418	77 683 523	53.9 (52.7 to 55.2)
Female	2920	66 326 035	46.1 (44.8 to 47.3)
Race/ethnicity			
Non-Hispanic white	2809	100 189 029	69.6 (64.8 to 74.1)
Non-Hispanic black	1401	15 828 167	11.0 (8.4 to 14.0)
Hispanic	1833	19 048 189	13.2 (10.9 to 15.8)
Others/multiracial	295	8 944 173	6.2 (5.0 to 7.6)
Marital status			
Married/living with partner	3875	94 734 258	66.9 (64.4 to 69.3)
Never married	1388	27 218 138	19.2 (17.3 to 21.3)
Widowed/divorced/separated	920	19 689 860	13.9 (12.7 to 15.1)
Education level			
<High school	1462	21 323 686	14.8 (13.0 to 16.9)
≥High school	4854	122 470 037	85.2 (83.1 to 87.0)
PIR†			
<1	864	12 264 426	10.5 (9.2 to 11.9)
1 to <3	1327	22 776 540	19.4 (17.3 to 21.7)
≥3	2813	82 192 176	70.1 (66.9 to 73.2)
Health factors			
Self-rated health status			
Excellent/very good/good	4941	118 919 466	89.4 (88.3 to 90.5)
Fair/poor	873	14 064 200	10.6 (9.5 to 11.7)
Body mass index‡			
<25.0 (underweight/normal weight)	1992	47 726 272	33.4 (31.4 to 35.5)
25.0–29.9 (overweight)	2202	48 831 200	34.2 (32.8 to 35.6)
≥30.0 (obese)	2097	46 355 760	32.4 (30.1 to 34.8)
Prescription medication use			
No	3664	75 463 966	52.4 (50.5 to 54.3)
Yes	2673	68 489 726	47.6 (45.7 to 49.5)
Health insurance			
No	1703	28 751 089	20.0 (17.7 to 22.5)
Yes	4626	115 129 979	80.0 (77.5 to 82.3)
Symptomatic depression			
Not symptomatic (PHQ-9<10)	5496	126 889 653	95.8 (95.0 to 96.5)
Symptomatic (PHQ-9≥10)	298	5 592 842	4.2 (3.5 to 5.0)
Lifestyle factors			
Smoking status (serum cotinine in ng/mL)			
Non-smoker (≤10)	4358	98 187 872	72.0 (69.6 to 74.2)
Current smoker (>10)	1595	38 231 850	28.0 (25.8 to 30.4)
Alcohol intake§			
None	813	16 598 864	14.1 (12.2 to 16.2)
Low/moderate	3540	88 561 916	75.5 (73.6 to 77.3)
Excessive	455	12 160 343	10.4 (9.1 to 11.7)
Binge drinking¶			
None	2274	55 996 888	55.6 (53.1 to 58.1)
≤12 days	913	24 608 873	24.4 (22.3 to 26.7)
>12 days	804	20 046 680	19.9 (17.9 to 22.0)
Caffeine intake (daily average, mg)**			
0–29.5	1314	23 655 076	19.5 (17.7 to 21.4)
29.6–97.0	1319	25 546 591	21.0 (19.9 to 22.2)

Continued

Table 1 Continued

	n*	Weighted n	% (95% CI)
97.1–208.5	1307	32 050 318	26.4 (24.9 to 27.9)
>208.5	1308	40 153 064	33.1 (30.6 to 35.6)
Job characteristics			
Hours worked in all jobs in preceding week			
1–34 hours (part-time)	1430	28 052 293	20.4 (19.2 to 21.7)
35–47 hours (standard)	3005	67 054 294	48.8 (46.6 to 51.0)
≥48 (long)	1635	42 341 909	30.8 (28.7 to 33.0)
Months worked in current/main job			
0–12	1934	38 496 194	26.7 (25.4 to 28.1)
13–48	1613	35 885 117	24.9 (23.4 to 26.5)
49–119	1177	28 911 552	20.1 (18.8 to 21.4)
≥120	1610	40 624 276	28.2 (25.9 to 30.7)
Occupation categories			
White collar	3117	81 602 165	56.7 (53.6 to 59.8)
Service	1427	25 595 560	17.8 (16.2 to 19.5)
Farm and blue collar	1782	36 607 064	25.5 (23.0 to 28.0)
Sleep characteristics			
Sleep duration per weekday/workday			
<7 hours	2512	54 119 388	37.6 (35.2 to 40.0)
7–9 hours	3724	87 945 034	61.1 (58.6 to 63.5)
10 or more hours	101	1 934 837	1.3 (1.0 to 1.8)
Sleep latency (time required to fall asleep)			
0–10 min	2873	67 745 916	47.1 (44.9 to 49.3)
11–29 min	1232	28 723 589	20.0 (18.6 to 21.5)
30–59 min	1371	30 593 742	21.3 (19.7 to 22.9)
60 or more min	849	16 722 239	11.6 (10.6 to 12.8)
Physician-diagnosed sleep disorder††			
No	5986	134 884 353	93.8 (93.0 to 94.5)
Yes	343	8 943 077	6.2 (5.5 to 7.0)
Sleeping pills or other medication use to help with sleep (times/previous month)			
0	5455	120 602 534	83.8 (82.8 to 84.7)
>0 to <5	555	14 140 653	9.8 (8.8 to 10.9)
≥5	327	9 235 618	6.4 (5.6 to 7.3)

*Unweighted sample size.
†PIR is calculated as the ratio of self-reported family income to the poverty threshold level according to US Census Bureau poverty guidelines.[22]
‡Body mass index=measured weight in kilograms/(measured height in metres)^2.
§Self-reported alcohol intake for the 12 months that preceded interview was determined for participants aged ≥20 years. Alcohol intake was categorised as: excessive (>2 drinks per day for men and >1 drink per day for women), low/moderate (>0 but <2 drinks per day for men and ≤1 drink per day for women) and none.
¶Binge drinking=days in preceding year that participant consumed five or more alcoholic drinks in a single day.
**Calculated from fluid (coffee, tea and soda) and food sources (chocolate) reported in two 24-hour dietary recalls, and categorised into quartiles based on intake distribution.
††Participant ever told by a doctor or other health professional that they had a sleep disorder, including sleep apnoea, insomnia, restless leg syndrome or 'other'.
NHANES, National Health and Nutrition Examination Survey; PHQ-9, Patient Health Questionnaire-9; PIR, poverty income ratio.

The prevalence of impaired sleep-related ADL was 24.8% among all workers (ie, 35.6 million US workers) with a higher prevalence among the night shift (36.2%) compared with daytime (23.7%) workers. The prevalence of insomnia was 8.8% among all workers (ie, representing 12.7 million US workers) with a higher prevalence among the night shift (18.5%) compared with daytime (8.4%) workers.

Sleep-related problems by sleep duration and shift

Among all workers combined, those who sleep <7 hours were more likely to have poor sleep quality, impaired ADL and insomnia compared to those who sleep 7 hours or more (figure 1). This finding was also true for day shift workers, night shift workers, rotating shift workers and workers of another schedule. Among regular night shift workers who sleep <7 hours, the prevalence of each sleep problem was higher compared to day shift workers in the same sleep duration category.

Predictors of selected sleep-related problems

Workers aged ≥60 years had a lower prevalence of short sleep duration, impaired sleep-related ADL and insomnia compared with those aged 30–59 years (table 3). Female workers had a lower prevalence of short sleep duration but higher prevalence of the other three sleep outcomes compared to male workers. Workers with PIR ≥3 had a lower prevalence of poor sleep quality, impaired sleep-related ADL and insomnia compared with those with PIR <1. Obese workers had a higher prevalence of short sleep duration and poor sleep quality compared with those who were normal weight/underweight. Current smokers had a higher prevalence of short sleep duration, poor sleep quality and insomnia (but not impaired sleep-related ADL) compared with non-smokers. Workers who worked ≥48 hours had a higher prevalence of short sleep duration, poor sleep quality and insomnia compared with those who worked <48 hours per week. Workers with frequent use of sleeping pills had a higher prevalence of poor sleep quality, impaired sleep-related ADL

Table 2 Weighted prevalence of selected sleep-related problems and job characteristics by usual shift worked among US workers (NHANES, 2005–2008)

			Shiftwork status*									
	Total (n=6338)		Regular daytime shift (n=4568)		Regular night shift (n=277)		Regular evening shift (n=381)		Rotating shift (n=570)		Another schedule† (n=540)	
	n‡	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Sleep-related problems												
Short sleep duration (<7 hours per weekday/workday)§	2512	37.6 (35.3 to 39.9)	1717	35.9 (33.5 to 38.4)	172	61.8 (55.0 to 68.3)	157	39.1 (33.2 to 45.0)	248	41.3 (35.5 to 47.1)	217	37.1 (31.7 to 42.5)
Physician-diagnosed sleep disorder¶	343	6.2 (5.5 to 7.0)	248	6.5 (5.8 to 7.3)	15	3.8 (1.9 to 7.6)**	19	4.4 (1.2 to 7.6)**	26	5.9 (2.7 to 9.2)	35	6.2 (3.0 to 9.4)
Sleeping pills/other medications to help with sleep (five or more times in preceding month)	327	6.4 (5.6 to 7.3)	238	6.4 (5.5 to 7.5)	16	8.1 (5.4 to 12.2)	18	6.4 (3.2 to 9.7)	26	5.9 (3.2 to 8.6)	29	6.2 (4.0 to 8.4)
Sleep latency/time to sleep at bedtime (≥30 min)§	2220	32.9 (30.9 to 35.0)	1514	31.0 (29.0 to 33.0)	118	46.2 (39.9 to 52.6)	167	43.0 (36.8 to 49.3)	252	42.1 (36.4 to 47.8)	168	29.6 (23.0 to 36.2)
Ever told physician had trouble falling asleep	1103	20.2 (19.2 to 21.2)	782	19.8 (18.6 to 21.0)	49	22.2 (15.0 to 31.5)	60	15.9 (11.0 to 20.8)	96	21.8 (16.6 to 27.1)	116	24.1 (18.7 to 29.6)
Sleep quality, self-reported (five or more times in the past month)												
Trouble falling asleep§	824	14.0 (12.8 to 15.2)	534	12.7 (11.4 to 14.1)	54	21.7 (16.7 to 27.5)	73	21.2 (15.6 to 26.8)	92	17.5 (12.4 to 22.7)	71	14.4 (10.5 to 18.2)
Wake up during the night with trouble getting back to sleep	1015	17.4 (16.1 to 18.8)	718	17.1 (15.7 to 18.5)	52	19.9 (14.2 to 27.2)	65	19.0 (13.7 to 24.2)	81	14.9 (11.6 to 18.2)	99	20.2 (15.7 to 24.8)
Wake up too early in the morning and unable to get back to sleep§	874	14.3 (13.0 to 15.6)	633	14.2 (12.8 to 15.7)	46	20.6 (14.8 to 27.9)	52	15.0 (11.0 to 19.0)	61	9.7 (7.2 to 12.3)	82	15.7 (12.1 to 19.3)
Feel unrested during the day regardless of hours of sleep	1528	26.6 (25.1 to 28.2)	1054	25.5 (23.6 to 27.4)	75	32.1 (25.2 to 40.0)	100	28.7 (22.0 to 35.4)	155	28.5 (21.2 to 35.8)	144	31.4 (27.3 to 35.6)
Feel excessively or overly sleepy during the day	1020	17.0 (15.5 to 18.5)	695	16.2 (14.7 to 17.8)	56	22.3 (17.5 to 27.9)	64	17.6 (11.7 to 23.4)	104	17.5 (12.5 to 22.4)	101	20.7 (16.3 to 25.1)
Not getting enough sleep§	1587	26.9 (25.3 to 28.5)	1061	25.2 (23.4 to 27.1)	92	37.2 (31.6 to 43.2)	122	31.9 (26.7 to 37.2)	159	27.6 (20.9 to 34.3)	153	32.8 (28.2 to 37.4)
Sleep quality index§,††												
Good	3555	53.5 (52.0 to 54.9)	2646	55.2 (53.2 to 57.3)	142	46.9 (39.9 to 54.0)	192	48.0 (40.0 to 56.0)	299	50.7 (44.1 to 57.3)	274	47.2 (42.5 to 51.9)
Moderate	1620	27.3 (25.8 to 28.9)	1120	26.4 (24.5 to 28.4)	60	22.4 (17.4 to 28.2)	107	28.9 (23.8 to 34.0)	165	30.1 (24.3 to 35.8)	168	34.1 (29.0 to 39.3)
Poor	1163	19.2 (17.6 to 20.8)	802	18.4 (17.0 to 19.9)	75	30.7 (25.7 to 36.2)	82	23.1 (16.8 to 29.3)	106	19.3 (14.2 to 24.3)	98	18.7 (13.9 to 23.5)
Sleep-related ADL												
Difficulty concentrating	1387	22.9 (21.5 to 24.3)	942	22.1 (20.8 to 23.5)	83	30.4 (22.9 to 39.0)	95	22.5 (16.6 to 28.4)	122	22.0 (16.9 to 27.1)	144	26.7 (21.1 to 32.3)
Difficulty remembering§	1086	17.3 (16.2 to 18.5)	734	16.4 (15.1 to 17.7)	67	25.7 (20.4 to 31.9)	79	18.4 (13.6 to 23.1)	89	16.0 (12.1 to 20.0)	117	22.5 (18.6 to 26.3)
Difficulty eating	207	2.8 (2.3 to 3.3)	129	2.3 (1.9 to 2.8)	15	3.2 (1.6 to 6.3)**	22	6.3 (2.8 to 9.8)	27	4.6 (2.1 to 7.0)	14	2.6 (0.8 to 4.3)**
Difficulty with a hobby	782	13.4 (12.3 to 14.6)	531	13.2 (12.0 to 14.4)	48	18.6 (14.0 to 24.3)	51	12.2 (7.7 to 16.7)	77	14.8 (10.9 to 18.8)	75	13.0 (9.2 to 16.8)
Difficulty getting things done because too sleepy to drive	721	11.3 (10.3 to 12.3)	465	10.5 (9.5 to 11.5)	46	16.9 (11.8 to 23.7)	60	13.2 (8.3 to 18.1)	70	11.3 (8.1 to 14.6)	80	14.3 (10.1 to 18.6)
Difficulty with finance	749	11.9 (10.7 to 13.2)	478	11.3 (10.1 to 12.6)	34	13.4 (8.5 to 20.5)	68	12.9 (9.7 to 16.2)	83	12.5 (8.7 to 16.4)	86	15.4 (11.5 to 19.3)
Difficulty with paid or volunteer work	632	10.5 (9.6 to 11.4)	436	10.4 (9.3 to 11.7)	37	13.1 (8.7 to 19.2)	47	11.2 (7.9 to 14.6)	57	8.7 (6.4 to 11.0)	55	10.8 (7.5 to 14.0)
Difficulty maintaining phone conversation§	605	8.4 (7.5 to 9.4)	360	7.1 (6.2 to 8.0)	46	15.0 (10.2 to 21.6)	58	14.2 (9.8 to 18.5)	80	12.7 (8.5 to 16.8)	61	10.0 (6.6 to 13.4)
Impaired ADL score§,‡‡	1545	24.8 (23.1 to 26.5)	1030	23.7 (22.2 to 25.3)	97	36.2 (28.8 to 44.4)	118	29.1 (23.1 to 35.1)	147	23.5 (18.5 to 28.4)	153	27.7 (22.3 to 33.1)
Insomnia§,§§	537	8.8 (7.9 to 9.8)	368	8.4 (7.5 to 9.5)	41	18.5 (13.2 to 25.4)	36	9.7 (6.6 to 12.8)	48	9.3 (5.9 to 12.8)	44	7.0 (4.3 to 9.7)
Job characteristics												
Hours worked in all jobs in preceding week (≥48)§	1635	30.8 (28.7 to 33.0)	1155	30.0 (27.9 to 32.3)	80	29.8 (24.6 to 35.6)	65	22.2 (17.7 to 26.7)	149	29.6 (24.6 to 34.6)	186	43.7 (38.1 to 49.4)
Years worked in current/main job (≥10 years)§	1610	28.2 (25.9 to 30.6)	1261	29.9 (27.3 to 32.6)	45	15.1 (10.4 to 21.3)	47	13.1 (7.4 to 18.7)	81	19.8 (14.0 to 25.7)	176	36.1 (30.0 to 42.2)

Continued

Table 2 Continued

	Total (n=6338)		Shiftwork status* Regular daytime shift (n=4568)		Regular night shift (n=277)		Regular evening shift (n=381)		Rotating shift (n=570)		Another schedule† (n=540)	
	n‡	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Occupation categories§												
White collar	3117	56.7 (53.7 to 59.8)	2369	60.2 (56.8 to 63.4)	84	34.1 (26.6 to 42.5)	134	33.3 (28.3 to 38.4)	253	48.8 (42.5 to 55.0)	277	58.2 (51.7 to 64.7)
Service	1427	17.8 (16.2 to 19.5)	859	14.2 (12.7 to 15.9)	95	32.1 (26.5 to 38.2)	141	38.5 (32.8 to 44.1)	197	29.4 (24.0 to 34.8)	134	19.6 (16.1 to 23.0)
Farm and blue collar	1782	25.5 (23.1 to 28.0)	1332	25.6 (23.1 to 28.4)	98	33.8 (28.2 to 39.9)	106	28.2 (21.6 to 34.8)	118	21.8 (15.9 to 27.8)	128	22.2 (16.4 to 27.9)

*Among workers, 72.1% reported that they usually worked a regular daytime shift, 4.4% worked a regular night shift, 6.0% worked a regular evening shift, 9.0% worked a rotating shift and 8.5% had another schedule (excluded two participants with unknown shiftwork status).
†No additional information is available on this shift category. This category was selected by the participant if none of the other categories applied. It could include a split shift consisting of two distinct work periods each day, an irregular schedule arranged by the employer or any other schedule not already specified.
‡Unweighted sample size.
§Wald χ^2 test for equal prevalence of sleep or job characteristic across shiftwork status, $p<0.05$.
¶Participant ever told by a doctor or other health professional that they had a sleep disorder, including sleep apnoea, insomnia, restless leg syndrome or 'other'.
**Estimates have a RSE >30% and ≤50% and should be interpreted with caution as they do not meet standards of reliability/precision.
††Participants categorised as having poor sleep quality if the response to any of the six self-reported sleep quality items was 16–30 times/month; else as moderate sleep quality if any response was 5–15 times/month; and all others as having good sleep quality.
‡‡Response to each of the eight ADL items on a 0–3 scale, with 0=no difficulty, 1=a little difficulty, 2=moderate difficulty and 3=severe difficulty. Participants were dichotomised at 2 (sample mean score of eight completed items): a score ≥2 is considered to indicate a greater daily sleep-related impairment than a score <2.
§§Participants with poor sleep quality and impaired ADL score.
ADL, activities of daily living; NHANES, National Health and Nutrition Examination Survey; RSE, relative SE.

and insomnia (but not short sleep duration) compared to those without. Finally, compared to workers without these characteristics, a higher prevalence of all four sleep outcomes was observed among workers who were widowed, divorced or separated; workers who reported fair or poor health; workers with symptomatic depression; and workers who had a physician-diagnosed sleep disorder.

Modelling of sleep problems and shiftwork status

Compared with daytime workers, night shift workers were more likely to have short sleep duration (model 2: PR=1.70; 95% CI 1.48 to 1.96) (table 4). The likelihood of poor self-reported sleep quality, impaired sleep-related ADL and insomnia was higher among night shift workers compared with daytime workers (PR=1.52, 1.39 and 2.03, respectively). The likelihood of moderate self-reported sleep quality was higher among workers on another schedule compared with daytime workers (model 2: PR=1.25; 95% CI 1.06 to 1.47).

DISCUSSION

Using 2005–2008 NHANES data, we found that sleep-related problems were common in a nationally representative sample of US adult workers. Furthermore, night shift workers had a higher risk for all of these sleep problems, and these higher risks persisted after adjustment for potential confounders, including long work hours (≥48 hours/week), sociodemographic characteristics and health/lifestyle/work factors.

Although it has long been recognised that shift workers, particularly those working in the night shift, have more sleep problems or sleepiness than daytime workers,[12 13 26] to the best of our knowledge, this is the first study to use a nationally representative sample of the US working population to examine the role of shiftwork on sleep quality, sleep-related ADL and insomnia. The sleep problems we observed may be explained by a desynchronisation between the circadian system and the sleep/wake cycle that has been detected in night shift workers.[12 27] Although we only reported on the sleep problems present at the time of interview, the sleep problems observed among night shift workers may not quickly reverse by switching to day shift. Instead, the effects of shiftwork on sleep duration and sleep quality may persist into retirement,[28] although this is disputed by others.[29]

Sleep-related problems were significantly more prevalent among those with short sleep duration, especially among night shift workers (figure 1), consistent with previous reports. In the general population, it has previously been found that sleep duration is lower among those with insomnia,[30] and those with short sleep duration are more likely to have impaired ADL[31] and poor sleep quality.[32] This coexistence of short sleep duration with other sleep problems is cause for concern. For example, there appears to be a synergism between short sleep duration and poor sleep quality in their effect on health outcomes, as those with both had the highest risk for coronary heart disease[3] and all-cause mortality.[4]

We found that 25% of all workers have sleep-related ADL impairment, similar to that observed for the general population,[31] which rose to 36% among regular night shift workers. Such impairment of ADL activities and poor sleep quality may contribute to some of the adverse outcomes observed among night shift workers, including increased fatal and non-fatal injury rates,[33] reckless behaviour (eg, unsafe driving, excessive drinking, poor diet and higher smoking prevalence) and impaired work performance.[34] For example, the reasons for an

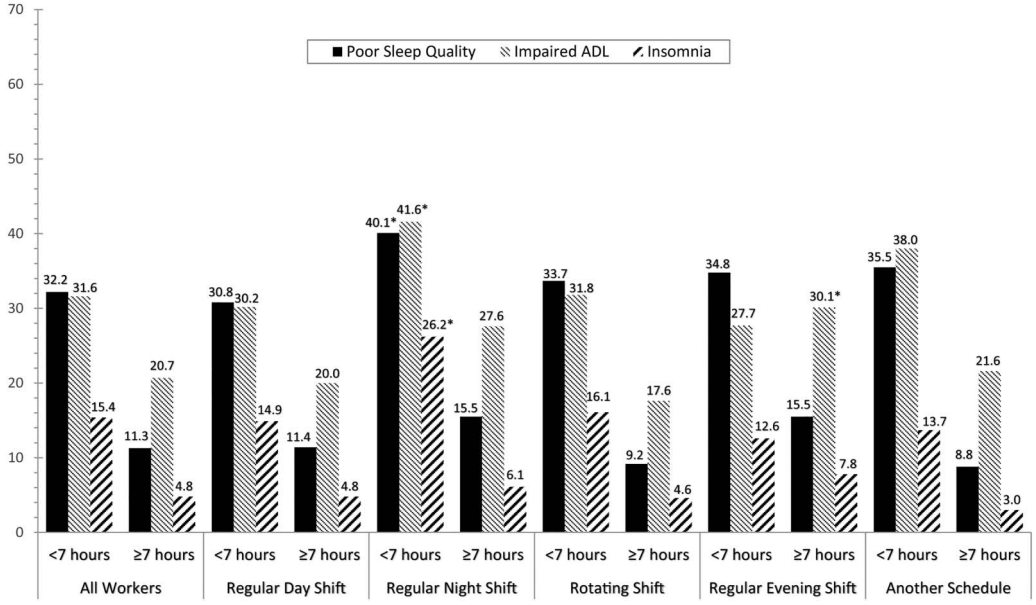

Figure 1 Weighted prevalence (%) of poor sleep quality, impaired ADL and insomnia by usual sleep duration and shift—USA (NHANES, 2005–2008). *Wald χ^2 test for equal prevalence of sleep characteristics between the designated shift and regular day shift in the same sleep duration, p<0.05. ADL, activities of daily living; NHANES, National Health and Nutrition Examination Survey.

elevated smoking prevalence among shift workers may include its effects on relieving fatigue and sleepiness.[35]

Prevalence estimates of short sleep duration from nationally representative samples of US workers vary. While we reported a prevalence of 38% using NHANES data, the 2004–2007[14] and 2010[15] National Health Interview Survey (NHIS) reported a 30% prevalence among US workers, which are in line with estimates for the general US population from NHANES and NHIS, respectively.[31 36] The NHANES and NHIS discrepancies may be due to the difference in how these surveys ask about sleep duration. NHANES asks about the amount of sleep obtained at night on weekdays or workdays, whereas NHIS asks 'on average, how many hours of sleep do you get in a 24-hour period?'. Since NHANES only asked about amount of sleep 'at night', night shift workers may have difficulty with their response since they typically do not sleep at night. This may also explain why the prevalence estimates for short sleep duration among night shift workers differed between our study (62%) and NHIS (44%).[15] In addition, NHANES asked about sleep duration on workdays, whereas NHIS asked about 'a 24-hour period' without distinguishing between workdays and non-workdays. The amount of sleep obtained on a workday may be a better measure of work-related short sleep duration.

Insomnia is a disorder that involves poor sleep quality and impaired sleep-related ADL function.[21] In contrast to sleep duration, few estimates on insomnia prevalence in the working population exist. The APA reported that 6–10% of the US population has insomnia disorder,[21] which is consistent with the 9% prevalence we found among US workers. However, in a study of workers enrolled in a national US commercial health plan between 2008 and 2009, self-reported insomnia prevalence was 23%.[5] Kessler *et al*[5] defined insomnia in a manner more consistent with the APA definition (eg, their definition required night-time symptoms occurring three or more times/week vs NHANES data which can identify high frequency sleep symptoms only when they occurred at least 16 times per month). Neither Kessler *et al*[5] nor our study included two other APA definitional criteria for insomnia: sleep difficulty present at least 3 months and exclusion of secondary insomnia.

Study limitations

This study has several limitations. First, the cross-sectional design limits making inferences regarding the direction of our observed sleep–shiftwork association; for example, there may be self-selection into a given shift according to sleep characteristics. Second, our findings are based on self-reports and may be prone to misclassification bias. For example, comparisons of sleep duration based on self-reports versus actigraphy and polysomnography have shown that self-reports often overestimate sleep duration, except those with short sleep duration often underestimate sleep duration.[37 38] Fortunately, these earlier studies comparing self-report and objective sleep duration suggest that our distribution of dichotomised sleep duration may be accurate. Third, although we are not aware of studies to establish the psychometric properties of the sleep quality index we used, it has been used previously to examine the effect of sleep quality on hypertension.[18] Fourth, data were incomplete for several covariates. The exclusion of workers with missing covariates may result in selection bias and residual confounding by unmeasured covariates. However, we think the potential for such bias and confounding is low because the magnitude of the association between shiftwork status and sleep problems remained essentially unchanged with or without adjustment for various sociodemographic/lifestyle/work factors. Fifth, there is a possibility that night shift workers' response to some sleep questions, such as 'waking too early in the morning' and 'feeling excessively sleepy during the day', may be inaccurate as they likely slept during the day. Finally, due to a lack of data, we were unable to evaluate shift characteristics (eg, number of years employed on a given shift; speed, direction and pattern of rotating shifts; and amount of time off between shifts) and due to small sample size, we were unable to evaluate detailed industry and occupation categories, each of which may modify the association between shiftwork and sleep. For example, those with a long tenure on night shift may be more tolerant of that shift as demonstrated by the absence of an elevated injury risk among such workers.[39]

Table 3 Weighted prevalence of short sleep duration, poor sleep quality, poor sleep-related ADL score and insomnia among US workers by sociodemographic characteristics, health/lifestyle factors, and job and sleep characteristics (NHANES, 2005–2008)

	Short sleep duration*			Poor sleep quality†			Poor sleep-related ADL score‡			Insomnia§		
	n¶	% (95% CI)	p Value	n	% (95% CI)	p Value	n	% (95% CI)	p Value	n	% (95% CI)	p Value
Total	2512	37.6 (35.3 to 39.9)	–	1163	19.2 (17.6 to 20.8)	–	1545	24.8 (23.1 to 26.5)	–	537	8.8 (7.9 to 9.8)	–
Sociodemographic characteristics												
Age group (years)			0.036			0.084			0.001			0.027
18–29	620	35.1 (31.9 to 38.2)		336	19.9 (17.3 to 22.5)		522	28.6 (24.9 to 32.3)		173	9.7 (7.9 to 11.4)	
30–39	559	38.6 (34.7 to 42.5)		275	20.7 (18.0 to 23.4)		330	24.1 (21.5 to 26.7)		119	8.6 (7.1 to 10.0)	
40–49	572	39.0 (35.5 to 42.5)		244	18.1 (15.6 to 20.6)		328	24.2 (21.3 to 27.0)		116	8.7 (6.5 to 10.8)	
50–59	457	39.5 (35.9 to 43.2)		202	19.7 (16.8 to 22.6)		243	25.1 (22.0 to 28.2)		94	9.8 (7.9 to 11.7)	
≥60	304	33.7 (30.1 to 37.2)		106	15.1 (11.4 to 18.8)		122	16.6 (13.5 to 19.6)		35	5.1 (3.0 to 7.2)	
Gender			0.001			0.001			0.001			0.002
Male	1426	40.4 (37.9 to 43.0)		529	16.3 (14.7 to 18.0)		713	21.7 (19.7 to 23.8)		228	7.2 (5.9 to 8.6)	
Female	1086	34.3 (31.4 to 37.3)		634	22.6 (20.1 to 25.2)		832	28.4 (25.9 to 31.0)		309	10.7 (9.3 to 12.3)	
Race/ethnicity			0.001			0.001			0.001			0.091
Non-Hispanic white	974	34.9 (32.2 to 37.8)		586	20.3 (18.4 to 22.4)		702	24.6 (22.7 to 26.7)		259	9.2 (8.1 to 10.5)	
Non-Hispanic black	774	55.4 (52.5 to 58.3)		254	18.4 (16.3 to 20.8)		374	27.6 (23.4 to 32.3)		123	8.9 (7.4 to 10.6)	
Hispanic	638	34.9 (32.0 to 37.9)		263	14.4 (12.5 to 16.5)		374	19.8 (18.0 to 21.8)		125	6.7 (5.3 to 8.3)	
Others/multiracial	126	41.5 (34.5 to 48.9)		60	17.7 (13.3 to 23.2)		95	31.9 (26.8 to 37.5)		30	8.9 (5.6 to 13.7)	
Marital status			0.020			0.041			0.001			0.010
Married/living with partner	1502	36.2 (33.7 to 38.8)		699	18.6 (17.0 to 20.2)		854	22.6 (21.0 to 24.2)		299	7.9 (7.1 to 8.9)	
Never married	543	38.5 (34.9 to 42.1)		234	17.9 (14.8 to 21.5)		371	27.6 (23.9 to 31.7)		112	8.1 (6.3 to 10.4)	
Widowed/divorced/separated	420	43.7 (38.7 to 48.9)		204	23.4 (19.4 to 28.1)		260	29.8 (26.1 to 33.7)		108	13.1 (10.3 to 16.4)	
Education level			0.660			0.001			0.288			0.854
<High school	542	36.9 (32.8 to 41.1)		259	18.3 (15.8 to 21.0)		315	22.9 (19.6 to 26.6)		123	8.6 (6.8 to 10.9)	
≥High school	1964	37.7 (35.4 to 40.1)		902	19.4 (17.7 to 21.1)		1226	25.1 (23.3 to 27.1)		412	8.8 (7.9 to 9.9)	
PIR			0.057			0.019			0.041			0.040
<1	327	38.0 (33.2 to 43.0)		183	23.3 (20.2 to 26.7)		236	28.5 (22.9 to 34.8)		92	11.5 (8.9 to 14.6)	
1 to <3	550	40.0 (36.2 to 44.0)		246	20.2 (17.4 to 23.3)		334	28.0 (24.4 to 32.0)		120	9.8 (7.8 to 12.1)	
≥3	1070	34.9 (32.1 to 37.8)		481	17.9 (16.1 to 19.8)		639	23.0 (21.3 to 24.7)		204	7.7 (6.7 to 8.8)	
Health factors												
Self-rated health status			0.001			0.001			0.001			0.001
Excellent/very good/good	1873	36.1 (33.8 to 38.6)		837	17.8 (16.5 to 19.3)		1125	23.3 (21.5 to 25.2)		370	7.9 (7.0 to 8.8)	
Fair/poor	410	46.6 (41.6 to 51.8)		236	30.9 (26.8 to 35.4)		287	35.2 (31.4 to 39.3)		119	15.1 (12.1 to 18.6)	
Body mass index			0.001			0.044			0.814			0.422
<25.0 (underweight/normal weight)	657	31.9 (28.5 to 35.5)		345	18.7 (16.5 to 21.1)		495	25.5 (22.8 to 28.3)		153	7.9 (6.6 to 9.5)	
25.0–29.9 (overweight)	887	38.0 (35.6 to 40.6)		371	17.5 (15.5 to 19.7)		517	24.5 (22.6 to 26.5)		180	9.1 (7.7 to 10.7)	
≥30.0 (obese)	950	42.9 (39.7 to 46.2)		434	21.3 (18.4 to 24.4)		521	24.5 (22.0 to 27.2)		198	9.4 (7.9 to 11.1)	
Prescription medication use			0.565			0.001			0.001			0.001
No	1417	37.9 (35.6 to 40.2)		592	16.3 (15.0 to 17.5)		837	22.7 (21.2 to 24.3)		270	7.2 (6.4 to 8.0)	
Yes	1094	37.2 (34.4 to 40.1)		571	22.4 (20.1 to 24.9)		708	27.0 (24.8 to 29.5)		267	10.6 (9.2 to 12.3)	
Health insurance			0.146			0.013			0.710			0.208
No	645	40.1 (35.9 to 44.4)		326	21.9 (19.2 to 24.9)		384	24.3 (21.2 to 27.7)		150	9.7 (7.9 to 11.9)	
Yes	1865	36.9 (34.5 to 39.4)		836	18.5 (17.0 to 20.1)		1158	24.9 (23.3 to 26.6)		386	8.6 (7.8 to 9.4)	
Symptomatic depression			0.001			0.001			0.001			0.001
Not symptomatic (PHQ-9<10)	2109	36.4 (34.1 to 38.7)		929	17.8 (16.3 to 19.3)		1237	23.0 (21.3 to 24.9)		398	7.5 (6.6 to 8.6)	
Symptomatic (PHG-9≥10)	165	54.7 (47.6 to 61.7)		138	52.0 (43.7 to 60.1)		171	59.6 (51.6 to 67.1)		89	33.5 (26.3 to 41.6)	

Continued

Table 3 Continued

	Short sleep duration*			Poor sleep quality†			Poor sleep-related ADL score‡			Insomnia§		
	n¶	% (95% CI)	p Value	n	% (95% CI)	p Value	n	% (95% CI)	p Value	n	% (95% CI)	p Value
Lifestyle factors												
Smoking status (cotinine in ng/mL)			0.001			0.001			0.493			0.008
Non-smoker (≤10)	1649	34.8 (32.6 to 37.2)		725	17.2 (15.6 to 18.9)		1081	25.2 (23.3 to 27.1)		351	8.3 (7.4 to 9.4)	
Current smoker (>10)	711	44.4 (40.9 to 47.9)		369	24.8 (22.2 to 27.4)		382	24.3 (21.7 to 27.0)		158	10.5 (9.2 to 11.9)	
Alcohol intake**												
Frequency			0.118			0.136			0.830			0.044
None	363	41.0 (36.5 to 45.7)		166	23.3 (19.1 to 28.0)		193	24.7 (21.2 to 28.5)		84	11.5 (9.0 to 14.7)	
Low/moderate	1383	36.7 (34.1 to 39.5)		649	18.7 (16.9 to 20.7)		824	23.9 (21.9 to 26.0)		273	7.8 (6.8 to 8.9)	
Excessive	179	40.1 (33.4 to 47.3)		90	20.2 (16.3 to 24.8)		108	25.0 (20.5 to 30.1)		42	10.0 (6.9 to 14.3)	
Binge drinking (days in preceding year consumed five or more alcoholic drinks in a single day)			0.382			0.075			0.701			0.742
None	898	37.1 (34.5 to 39.7)		415	18.7 (16.7 to 20.8)		533	23.7 (21.6 to 26.0)		175	7.8 (6.9 to 8.9)	
≤12 days	347	35.6 (31.6 to 39.8)		167	17.9 (14.7 to 21.5)		226	25.1 (21.8 to 28.8)		77	8.1 (6.1 to 10.7)	
>12 days	315	39.2 (34.9 to 43.7)		158	20.8 (17.5 to 24.6)		174	23.6 (20.3 to 27.2)		64	8.7 (6.5 to 11.5)	
Caffeine intake (daily average, mg)			0.372			0.052			0.463			0.126
0–29.5	476	33.0 (28.5 to 37.9)		214	16.0 (12.6 to 20.1)		334	26.6 (22.5 to 31.1)		90	7.0 (4.7 to 10.5)	
29.6–97.0	516	36.7 (32.2 to 41.5)		237	18.1 (15.3 to 21.2)		315	22.9 (19.2 to 27.2)		115	7.4 (5.8 to 9.4)	
97.1–208.5	515	37.3 (33.7 to 41.1)		239	20.5 (17.4 to 24.0)		312	25.3 (22.1 to 28.8)		117	9.9 (7.9 to 12.4)	
>208.5	538	37.7 (33.8 to 41.8)		268	21.7 (18.2 to 25.6)		306	22.8 (19.9 to 25.8)		121	9.8 (7.4 to 12.9)	
Job characteristics												
Hours worked in all jobs in preceding week			0.001			0.006			0.336			0.035
<48	1637	34.4 (32.0 to 37.0)		781	18.4 (17.0 to 19.9)		1061	24.4 (22.7 to 26.2)		350	8.2 (7.3 to 9.2)	
≥48	792	46.1 (42.2 to 50.1)		337	21.4 (18.5 to 24.6)		417	25.9 (23.0 to 29.0)		164	10.5 (8.7 to 12.5)	
Years worked in current/main job			0.153			0.804			0.017			0.562
<10	1820	37.0 (34.7 to 39.3)		883	19.3 (17.6 to 21.0)		1209	26.0 (24.1 to 28.0)		413	8.6 (7.6 to 9.7)	
≥10	691	39.0 (35.7 to 42.5)		280	19.0 (16.1 to 22.3)		336	21.7 (19.0 to 24.6)		124	9.3 (7.4 to 11.7)	
Occupation categories			0.001			0.044			0.003			0.593
White collar	1167	34.1 (31.5 to 36.8)		586	18.9 (16.7 to 21.2)		817	25.9 (23.9 to 27.9)		273	8.5 (7.4 to 9.9)	
Service	554	36.0 (32.1 to 40.1)		278	20.3 (17.9 to 22.9)		361	26.2 (22.7 to 30.1)		135	10.0 (8.0 to 12.3)	
Farm and blue collar	786	46.2 (42.3 to 50.2)		299	19.2 (16.6 to 22.2)		366	21.5 (19.1 to 24.0)		129	8.6 (7.0 to 10.6)	
Sleep characteristics												
Physician-diagnosed sleep disorder††			0.005			0.001			0.001			0.001
No	2335	37.0 (34.8 to 39.4)		1016	17.7 (16.1 to 19.3)		1396	23.9 (22.2 to 25.8)		454	8.0 (7.1 to 9.0)	
Yes	174	46.1 (39.5 to 52.7)		144	41.6 (36.0 to 47.5)		146	36.9 (31.4 to 42.8)		82	20.9 (15.5 to 27.5)	
Sleeping pills or other medication use to help with sleep (times in preceding month)			0.189			0.001			0.001			0.001
<5	2361	37.3 (35.1 to 39.6)		1010	17.2 (15.8 to 18.7)		1408	23.6 (21.9 to 25.2)		463	7.8 (7.0 to 8.7)	
≥5	151	41.5 (34.7 to 48.7)		153	48.6 (43.3 to 54.0)		136	42.4 (37.1 to 47.9)		74	23.0 (18.5 to 28.4)	

*Sleep duration <7 hours per week/work day.
†Participants categorised as having poor sleep quality if the response to any of the six sleep problem items was 16–30 times/month.
‡Participants with ADL score ≥2 (sample mean).
§Participants with poor sleep quality and poor ADL score.
¶Unweighted sample size.
**Self-reported alcohol intake for the 12 months that preceded interview was determined for participants aged ≥20 years. Alcohol intake was categorised as: excessive (>2 drinks per day for men and >1 drink per day for women), low/moderate (>0 but <2 drinks per day for men and ≤1 drink per day for women) and none.
††Participant ever told by a doctor or other health professional that they had a sleep disorder, including sleep apnoea, insomnia, restless leg syndrome or 'other'.
ADL, activities of daily living; NHANES, National Health and Nutrition Examination Survey; PHQ-9, Patient Health Questionnaire-9; PIR, poverty income ratio.

Table 4 PRs (95% CI) for sleep duration, quality, ADL score and insomnia in relation to regular shiftwork status among US workers (NHANES, 2005–2008)*

	Regular shiftwork status				
Outcome/model	**Daytime shift**	**Night shift**	**Rotating shift**	**Evening shift**	**Another schedule†**
Sleep duration					
<7 vs ≥7 hours per work or week night					
Unadjusted	Ref.	1.72 (1.52 to 1.94)	1.15 (0.99 to 1.33)	1.09 (0.93 to 1.27)	1.03 (0.91 to 1.17)
Model 1‡	Ref.	1.70 (1.50 to 1.93)	1.15 (0.99 to 1.34)	1.10 (0.95 to 1.27)	1.03 (0.90 to 1.17)
Model 2§	Ref.	1.70 (1.48 to 1.96)	1.14 (0.96 to 1.35)	1.06 (0.91 to 1.24)	1.06 (0.94 to 1.21)
Sleep quality index¶					
Poor quality					
Unadjusted	Ref.	1.67 (1.37 to 2.03)	1.05 (0.80 to 1.36)	1.25 (0.95 to 1.66)	1.01 (0.81 to 1.27)
Model 1‡	Ref.	1.70 (1.40 to 2.05)	1.05 (0.80 to 1.37)	1.25 (0.94 to 1.65)	1.03 (0.83 to 1.28)
Model 2**	Ref.	1.52 (1.24 to 1.85)	1.07 (0.82 to 1.39)	1.12 (0.82 to 1.52)	1.06 (0.85 to 1.32)
Moderate quality					
Unadjusted	Ref.	0.85 (0.65 to 1.10)	1.14 (0.92 to 1.42)	1.10 (0.90 to 1.33)	1.29 (1.10 to 1.52)
Model 1‡	Ref.	0.84 (0.65 to 1.08)	1.09 (0.88 to 1.34)	1.04 (0.86 to 1.27)	1.29 (1.10 to 1.50)
Model 2**	Ref.	0.86 (0.63 to 1.19)	1.07 (0.86 to 1.33)	1.08 (0.88 to 1.32)	1.25 (1.06 to 1.47)
Sleep-related ADL score††					
≥2 vs <2					
Unadjusted	Ref.	1.53 (1.24 to 1.89)	0.99 (0.81 to 1.21)	1.23 (1.01 to 1.50)	1.17 (0.96 to 1.41)
Model 1‡	Ref.	1.49 (1.20 to 1.85)	0.94 (0.77 to 1.14)	1.15 (0.96 to 1.40)	1.19 (0.98 to 1.45)
Model 2‡‡	Ref.	1.39 (1.11 to 1.73)	0.98 (0.82 to 1.18)	1.11 (0.91 to 1.36)	1.19 (0.99 to 1.43)
Insomnia					
Unadjusted	Ref.	2.19 (1.58 to 3.03)	1.11 (0.73 to 1.68)	1.15 (0.82 to 1.61)	0.83 (0.57 to 1.22)
Model 1‡	Ref.	2.19 (1.59 to 3.02)	1.08 (0.71 to 1.65)	1.11 (0.81 to 1.53)	0.86 (0.58 to 1.25)
Model 2§§	Ref.	2.03 (1.30 to 3.17)	1.11 (0.65 to 1.88)	0.92 (0.59 to 1.42)	0.88 (0.58 to 1.34)

*Weighted estimates derived from logistic regression for sleep duration as a binary outcome (<7 hours referenced to ≥7 hours per week/work day), sleep-related ADL score (≥2 referenced to <2) and insomnia (yes referenced to no); and from multinomial logistic regression for sleep quality index (poor and moderate referenced to good sleep quality).
†No additional information is available on this shift category. This category was selected by the participant if none of the other categories applied. It could include a split shift consisting of two distinct work periods each day, an irregular schedule arranged by the employer or any other schedule not already specified.
‡Model 1, adjusted for the demographic characteristics of age group, gender, race/ethnicity and education.
§Model 2: model 1 further adjusted for general health status, symptomatic depression, body mass index, current smoking status and weekly working hours.
¶Categorised as poor sleep quality if the response to any of the six sleep problem items was 16–30 times/month; else as moderate sleep quality if any response was 5–15 times/month and all others as good sleep quality.
**Model 2: model 1 further adjusted for self-rated health status, symptomatic depression, current smoking status and weekly working hours.
††A score ≥2 is considered to indicate a greater daily sleep-related impairment than a score <2.
‡‡Model 2: model 1 further adjusted for self-rated health status, symptomatic depression and prescription medication use.
§§Model 2: model 1 further adjusted for self-rated health status, symptomatic depression, prescription medication use, weekly working hours and alcohol intake.
ADL, activities of daily living; NHANES, National Health and Nutrition Examination Survey; PR, prevalence ratio.

Recommendations

Although night shift is associated with all of the sleep problems we investigated, some workers are better able to tolerate night shifts, as demonstrated by the fact that not all night shift workers had sleep problems. These higher tolerant workers may be more receptive to the advantages to night shiftwork which include: commuting when roads are less crowded, higher wages to compensate for the inconvenience of night shift, enjoying public places that are often less crowded when they are off work and having greater independence since fewer supervisors may be present on night shifts.

Given the likely growth in the demands from globalisation and societies' need for services around the clock, work-based prevention programmes and policies should be adopted to improve the quantity and quality of sleep among workers. Unfortunately, there is no single ideal strategy to successfully address the sleep risks of every demanding shiftwork situation. Instead, interventions often need to be customised to the specific employer and worker.[40] These include designing new shift schedules with frequent rest breaks, avoiding night shifts that exceed 8 hours, improving the sleep environment (eg, blocking sunlight and sound from the bedroom, and keeping the bedroom cool), taking a long nap before the night shift begins (eg, from 19:30 to 22:00), accelerating the modulation of circadian rhythms using bright lights, improving physical fitness, engaging in stress reduction activities, and strengthening family and social support.

Correction notice This paper has been updated since it first published online. Tables 2,3 and 4 have been reformatted to make them clearer to the reader.

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