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Sleep Disorders, Health, and Safety in Police Officers

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Context Sleep disorders often remain undiagnosed. Untreated sleep disorders among police officers may adversely affect their health and safety and pose a risk to the public.

Objective To quantify associations between sleep disorder risk and self-reported health, safety, and performance outcomes in police officers.

Design, Setting, and Participants Cross-sectional and prospective cohort study of North American police officers participating in either an online or an on-site screening (n=4957) and monthly follow-up surveys (n=3545 officers representing 15 735 person-months) between July 2005 and December 2007. A total of 3693 officers in the United States and Canada participated in the online screening survey, and 1264 officers from a municipal police department and a state police department participated in the on-site survey.

Main Outcome Measures Comorbid health conditions (cross-sectional); performance and safety outcomes (prospective).

Results Of the 4957 participants, 40.4% screened positive for at least 1 sleep disorder, most of whom had not been diagnosed previously. Of the total cohort, 1666 (33.6%) screened positive for obstructive sleep apnea, 281 (6.5%) for moderate to severe insomnia, 269 (5.4%) for shift work disorder (14.5% of those who worked the night shift). Of the 4608 participants who completed the sleepiness scale, 1312 (28.5%) reported excessive sleepiness. Of the total cohort, 1294 (26.1%) reported falling asleep while driving at least 1 time a month. Respondents who screened positive for obstructive sleep apnea or any sleep disorder had an increased prevalence of reported physical and mental health conditions, including diabetes, depression, and cardiovascular disease. An analysis of up to 2 years of monthly follow-up surveys showed that those respondents who screened positive for a sleep disorder vs those who did not had a higher rate of reporting that they had made a serious administrative error (17.9% vs 12.7%; adjusted odds ratio [OR], 1.43 [95% CI, 1.23-1.67]); of falling asleep while driving (14.4% vs 9.2%; adjusted OR, 1.51 [95% CI, 1.20-1.90]); of making an error or safety violation attributed to fatigue (23.7% vs 15.5%; adjusted OR, 1.63 [95% CI, 1.43-1.85]); and of exhibiting other adverse work-related outcomes including uncontrolled anger toward suspects (34.1% vs 28.5%; adjusted OR, 1.25 [95% CI, 1.09-1.43]), absenteeism (26.0% vs 20.9%; adjusted OR, 1.23 [95% CI, 1.08-1.40]), and falling asleep during meetings (14.1% vs 7.0%; adjusted OR, 1.95 [95% CI, 1.52-2.52]).

Conclusion Among a group of North American police officers, sleep disorders were common and were significantly associated with increased risk of self-reported adverse health, performance, and safety outcomes.

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Sleep disorders affect 50 to 70 million US residents.[1] Most are undiagnosed and remain untreated, resulting in adverse health, safety, and performance outcomes that have important economic ramifications.[1] Obstructive sleep apnea (OSA)[2] is associated with hypertension,[3,4] cardiovascular disease,[3,5,6] cognitive impairment,[7] and increased risk of motor vehicle crashes.[8] Insomnia is a risk factor for depression[9] and hypertension[10] and causes daytime functional impairments[3] leading to absenteeism and productivity losses.[11] Shift work disorder, affecting approximately 10% of night and rotating shift workers,[12] is associated with social disturbances and higher rates of ulcers, unintentional injury, absenteeism, and de-

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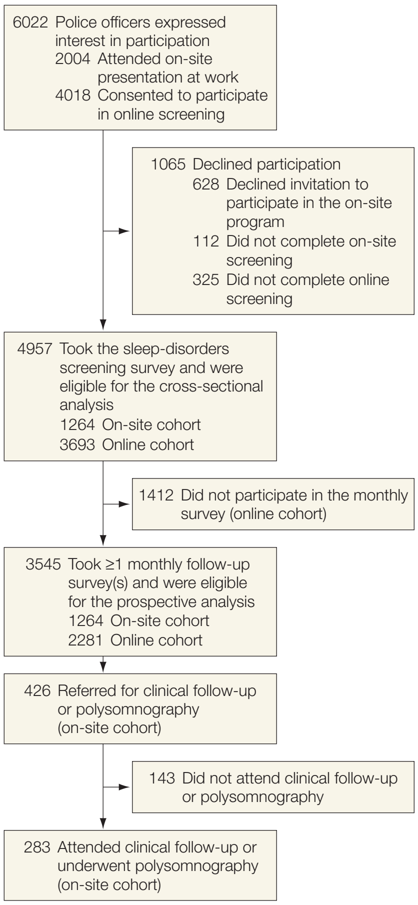
Figure 1. Flow of Participants in the Study in the On-site and Online Cohorts



pression.[12] Untreated sleep disorders and chronic sleep deficiency[1] increase the risk of unintential motor vehicle crashes and injuries.[3] These problems are exacerbated in shift workers, who experience circadian rhythm disruption and chronic sleep deficiency due to their work schedules.[13]

Police officers frequently work extended shifts and long work weeks,[14] which in other occupations are associated with increased risk of errors, unintended injuries, and motor vehicle crashes.[15] According to data through the year 2003, more officers are killed by unintended adverse events than during the commission of felonies.[14] It has been hypothesized that fatigue—likely due to reduced duration and quality of sleep[16] and untreated sleep disorders[17]—may play an important role in police officer unintentional injuries and fatalities.[14] To date, the effect of sleep disorders on police officer health, safety, and performance has not been systematically investigated.

We examined, among North American police officers, the risk of major sleep disorders, including those described above as well as restless legs syndrome and narcolepsy.[2] This prospective cohort study examined the association between screening positive for a sleep disorder and self-reported adverse health, safety, and performance outcomes.

METHODS

Study Population and Recruitment

A total of 4957 sworn police officers in North America (United States 97%, Canada 3%) volunteered to participate in either the online or on-site study component (FIGURE 1). The on-site portion of the study included intense investigations of a municipal police department serving 1 of the 10 largest US cities and a state police department serving 1 of the 10 most densely populated states. The participating police departments were not from the same state. The on-site cohort was included to achieve a high cooperation rate within those departments and to compare characteristics of responders and nonresponders (in the municipal police department). The online cohort was included to provide a comparison group of police officers from across North America. Both cohorts included monthly follow-up surveys.

To recruit for the online cohort, we corresponded with large law enforcement agencies across North America to solicit participation and placed advertisements in police magazines and newsletters and on police-focused Web sites. For the on-site cohorts, we solicited participation from several municipal and state police departments. Ultimately a municipal department and a state department were selected and agreed to participate in the study protocol. Of the 3329 potential attendees from the departments participating in the on-site study, 2004 participated in informational sessions. In addition, 4018 registered for the online study (Figure 1). Of these police officers, 4957 completed the baseline survey, which included a sleep disorders screening: 1264 (63.1%, cooperation rate[18]) in the on-site cohort and 3693 (91.9%, participation rate[18]) in the online cohort, which made them eligible for the cross-sectional analyses.[18] In both cohorts, the 3545 officers who had completed at least 1 of the monthly follow-up surveys were eligible for the prospective analyses: 1264 in the on-site and 2281 in the online cohort. This represents a 63.1% cooperation rate and 56.8% participation rate, respectively; these were deemed the prospective study cohort.

The study protocol was approved by the Partners Human Research Committee and was conducted between July 2005 and December 2007. Participants provided written or electronic informed consent and were not informed about study hypotheses. For reporting purposes to the human research committee and to funding agencies, participants were required to self-report race and ethnicity using prespecified categories (TABLE 1). Participants selected for polysomnography studies received up to $440, and survey participants were eligible for a prize drawing valued at up to $1000.

Design

In a cross-sectional baseline survey, we assessed demographics, physical and mental health status, and the risk of sleep disorders. For up to 2 years following the baseline screening, each month we sent all participants an e-mail with a link to a short online survey assessing work-related performance, work hours, and safety. Reminder e-mails were sent to those who did not immediately complete the survey. (The baseline screening questions and follow-up surveys are available from the authors.)

Survey Instruments

The sleep disorders screening questionnaire used validated, self-report screening tools for OSA (Berlin Questionnaire; sensitivity 0.86, specificity 0.77),[19] moderate to severe insomnia (Athens Insomnia Scale: sensitivity 0.93, specificity 0.85),[20] restless legs syndrome (RLS Epidemiology, Symptoms, and Treatment questionnaire: sensitivity 0.82, specificity 0.90),[21] and narcolepsy with cataplexy (Cataplexy Questionnaire: sensitivity 0.92, specificity 0.95[22] and Epworth Sleepiness Scale [ESS][23]). For shift work disorder, we created a screening tool based on the *International Classification of Sleep Disorders, Second Edition* (*ICSD-2*) diagnostic criteria[2] (criteria are provided in the eMethods, available at http://www.jama.com). The municipal police department allowed that only the OSA risk could be assessed for its 659 participants. Excessive sleepiness was assessed using the ESS (sensitivity 0.94, specificity 1.00)[23] to examine prevalence of this symptom and to compare across positive and negative sleep disorder groups.

In the baseline survey, participants reported current health status (poor to excellent); previous diagnoses of sleep and other medical disorders (eg, diabetes, cardiovascular disease, gastrointestinal tract disorder, depression, anxiety); likelihood of falling asleep while driving after work; and use of sleeping medications (never or nearly never to nearly every day), caffeine (0->8 servings/d), and alcohol (0- >14 servings/wk). The Maslach Burnout Inventory was used to assess 2 subscales of burnout: emotional exhaustion and depersonalization.[24]

In the monthly surveys, participants were asked about work and sleep hours, likelihood of falling asleep in various situations and outcome measures of work performance, such as administrative errors, injuries, uncontrolled anger toward suspects or citizens, absenteeism, citizen complaints, and safety violations. The work-hours instrument was previously validated against daily work diaries (for monthly work hours, r=0.76; for extended shifts, r=0.94; $P<.001$),[25] which in themselves were validated by direct observation (r=0.98, $P<.001$).[26]

Polysomnographic Assessment

To compare questionnaire OSA screening outcome with polysomnography, full, attended polysomnography studies were performed for 126 participants from the state police department. Of these, 63 had screened positive on the Berlin questionnaire and were the first from the overall study to agree to have sleep studies performed and agree to provide the investigators with access to relevant medical records; 61 had screened negative on the Berlin questionnaire and were selected randomly from the group of participants who screened negative; and 2 had invalid Berlin screening outcomes. Obstructive sleep apnea severity was classified by a sleep specialist, blind to questionnaire outcome, and was made on the basis of both the respiratory disturbance index and the minimal arterial oxyhemoglobin saturation level associated with respiratory disturbances (eMethods).

Data Analyses

Multiple logistic regression models were used for cross-sectional analysis of the associations between health outcomes at baseline and sleep disorder screening outcomes (for positive screening for any sleep disorder, or positive OSA screening). For the prospective analysis, the generalized estimating equations (GEE) method[27] was used to assess performance and attentional failures in those who screened positive and those who did not screen positive for any of the sleep disorders because these outcomes were measured monthly over the course of this study and hence likely to be correlated. For performance and attentional failures, we used a logit link in the GEE model for dichotomized outcomes (1 for any number of the performance and attentional failures and 0 for no performance and attentional failures). Supplemental analysis was conducted on the continuous version of each outcome, assuming that the actual number of events follow a Poisson distribution and using a log link in the GEE model.

Table 1. Self-reported Participant Characteristics (N = 4957)

Characteristic	Value
Age, mean (SD), y	38.5 (8.3)
Range	20-77
Sex, No. (%)	
Women	861 (17.4)
Men	4079 (82.3)
Not known	17 (0.3)
Race, No. (%)	
White	4216 (85.1)
Black	393 (7.9)
Asian	50 (1.0)
Native American	34 (0.7)
Pacific	6 (0.1)
Other	167 (3.4)
Not known	91 (1.8)
Ethnicity, No. (%)	
Hispanic	292 (5.9)
Other	4405 (88.9)
Not known	260 (5.3)
BMI, No. (%)	
<25	994 (20.1)
≥25-<30	2267 (45.7)
≥30-<35	1219 (24.6)
≥35	444 (9.0)
Not known	33 (0.7)
Mean (SD)	28.7 (4.6)
Range	15.8-56.5
Health status, No. (%)	
Poor	11 (0.2)
Fair	247 (5.0)
Good	1778 (35.9)
Very good	2099 (42.3)
Excellent	785 (15.8)
Not known	37 (0.7)
Employed in police work, mean (SD), y	12.7 (8.1)
Range	0-41
Employer type, No. (%)	
Municipal	3140 (63.3)
County	846 (17.1)
State	794 (16.0)
Federal	90 (1.8)
University, college, or school	26 (0.5)
Transit and railroad	2 (0.0)
Security	4 (0.1)
Other	30 (0.6)
Not known	25 (0.5)
Primary activity, No. (%)	
First-line supervisors or managers of police and detectives	743 (15.0)
Detectives and criminal investigators	408 (8.2)
Police and sheriff's patrol officers	3298 (66.5)
Other	488 (9.8)
Not known	20 (0.4)

(continued)

Table 1. Self-reported Participant Characteristics (N = 4957) (continued)

Characteristic	Value
Night shift work in past mo, No. (%)	
Never or nearly never	1922 (38.3)
1-4 times/mo	980 (19.8)
1-4 times/wk	938 (18.9)
Nearly every d	968 (19.5)
Not known	149 (3.0)
Work shift/24 h, No. (%)[a]	
<8	28 (0.8)
8-10	1694 (47.8)
11-13	1111 (31.3)
14-16	515 (14.5)
>16	64 (1.8)
Not known	133 (3.8)
Second job, No. (%)[a]	
Yes	723 (20.4)
None reported	2822 (79.6)
Shift rotation, No. (%)[a]	
Fixed	1966 (55.5)
Rotating	873 (24.6)
Other	563 (15.9)
Not known	143 (4.0)

Abbreviation: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared.
[a] Number of work hours per 24 hours, hours worked at second job, and shift rotation are taken from the first monthly follow-up survey (n=3545). Number of work hours per 24 hours is the usual number of hours worked at primary job, mandatory and voluntary overtime, detail or special assignment, second job, and court time.

For the cross-sectional analysis, we adjusted for the potentially confounding effects of age, sex, body mass index (BMI), hypertension, cigarette smoking, alcohol consumption, primary police activity, second job, usual shift length, night shift work, and shift rotation. For the prospective analysis, we adjusted for age, sex, BMI, primary police activity, second job, night shift work, shift rotation, mean total work hours per week, and monthly sleep time. We tested these confounders individually and only included those that were significant ($P < .10$) in the initial multivariable models. We then applied a backward elimination method to remove those that were not significant in the final model. Only significant variables of $P < .05$ were left in the final model. Because there were some missing data for some of the confounders, we repeated the analysis using the missing-indicator method.[28] Unadjusted and adjusted odds ratios (ORs) with 95% confidence intervals are reported for the complete-case analysis, and adjusted ORs are reported when the missing-indicator method was applied.

For the cross-sectional analysis, we deemed the following primary outcomes: diabetes, depression, burnout (emotional exhaustion), and falling asleep while driving. For the prospective analysis, we deemed the following as the primary outcomes: falling asleep while driving, making a serious administrative error, making fatigue-related errors or safety violations, and having an occupational injury. $P < .0125$ was considered statistically significant for the 4 primary outcomes of interest in each analysis with Bonferroni adjustment. $P < .05$ was considered statistically significant in all secondary analyses. Statistical analyses were conducted using SAS for Windows (version 9.2, SAS Institute Inc).

Sample size and power calculations are based on our previous studies examining the effects of extended duration shifts on performance and attentional failures. A similar magnitude of difference was expected in the present study because both sleep disorders and extended durations of wakefulness have been reported to induce neurobehavioral performance impairments comparable with that of alcohol intoxication.[3] For the sample size and power calculation, we considered 3 outcomes: falling asleep while driving, having an occupational injury, and making an error or committing a safety violation attributed to fatigue. Assuming that one-third of our sample would screen positive for a sleep disorder, with 15 000 person-months of data, we estimated 90% power to detect the following differences from those who had screened negative vs those who had screened positive for a sleep disorder: rate of falling asleep while driving, 0.066[25] vs 0.083 (OR, 1.28); rate of occupational injury, 0.010[29] vs 0.017 (OR, 1.71); and rate of error or safety violation due to fatigue, 0.038[30] vs 0.051 (OR, 1.36), with a 2-sided z test at $P < .05/3 = .0167$.

RESULTS

Sample Characteristics

A total of 4957 police officers (mean [SD] age: 38.5 [8.3] years; years of police service: 12.7 [8.1]) completed the baseline survey. All participants reported being 18 years or older and sworn police officers. A total of 3930 officers (79.3%) were overweight or obese and 1663 (33.5%) were obese (Table 1). In 256 participants who attended a follow-up clinic visit, BMI was measured and found to be highly correlated with self-reported BMI ($R = 0.912$, $P < .001$).

As is the case nationally, white males made up the majority of officers. Based on the national average, women were slightly overrepresented in our sample (17.4% [95% CI, 16.3%-18.4%] vs 13.7% nationwide) whereas racial/ethnic minorities were somewhat underrepresented (7.9% [95% CI, 7.2-8.7] vs 12.7% for black officers nationwide; 5.9% [95% CI, 5.2-6.5] vs 9.1% for Hispanic officers nationwide[31]; Table 1). Our sample of onsite participants from the municipal police department (responders) was generally consistent in age, sex, and rank to characteristics of the entire police department, although the responders were slightly younger and had fewer high-ranking officers (eTable 1, available at http://www.jama.com).

A total of 15 735 monthly surveys were completed during the 2-year follow-up, with a mean (SD) of 684.2 (254.1) completed monthly. Each participant completed a mean of 4.4 (5.2) surveys (median [interquartile range], 2 [1-6]). Officers who participated in the follow-up survey were similar to those who did not in terms of demographics and risk of sleep disorders (eTable 2).

Sleep Disorder Screening

A total of 2003 of 4957 participants (40.4%) screened positive for at least 1 sleep disorder (eTable 3 for demographic comparisons). One thousand six hundred sixty-six participants (33.6%) screened positive for OSA, the most common disorder, followed by 281 (6.5%) with moderate to severe insomnia; 269 (5.4%) with shift work disorder—those reporting excessive wake time sleepiness and insomnia associated with night work—representing 14.5% of those who work night shifts in the cohort; 70 (1.6%) with restless legs syndrome; and 16 (0.4%) with narcolepsy with cataplexy (TABLE 2). Applying the *ICSD-2*[2] criteria for shift work

Table 2. Sleep Disorder Screening Outcomes for All Participants by Subgroups

	All Participants, No. (%)	Subgroups, No. (%): Online Cohort	On-site Cohort: State Police	On-site Cohort: Municipal Police[a]	Participants Reporting Current Diagnosis in the Positive Screening Group, No./Total Positive (%)[b]	Participants Reporting Current Diagnosis, No./Total (%)[b]
No. of respondents	4957	3693	605	659		
Obstructive sleep apnea						
Positive	1666 (33.6)	1331 (36.0)	123 (20.3)	212 (32.2)	240/1588 (15.1)	305/4787 (6.4)
Negative	3205 (64.7)	2309 (62.5)	471 (77.9)	425 (64.5)		
Not known	86 (1.7)	53 (1.4)	11 (1.8)	22 (3.3)		
Insomnia, moderate to severe						
Positive	281 (6.5)	258 (7.0)	23 (3.8)	-	59/272 (21.7)	297/4771 (6.2)
Negative	3897 (90.7)	3316 (89.8)	581 (96.0)			
Not known	120 (2.8)	119 (3.2)	1 (0.2)			
Shift work disorder[c]						
Excessive waketime sleepiness and insomnia, mild, moderate, or severe						
Positive	269 (14.5)	256 (15.3)	13 (7.0)	-	20/264 (7.6)	141/1812 (7.8)
Negative	1444 (77.6)	1302 (77.8)	142 (75.9)			
Not known	148 (8.0)	116 (6.9)	32 (17.1)			
Excessive waketime sleepiness						
Positive	589 (31.6)	551 (32.9)	38 (20.3)	-		
Negative	1110 (59.6)	996 (59.5)	114 (61.0)			
Not known	162 (8.7)	127 (7.6)	35 (18.7)			
Insomnia (mild, moderate, or severe)						
Positive	684 (36.8)	632 (37.8)	52 (27.8)	-		
Negative	1026 (55.1)	923 (55.1)	103 (55.1)			
Not known	151 (8.1)	119 (7.1)	32 (17.1)			
Excessive waketime sleepiness or insomnia (mild, moderate, or severe)						
Positive	1004 (53.9)	927 (55.4)	77 (41.2)	-		
Negative	692 (37.2)	617 (36.9)	75 (40.1)			
Not known	165 (8.9)	130 (7.8)	35 (18.7)			
Wake-time drowsiness and insomnia (mild, moderate, or severe)[d]						
Positive	47 (2.5)	45 (2.7)	2 (1.1)	-		
Negative	1787 (96.0)	1603 (95.8)	184 (98.4)			
Not known	27 (1.5)	26 (1.6)	1 (0.5)			
Restless legs syndrome						
Positive	70 (1.6)	64 (1.7)	6 (1.0)	-	24/70 (34.3)	154/4759 (3.2)
Negative	4063 (94.5)	3470 (94.0)	593 (98.0)			
Not known	165 (3.8)	159 (4.3)	6 (1.0)			
Narcolepsy with cataplexy						
Positive	16 (0.4)	16 (0.4)	0 (0)	-	0/16 (0)	10/4743 (0.2)
Negative	4158 (96.7)	3553 (96.2)	605 (100)			
Not known	124 (2.9)	124 (3.4)	0 (0)			

[a] Participants from the municipal police department were screened only for obstructive sleep apnea.
[b] Some participants did not provide sufficient information to determine whether they had a sleep disorder diagnosis. Percentages are calculated from those who answered. Missing data are as follows: obstructive sleep apnea, 170; insomnia, 186; shift work disorder, 197; restless legs syndrome, 198; and narcolepsy with cataplexy, 214.
[c] For shift work disorder, percentages represent the number of individuals reporting the symptom divided by the number who reported working at least 1 night shift during the month before completing the survey (n=1861). Night shift was defined as work hours that included at least 6 hours between 10 PM and 8 AM. Percentage of respondents reporting symptoms consistent with shift work disorder taking only those with sufficient information to determine risk in all 3 definitions is presented in eTable 10 (available at http://www.jama.com).
[d] Wake-time drowsiness is defined as moderate to high chance of falling asleep while driving after working nights compared to never or slight chance during days off, and moderate to high chance of falling asleep during night shift compared to never or slight chance during day shift.

disorder, (ie, excessive wake time sleepiness or insomnia), 1004 (53.9%) of the police officers who work night shifts screened positive. Considering only those who showed both insomnia and night work–associated drowsiness (defined as a moderate to high chance of falling asleep while driving after working nights compared with never or a slight chance during days off, and moderate to high chance of falling asleep during night shift compared with never or slight chance during day shift), 47 (2.5%) on the night shift screened positive. To examine associations between positive sleep disorder screening and health and safety outcomes, the last definition of shift work disorder was used.

Higher proportions of participants in the online and in the on-site municipal police department cohorts screened positive for OSA than in the onsite state police department cohort: 36.0% (95% CI, 34.5%-37.6%) for the online cohort, 32.2% (95% CI, 28.6%-35.7%) for the municipal police cohort vs 20.3% (95% CI, 17.1%-23.5%) for the state police cohort. The state police cohort also reported a significantly lower mean (SD) BMI of 27.7 (3.6) than the municipal police cohort of 28.9 (4.6; $P<.001$) and the online cohort of 28.8 (4.8; $P<.001$). (BMI is calculated as weight in kilograms divided by height in meters squared.) Most participants who screened positive did not report a current diagnosis of the disorder (Table 2).

Positive Sleep Disorder Screening and Self-Reported Comorbid Conditions: Cross-Sectional Analysis

Positive screening for any sleep disorder was associated with increased risk of reported health- and safety-related outcomes: 203 (10.7%) of those who tested positive for a sleep disorder reported having depression vs 37 (4.4%) of those who did not screen positive (adjusted OR, 2.20; 95% CI [1.52-3.19]); 399 (34.1%) of the positive-screen group reported burnout (emotional exhaustion) vs 89 (17.9%) in the negative-screen group (adjusted OR, 2.85 [95% CI, 2.16-3.77]), and 388 (20.0%) in the positive-screen group reported falling asleep while driving vs 66 (7.7%) in the negative-screen group (adjusted OR, 3.79 [95% CI, 2.79-5.14]). Several of the secondary outcomes were also significantly associated with positive screening for sleep disorder, specifically gastrointestinal tract disorder, anxiety disorder, pharmacotherapy for insomnia, health status, and burnout (depersonalization) (TABLE 3 and eTable 4 available at http://www.jama.com).

Because OSA was the most prevalent disorder reported, we examined associations between positive OSA screening results and risk of reported health- and safety-related outcomes. In addition to the risks observed with posi-

Table 3. Comorbidities and Adverse Health Outcomes Associated With Positive Sleep Disorder Screening Result (N = 4957)

	Positive Result in Participants With Positive Sleep Disorder Screening, No. (%)		Unadjusted		Adjusted[b]		Adjusted Missing-Indicator Method[b]	
	Positive Screening	Negative Screening[a]	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Primary outcomes								
Diabetes[c]	86 (4.5)	15 (1.8)	2.56 (1.47-4.47)	<.001	1.05 (0.58-1.92)	.87	1.06 (0.58-1.94)	.85
Depression[c]	203 (10.7)	37 (4.4)	2.57 (1.79-3.69)	<.001	2.75 (1.66-4.56)	<.001	2.20 (1.52-3.19)	<.001
Burnout (emotional exhaustion)[d]	399 (34.1)	89 (17.9)	2.38 (1.83-3.08)	<.001	2.87 (2.17-3.80)	<.001	2.85 (2.16-3.77)	<.001
Fall asleep while driving after work								
Moderate-high vs never	388 (20.0)	66 (7.9)	3.11 (2.33-4.15)	<.001	4.64 (3.12-6.94)	<.001	3.79 (2.79-5.14)	<.001
Slight vs never	833 (43.0)	396 (47.1)	1.11 (0.94-1.32)	.23	1.50 (1.18-1.90)	.001	1.16 (0.96-1.41)	.11
Secondary outcomes								
CVD[c]	57 (3.0)	9 (1.1)	2.84 (1.40-5.76)	.004	1.45 (0.69-3.04)	.33	1.45 (0.69-3.04)	.33
GI tract disorder[c]	445 (23.1)	122 (14.6)	1.76 (1.41-2.19)	<.001	1.47 (1.11-1.95)	.007	1.44 (1.14-1.81)	.002
Anxiety disorder[c]	197 (10.3)	29 (3.5)	3.18 (2.14-4.74)	<.001	3.02 (1.75-5.19)	<.001	2.78 (1.85-4.19)	<.001
Pharmacotherapy for insomnia[e]	244 (18.3)	71 (12.7)	1.55 (1.17-2.06)	.003	1.87 (1.37-2.55)	<.001	1.86 (1.37-2.54)	<.001
Caffeine, serving/24 h								
≥7 vs 0	164 (12.3)	50 (8.9)	1.09 (0.67-1.78)	.72	1.10 (0.67-1.80)	.72	1.05 (0.64-1.71)	.85
1-6 vs 0	1051 (79.1)	473 (84.3)	0.74 (0.51-1.09)	.12	0.71 (0.48-1.05)	.08	0.73 (0.50-1.07)	.11
Lower health status[f]	1099 (55.2)	268 (31.8)	2.64 (2.23-3.13)	<.001	1.76 (1.40-2.22)	<.001	1.75 (1.44-2.11)	<.001
Burnout (depersonalization)[d]	608 (50.4)	214 (42.6)	1.37 (1.11-1.68)	.004	1.60 (1.28-1.99)	<.001	1.60 (1.29-1.99)	<.001

Abbreviations: CVD, cardiovascular disease; GI, gastrointestinal.
[a] Negative sleep disorder screening was defined as not meeting criteria for all 5 of the sleep disorders assessed (missing screening outcomes not included). We examined associations separately for obstructive sleep apnea and not for other sleep disorders because the sample sizes for those disorders were substantially less, reducing statistical power.
[b] Adjusted for age, sex, body mass index, hypertension, cigarette smoking, alcohol consumption, primary police activity, second job, mean total work hours per week, night shift work, and shift rotation. Variables included in each model are in eTable 4.
[c] Yes vs never or not now.
[d] High vs low to moderate.
[e] Takes at least 1 to 2 times a week vs never or 1 to 2 a month.
[f] Poor to good vs very good to excellent.

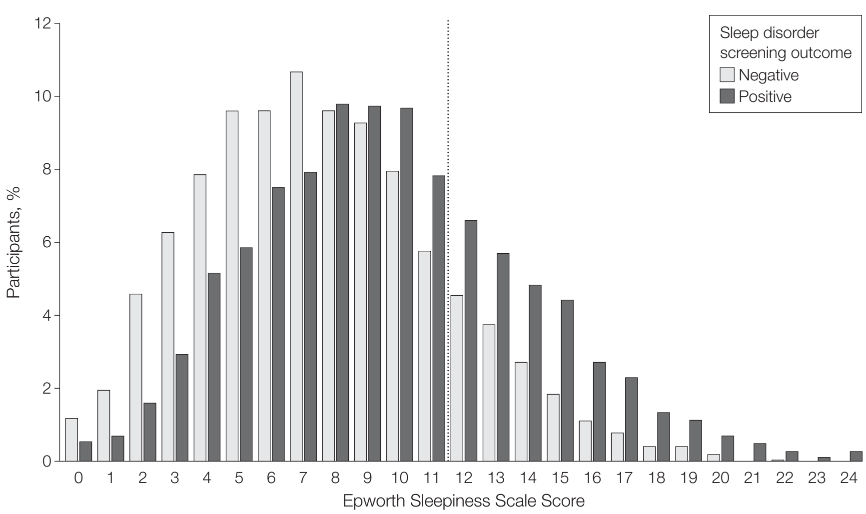
Table 4. Comorbidities and Adverse Health Outcomes Associated With Positive Obstructive Sleep Apnea Screening Result (N = 4957)

	Positive Result in Participants With Positive Sleep Disorder Screening, No. (%)		Unadjusted		Adjusted[b]		Adjusted Missing-Indicator Method[b]	
	Positive Screening	Negative Screening[a]	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Primary outcomes[d]								
Diabetes	84 (5.3)	46 (1.5)	3.77 (2.62-5.43)	<.001	2.10 (1.26-3.50)	.005	1.61 (1.05-2.47)	.03[c]
Depression	176 (11.2)	145 (4.6)	2.59 (2.06-3.25)	<.001	2.76 (2.00-3.82)	<.001	2.48 (1.93-3.19)	<.001
Burnout (emotional exhaustion)	332 (34.0)	408 (20.6)	1.98 (1.67-2.35)	<.001	2.74 (2.22-3.37)	<.001	2.69 (2.19-3.31)	<.001
Falling asleep while driving after work								
Moderate-high vs never	283 (17.6)	364 (11.7)	1.92 (1.60-2.30)	<.001	2.31 (1.83-2.92)	<.001	2.26 (1.83-2.80)	<.001
Slight vs never	713 (44.4)	1244 (40.0)	1.42 (1.24-1.61)	<.001	1.39 (1.18-1.64)	<.001	1.44 (1.24-1.68)	<.001
Secondary outcomes								
CVD	54 (3.4)	30 (1.0)	3.68 (2.34-5.77)	<.001	1.96 (1.07-3.59)	.03	1.95 (1.20-3.18)	.007
GI tract disorder	387 (24.2)	420 (13.4)	2.07 (1.77-2.41)	<.001	1.74 (1.42-2.13)	<.001	1.72 (1.45-2.03)	<.001
Anxiety disorder	162 (10.3)	151 (4.8)	2.25 (1.79-2.84)	<.001	2.23 (1.60-3.09)	<.001	2.02 (1.57-2.60)	<.001
Pharmacotherapy for insomnia	199 (17.8)	253 (11.3)	1.70 (1.39-2.08)	<.001	2.19 (1.71-2.81)	<.001	2.18 (1.70-2.78)	<.001
Caffeine, serving/24 h								
≥7 vs 0	141 (12.6)	164 (7.3)	2.86 (2.05-3.98)	<.001	2.36 (1.67-3.34)	<.001	1.94 (1.32-2.85)	<.001
1-6 vs 0	894 (79.9)	1804 (80.3)	1.65 (1.27-2.13)	<.001	1.49 (1.14-1.95)	.004	1.28 (0.96-1.73)	.10
Lower health status	981 (59.2)	1015 (31.9)	3.10 (2.74-3.51)	<.001	1.82 (1.52-2.19)	<.001	1.85 (1.60-2.15)	<.001
Burnout (depersonalization)	505 (49.9)	822 (40.9)	1.44 (1.23-1.67)	<.001	1.59 (1.36-1.87)	<.001	1.62 (1.37-1.91)	<.001

Abbreviations: CVD, cardiovascular disease; GI, gastrointestinal; OR, odds ratio; OSA, obstructive sleep apnea.
[a] Negative sleep disorder screening was defined as not meeting criteria for all 5 of the sleep disorders assessed (missing screening outcomes not included). We examined associations separately for OSA and not for other sleep disorders because the sample sizes for those disorders were substantially less, reducing statistical power.
[b] Adjusted for age, sex, body mass index, hypertension, cigarette smoking, alcohol consumption, primary police activity, second job, mean total work hours per week, night shift work, and shift rotation. Variables included in each model are in eTable 4.
[c] Not significant when significance level is adjusted for multiple comparisons (*P* = .0125).
[d] For response ranges for each variable see Table 3.

tive screening results for any sleep disorder, positive OSA screening was also associated with a diagnosis of diabetes, 84 (5.3%) of the positive-screen group vs 46 (1.5%) in the negative-screen group (adjusted OR, 1.61 [95% CI, 1.05-2.47]; of cardiovascular disease: 54 participants (3.4%) vs 30 (1.0%; adjusted OR, 1.95 [95% CI, 1.20-3.18]); and high caffeine consumption: 141 (12.6%) vs 164 (7.3%; adjusted OR, 1.94 [95% CI, 1.32-2.85]) (TABLE 4). All of these outcomes were statistically significant when adjusted for potential confounders; however, when adjusted for missing values using the missing indicator method, the significance level for diabetes (*P* = .03) fell short of statistical significance when accounting for multiple comparisons (*P*=.0125).

Figure 2. Epworth Sleepiness Scale Scores



Epworth sleepiness scale scores range from 0 to 24, with the higher values representing increasing sleepiness. The vertical dashed line represents the cut off for excessive sleepiness. Positive sleep disorder screening result was defined as meeting criteria for any of the sleep disorders assessed. A screening result negative for a sleeping disorder was defined as not meeting criteria for any of the sleep disorders assessed.

Excessive Sleepiness

At baseline, 1312 of 4608 participants (28.5%) who completed the ESS had scores of 11 or higher, which means that they experienced excessive sleepiness.[23] Of the total 4957 baseline survey respondents, 2276 (45.9%) reported having nodded off or fallen asleep while driving; 1294 of these (56.9%, 26.1% of the total cohort) reported falling asleep while driving at least 1 to 2 times a month; and 307 (13.5%, representing 6.2% of the total cohort) reported falling asleep while driving at least 1 to 2 times a week.

Those who screened positive for a sleep disorder also had a higher mean (SD) ESS score than those who did not (9.65 [4.25] vs 7.63 [3.80]; $P<.001$, FIGURE 2). Furthermore, 38.6% (95% CI, 36.4%-40.8%) of those who screened positive for any sleep disorder had an ESS score of 11 or higher vs 21.5% (95% CI, 19.9%-23.0%; $P<.001$) of those who did not.

Sleep Disorder Risk and Self-Reported Performance: Prospective Analysis

During the 2-year follow-up, 15 735 monthly surveys were collected, 6587 person-months with positive screens for sleep disorders and 9148 with negative screens for a sleep disorder. Of the participants who screened positive for any sleep disorder and responded to the question, 17.9% reported making important administrative errors vs 12.7% of those who screened negative (adjusted OR, 1.43; 95% CI, 1.23-1.67), 14.4% vs 9.2% reported falling asleep while driving (adjusted OR, 1.51; 95% CI, 1.20-1.90), and 23.7% vs 15.5% reported making errors or committing safety violations due to fatigue (adjusted OR, 1.63; 95% CI, 1.43-1.85; TABLE 5 and eTable 5 available at http://www.jama.com). Similarly, 34.1% vs 28.5% reported having uncontrolled anger toward a citizen or suspect (adjusted OR, 1.25; 95% CI, 1.09-1.43), 11.2% vs 9.4% incurring citizen complaints (adjusted OR 1.35; 95% CI, 1.13-1.61), 26.0% vs 20.9% absenteeism (adjusted OR, 1.23; 95% CI, 1.08-1.40), and 14.1% vs 7.0% falling asleep during meetings (OR, 1.95; 95% CI, 1.52-2.52). When these outcomes were analyzed as continuous variables rather than as dichotomized outcomes), the results were similar (eTable 6 and eTable 7).

To address possible reporting bias, we calculated these ratios for the 459 police officers who completed at least 1 year of monthly surveys (5508 person-months; eTable 8). The results were comparable, although falling asleep while driving and occupational injury did not reach statistical significance in the smaller sample.

Two hundred eighty-seven participants reported being in a motor vehicle crash during the follow-up period. Motor vehicle crashes were more likely to be reported by those who reported falling asleep while driving (29

Table 5. Self-reported Performance and Safety Outcomes and Attentional Failures Associated With Positive Sleep Disorder Screening (N = 3545)[a]

	Positive Result in Positive Screening Group, No. of Person-Months, (%)[b]	Positive Result in Negative Screening Group, No. of Person-Months, (%)[b]	Unadjusted		Adjusted[c]		Adjusted Missing-Indicator Method[c]	
			OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Primary outcomes								
Serious administrative error, actual	861 (17.9)	864 (12.7)	1.39 (1.20-1.62)	<.001	1.59 (1.29-1.94)	<.001	1.43 (1.23-1.67)	<.001
Fall asleep while driving	626 (14.4)	535 (9.2)	1.58 (1.27-1.97)	<.001	1.46 (1.16-1.84)	.001	1.51 (1.20-1.90)	<.001
Error or safety violation attributed to fatigue	1470 (23.7)	1334 (15.5)	1.76 (1.55-1.99)	<.001	1.79 (1.49-2.14)	<.001	1.63 (1.43-1.85)	<.001
Occupational injury	272 (5.9)	316 (4.7)	1.23 (1.01-1.51)	.04	1.19 (0.95-1.50)	.13	1.22 (1.01-1.49)	<.05[d]
Secondary outcomes								
Uncontrolled anger toward suspect or citizen	1669 (34.1)	1927 (28.5)	1.21 (1.07-1.38)	.003	1.12 (0.94-1.33)	.22	1.25 (1.09-1.43)	.001
Citizen complaints	520 (11.2)	621 (9.4)	1.24 (1.04-1.48)	.02	1.29 (1.04-1.60)	.02	1.35 (1.13-1.61)	<.001
Commendations	1056 (22.2)	1581 (23.1)	1.00 (0.87-1.15)	.97	1.04 (0.88-1.23)	.64	1.02 (0.89-1.18)	.76
Serious administrative error, near-miss	949 (19.9)	950 (14.1)	1.48 (1.28-1.71)	<.001	1.51 (1.22-1.88)	<.001	1.55 (1.32-1.80)	<.001
Absenteeism	1466 (26.0)	1641 (20.9)	1.26 (1.12-1.42)	<.001	1.26 (1.09-1.47)	.003	1.23 (1.08-1.40)	.002
Error or safety violation, not attributed to fatigue	361 (5.8)	380 (4.4)	1.36 (1.12-1.63)	.002	1.30 (1.04-1.63)	.02	1.32 (1.09-1.60)	.004
Fall asleep								
During meetings	393 (14.1)	265 (7.0)	1.97 (1.53-2.55)	<.001	2.26 (1.67-3.07)	.001	1.95 (1.52-2.52)	<.001
On the telephone	144 (3.3)	98 (1.7)	1.96 (1.26-3.06)	.003	1.89 (1.15-3.10)	.012	1.86 (1.20-2.89)	.005
While stopped in traffic	474 (11.0)	423 (7.3)	1.39 (1.09-1.76)	.007	1.34 (1.04-1.74)	.02	1.38 (1.08-1.76)	.009

[a] Positive screening result for sleep disorders was defined as meeting criteria for any of the sleep disorders assessed. For shift work disorder, positive result required both wake time drowsiness and insomnia (mild, moderate, or severe), with wake time drowsiness defined as moderate to high chance of falling asleep while driving after working nights compared to never or slight chance during days off, and moderate to high chance of falling asleep during night shift compared to never or slight chance during day shift. Negative sleep disorder screening was defined as not meeting criteria for the sleep disorders assessed (missing screening outcomes included). Variables included in each model are in eTable 5.

[b] Missing data and negative outcomes for these variables are not shown.

[c] Odd ratios were adjusted for sex, age, body mass index, primary police activity, shift rotation, second job, number of night shifts worked, mean total work hours per week, and monthly sleep.

[d] Not significant when significance level is adjusted for multiple comparisons ($P=.0125$).

of 180 person-months) than by those who did not (1132 of 9980 person-months; risk ratio [RR], 1.49 [95% CI, 1.01-2.20]; $P < .05$) or by those who reported falling asleep while stopped in traffic (25 of 177 person-months) than by those who did not (872 of 9898 person-months; RR, 1.68 [95% CI, 1.11-2.55], $P = .01$).

Polysomnography Assessment

Of the 126 completed polysomnograph studies, 116 had complete data available. Forty-four of 54 participants who underwent polysomnography assessment and who screened positive for OSA on the survey (positive predictive value, 81.5%) were classified by the assessment as having mild to moderate, moderate to severe, or severe OSA compared with 28 of 60 (46.7%) of those who screened negative. Eleven of 60 (18.3%) of those who screened negative were found to have moderate to severe or severe OSA (eTable 9 available at http://www.jama.com). We found that 35 of 44 (positive predictive value, 79.5%) of participants with a BMI of 30 or higher and 11 of 12 (positive predictive value, 91.6%) of participants with BMI of 35 or higher had mild to moderate, moderate to severe, or severe OSA (eTable 9).

COMMENT

Sleep disorders are common and are largely undiagnosed and untreated in North American police officers. Our comprehensive sleep disorders screening program found that 40.4% of police officers reported symptoms consistent with at least 1 sleep disorder. The majority reported not having been diagnosed in the past or not taking regular treatment. Obstructive sleep apnea was the most prevalent disorder, with one-third of officers screening positive. Given that obesity is a major risk factor for OSA[3] and that one-third of our sample had a BMI of 30 or higher, the high prevalence of OSA could be anticipated but is nevertheless a concern. There are several factors that might account for the lower prevalence of OSA in the state police department cohort, including their lower reported BMI and the department's physical fitness program, which provides fitness facilities and the opportunity to exercise at all stations during paid work time and job performance standards associated with physical ability.

The OSA prevalence in our sample is comparable with recent reports,[32,33] but higher than reported 2 decades ago.[34] Although only a subset of patients with OSA report excessive sleepiness, many describe related symptoms (eg, fatigue, nonrestorative sleep, inattention). The prevalence of OSA without a complaint of excessive sleepiness, even in 1993, was 24% in men and 9% in women.[34] Today, it is likely even higher, given that the prevalence of some of the major risk factors for OSA (eg, aging and obesity) is increasing. In 2009, self-reported obesity prevalence in the United States was 26.7%, up from 19.8% in 2000.[35] In addition, recent improvements in diagnostic technology would likely yield higher apnea prevalence estimates.

Although in-the-line-of-duty death rates in police have decreased by almost half since 1972, the proportion of deaths due to unintentional injury have shown little change and in 2003 were greater than the rate of felonious deaths.[14] Across 2009-2010, more than one-third of in-the-line-of-duty deaths were due to motor vehicle crashes.[36] Driver sleepiness is a major cause of motor vehicle crashes,[3] and excessively sleepy individuals have an increased risk of having more crashes and more serious crashes.[37] Obstructive sleep apnea exposes individuals to increased sleepiness and a 2- to 3-fold higher risk of motor vehicle crashes.[8] We found that excessive sleepiness is common in police officers, with almost half reporting having fallen asleep while driving and about one-quarter reporting that this occurs 1 to 2 times per month. This is despite police officers apparently recognizing the dangers associated with drowsy driving; in a survey of North American police officers, almost 90% regarded drowsy driving to be as dangerous as drunk driving.[38]

Police officers who screened positive for a sleep disorder were likely to report more actual and near-miss administrative errors and safety violations. The loss of even 2 hours of nightly sleep for 1 week is associated with decrements in performance comparable with those seen after 24 hours of continuous wakefulness.[3] Sleep disorders resulting in chronic sleep deficiency may therefore adversely affect on-the-job performance. Because long work hours are also associated with decrements in performance and attentional failures,[13,14] we adjusted for mean work hours in our analysis (eTable 5).

There may be a biological basis to our finding that those who screened positive for a sleep disorder were significantly more likely to report displaying uncontrolled anger toward a citizen or suspect. Yoo et al[39] studied changes in the amygdala with functional magnetic resonance imaging and reported that those in a sleep deprived state were unable to appropriately govern behavioral responses to negative emotional stimuli. This may also explain the self-reported increased number of citizen complaints filed against those officers who screened positive for a sleep disorder, although further studies are required to test this potential mechanism.

Cardiovascular disease–related morbidity and mortality and vascular markers associated with these are increased in police officers, and these increases are not fully explained by traditional risk factors.[40,41] We found significantly increased risk of diagnosed cardiovascular disease and diabetes in those who screened positive for OSA, which is recognized as a major risk factor for cardiovascular disease, diabetes, hypertension, and stroke, independent of obesity.[3,6,42,43] Untreated OSA may therefore contribute to the increased prevalence of cardiovascular disease and diabetes in police. Furthermore, sleep loss is associated with metabolic abnormalities and may be the pathway contributing to sleep-related increases in the risk of obesity and diabetes.[3] Many police officers are at an even greater risk of these outcomes because they are often required to work overnight, on rotating shifts, or both. Impaired cardiometabolic responses are observed in healthy volunteers scheduled to eat and sleep out of phase from their habitual times,[44,45] and night work greatly increases the risk of progression to diabetes.[46] These findings may at least in part explain the increased risk of cardiovascular disease and diabetes in shift workers,[47] in particular police officers.[48] We note, however, that although we adjusted our analysis for many of the possible variables that influence cardiovascular disease risk, behavioral factors such as physical activity and diet were not assessed and may also account for the observed increased risk.

Our finding of increased risk of adverse mental health outcomes (diagnosed depression and risk of burnout) with positive screening for sleep disorders has significant implications, given the reported increased risk for suicide in police officers.[49] Obstructive sleep apnea, in particular the excessive sleepiness symptoms, and insomnia are associated with depression.[9] Research has also demonstrated relationships between sleep loss and mental health problems. Resident physicians, who work protracted hours as do police in many municipalities,[14] have been found to have rates of depression and burnout roughly double those in the general population.[50] Depression and burnout typically develop over the first several months of residency as sleep loss increases[51] and are associated with making more errors.[50] By analogy, officers who are burned out may be at increased risk of making mistakes on the job, which could compromise public safety; however, further studies will be needed to determine whether this is in fact the case.

This study had several limitations. By collecting data on a monthly basis, we attempted to reduce, but could not eliminate, the effect of recall bias. Performance outcomes and attentional failures were self-reported and therefore may be overreported or underreported. Although participants were assured of confidentiality, underreporting of work-related outcomes may have occurred, possibly due to the stigma associated with these. Additionally, reporting bias could have confounded the results if participants preferentially completed monthly surveys after having had a negative health or safety outcome. However, analysis of a subgroup that completed a full year of monthly surveys yielded a similar pattern of results. Because response rate could not be determined for this study, it is possible that those who participated may not be representative of all North American police officers, although demographic characteristics in municipal police department responders were similar to the entire department. The magnitude of difference in absolute risk of some of the outcomes we assessed was relatively small, and the clinical significance of such differences is unknown. Although we observed a positive relationship between sleep disorders screening result and health and safety outcomes (Table 3), the cross-sectional analysis cannot determine causality. Hypertension and BMI are used in the Berlin questionnaire to identify those at high risk of OSA, which could have contributed to the observed association between OSA risk and cardiovascular disease, even though we adjusted for these variables in our analyses. Finally, the shift work disorder questionnaire remains to be validated.

Questionnaire screening instruments are inherently less precise than objective tests. Although the Berlin questionnaire had a positive predictive value of 81.5% for detecting mild to moderate, moderate to severe, or severe OSA, and negative predictive value of 81.7% for those with moderate to severe or severe OSA, its performance in predicting OSA in our study did not match that reported initially.[19] Several factors likely account for this difference. First, the initial validation of the Berlin quesionnaire was conducted among individuals preselected with high pretest probability for OSA, such as sleep clinic populations.[19] Second, the techniques we used to record breathing abnormalities are much more sensitive than those used in many previous studies on the prevalence of sleep apnea,[34,52] including the initial studies used to validate the Berlin questionnaire in a sleep clinic population.[19] Third, different criteria are now used for the definition of hypopnea,[53] influencing respiratory disturbance index values.[54] As a result of these increases in sensitivity, sleep apnea would now be detected in many individuals who were classified as not having sleep apnea in the initial validation studies for the Berlin questionnaire.[19] This may explain why in our study the positive predictive value remained high for all levels of sleep apnea severity, whereas the negative predictive value was high only for those with more severe illness. Moreover, excessive sleepiness is a criterion for positive screening on the Berlin questionnaire, and given that our sample had high incidences of night shift work and chronic sleep loss, it is possible that excessive sleepiness associated with behaviorally induced insufficient sleep syndrome,[55] shift work disorder, or OSA were being detected. The utility of the Berlin questionnaire in predicting outcomes in our study may thus have been due in part to the clinical consequences of all 3 of these sleep disorders; for this reason, we extended our prospective analysis to all sleep disorders, rather than to OSA alone. Research to develop more specific diagnostic questionnaires that distinguish OSA from behaviorally induced insufficient sleep syndrome and shift work disorder would be useful because the therapeutic interventions differ.

In conclusion, a large proportion of police officers in our sample showed a positive sleep disorder screening result, which was associated with adverse health, safety, and performance outcomes. Further research is needed to determine whether sleep disorder prevention, screening, and treatment programs in occupational settings will reduce these risks.

Author Contributions: Drs Rajaratnam and Barger had full access to all of the data and take responsibility for integrity of the data and the accuracy of the data analysis. Drs Rajaratnam and Barger as co-first authors contributed equally to this article.
Study concept and design: Rajaratnam, Barger, Lockley, Landrigan, O'Brien, Cade, White, Czeisler.
Acquisition of data: Rajaratnam, Barger, Lockley, Landrigan, O'Brien, Qadri, Sullivan, Cade, Czeisler.

Analysis and interpretation of data: Rajaratnam, Barger, Shea, Wang, Landrigan, Qadri, Sullivan, Epstein, Czeisler.

Drafting of the manuscript: Rajaratnam, Barger, Shea, Wang, O'Brien, Qadri, Czeisler.

Critical revision of the manuscript for important intellectual content: Rajaratnam, Barger, Lockley, Shea, Landrigan, Sullivan, Cade, Epstein, White, Czeisler.

Statistical analysis: Rajaratnam, Barger, Wang, Landrigan, Qadri, Sullivan.

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Study supervision: Rajaratnam, Landrigan, O'Brien, Epstein, White, Czeisler.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Rajaratnam reported that he has served as a consultant through his institution to Vanda Pharmaceuticals, Philips Respironics, EdanSafe, the Australian Workers' Union, and National Transport Commission, and has through his institution received research grants and unrestricted educational grants from Vanda Pharmaceuticals, Takeda Pharmaceuticals North America, Philips Lighting, Philips Respironics, Cephalon, and ResMed Foundation, and reimbursements for conference travel expenses from Vanda Pharmaceuticals. His institution has received equipment donations or other support from Optalert, Compumedics, and Tyco Healthcare. He has also served as an expert witness and consultant to shift work organizations. Dr Barger reported receiving a research grant through her institution from Cephalon, receiving payment for lectures from Vital Issues in Medicine and National Sleep Foundation, and serving as a consultant for Alertness Solutions. Dr Lockley reported that he received 2 investigator-initiated research grants from the ResMed Foundation and an unrestricted equipment gift from ResMed Inc, in support of the studies described in this article; receiving consulting fees from Apollo Lighting, Naturebright, Sound Oasis, and Wyle Integrated Science and Engineering, and federally funded projects at Brigham and Women's Hospital, Thomas Jefferson University, and Warwick Medical School; lecture fees from Takeda Pharmaceuticals North America, I Slept Great/Euforma, LLC, and Emergency Social Services Association Conference, UK; unrestricted equipment gifts from Philips Lighting and Bionetics Corporation; an unrestricted monetary gift to support research from Swinburne University of Technology, Australia; a fellowship gift from Optalert, Pty Ltd, Melbourne, Australia; advance author payment and royalties from Oxford University Press, and honoraria from Servier Inc for writing an article for Dialogues in Clinical Neuroscience and from AMO Inc, for writing an educational monograph, neither of which refer to the companies' products; honoraria or travel and accommodation support for invited seminars, conference presentations or teaching from the Second International Symposium on the Design of Artificial Environments, Eighth International Conference on Managing Fatigue, American Academy of Sleep Medicine, American Society for Photobiology, Apollo Lighting, Bar Harbor Chamber of Commerce, Bassett Research Institute, Canadian Sleep Society, Committee of Interns and Residents, Coney Island Hospital, FASEB, Harvard University, Illinois Coalition for Responsible Outdoor Lighting, International Graduate School of Neuroscience, Japan National Institute of Occupational Safety and Health, Lightfair, National Research Council Canada, New York Academy of Sciences, North East Sleep Society, Ontario Association of Fire Chiefs, Philips Lighting, Thomas Jefferson University, University of Montreal, University of Tsukuba, University of Vermont College of Medicine, Utica College, Vanda Pharmaceuticals, Velux, Warwick Medical School, Woolcock Institute of Medical Research, and Wyle Integrated Science and Engineering (NASA); investigator-initiated research grants from Respironics Inc, Philips Lighting, Apollo Lighting, and Alcon Inc; and a service agreement and sponsor-initiated research contract from Vanda Pharmaceuticals. Dr Lockley also holds a process patent for the use of short-wavelength light for resetting the human circadian pacemaker and improving alertness and performance which is assigned to the Brigham and Women's Hospital per Hospital policy and has received revenue from a patent on the use of short-wavelength light, which is assigned to the University of Surrey. Dr Lockley has also served as a paid expert witness on behalf of 2 public bodies on arbitration panels related to sleep, circadian rhythms, and work hours. Dr Shea reported receiving fees for interpretation of polysomnographic sleep studies of participants in this study from Sleep HealthCenters, a sleep medicine specialty practice group; receiving fees for attendance at directors meeting of the American Academy of Sleep Medicine; and lecture fees from Tufts University School of Dental Medicine. Dr Landrigan reported serving as a consultant for Vital Issues in Medicine, developing an educational course for physicians on Shift Work Disorder (supported by an unrestricted educational grant from Cephalon Inc to Vital Issues in Medicine); and AXDev, to assist in the development of a study of Shift Work Disorder (supported by an unrestricted research grant from Cephalon Inc to AXDev). Dr Landrigan also reported receiving monetary awards, honoraria, and travel reimbursement from multiple academic and professional organizations for delivering lectures on sleep deprivation and safety. Mr O'Brien reported receiving support for travel to meetings for the study or other purposes from National Institute of Justice and Centers for Disease Control and Prevention. Dr Cade reported receiving a monetary award from the World Sleep Federation. Dr Epstein reported being employed by Sleep HealthCenters, a sleep medicine specialty practice group. Dr White reported being employed as the chief medical officer for Philips Respironics, for which he owns stock. Dr Czeisler reported that he has received consulting fees from or served as a paid member of scientific advisory boards for: Actelion Ltd; Bombardier Inc; Boston Celtics, Celedon Trucking, Cephalon, Inc, Delta Airlines, Eli Lilly and Co, Garda Síochána Inspectorate, Gerson Lehrman Group, Global Ground Support, Johnson & Johnson, Koninklijke Philips Electronics, NV, Minnesota Timberwolves, Norfolk Southern, Novartis, Portland Trail Blazers, Philips, Respironics Inc, sanofi-aventis Group, Sepracor Inc, Sleep Multimedia Inc, Somnus Therapeutics Inc, Vanda Pharmaceuticals, Inc, and Zeo Inc. Dr Czeisler reported that he owns an equity interest in Lifetrac Inc, Somnus Therapeutics Inc, Vanda Pharmaceuticals Inc, and Zeo Inc; that he has received royalties from the Massachusetts Medical Society/*New England Journal of Medicine*, McGraw Hill, the *New York Times*, Penguin Press, and Philips Respironics Inc. Dr Czeisler reported receiving lecture fees from the Accreditation Council of Graduate Medical Education, Alliance for Epilepsy Research, American Academy of Sleep Medicine, Cephalon Inc, Duke University School of Medicine, Harvard School of Public Health, Hokkaido University Graduate School of Medicine, Japan Aerospace Exploration Agency (JAXA), LOTTE Health Products, Mount Sinai School of Medicine, National Academy of Sciences, National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK/NIH), National Sleep Foundation, New England College of Occupational and Environmental Medicine (NECOEM), North East Sleep Society, Office of Rare Diseases Resarch (NIH), Rockpointe, sanofi-aventis Inc, Sleep Research Society, Society for Obstetric Anesthesia and Perinatology (SOAP), St Lukes Roosevelt Hospital, University of Chicago, University of Colorado, University of Pittsburgh, University of Virginia Medical School, University of Washington Medical Center, University of Wisconsin Medical School, and the World Federation of Sleep Research and Sleep Medicine Societies. Dr Czeisler reported that he has received research prizes with monetary awards from the American Academy of Sleep Medicine and Sleep Research Society, a clinical trial research contract from Cephalon Inc, and an investigator-initiated research grant from Cephalon Inc and that his research laboratory at the Brigham and Women's Hospital has received unrestricted research and education funds and support for research expenses from Cephalon Inc, Koninklijke Philips Electronics NV, ResMed, and the Committee for Interns and Residents and the Brigham and Women's Hospital. The Harvard Medical School Division of Sleep Medicine (HMS/DSM), which Dr Czeisler directs, has received unrestricted research and educational gifts and endowment funds from Boehringer Ingelheim Pharmaceuticals Inc, Cephalon Inc, George H. Kidder Esq, Gerald McGinnis, GlaxoSmithKline, Herbert Lee, Hypnion, Jazz Pharmaceuticals, Jordan's Furniture, Merck & Co Inc, Peter C. Farrell, PhD, Pfizer, ResMed, Respironics Inc, sanofi-aventis Inc, Sealy Inc, Sepracor Inc, Simmons, Sleep Health Centers LLC, Spring Aire, Takeda Pharmaceuticals, and Tempur-Pedic. The HMS/DSM has received gifts from many outside organizations and individuals including: Brigham and Women's Hospital (Development Office), Catalyst Group, Cephalon Inc, Committee for Interns and Residents, Eisai Inc, Farrell Family Foundation, Fisher & Paykel Healthcare Corp, Jordan's Furniture, Lilly USA, LLC, Neurocare Center for Sleep, Philips-Respironics Inc, Praxair US Homecare, sanofi-aventis Inc, Select Comfort Corp, Sepracor Inc, Sleep HealthCenters LLC, Somaxon Pharmaceuticals, Synchrony Healthcare Communications, Vanda Pharmaceuticals Inc, Wake Up Narcolepsy Inc, Watermark Medical, and Zeo Inc. The HMS/DSM Sleep and Health Education Program has received Educational Grant funding from Cephalon Inc, Takeda Pharmaceuticals, sanofi-aventis Inc, and Sepracor Inc. Dr Czeisler is the incumbent of an endowed professorship provided to Harvard University by Cephalon Inc and holds a number of process patents in the field of sleep and circadian rhythms (eg, photic resetting of the human circadian pacemaker). Since 1985, Dr Czeisler has also served as an expert witness on various legal cases related to sleep, circadian rhythms, or both.

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Disclaimer: Points of view in this document are those of the authors and do not necessarily represent the official position or policies of the US Department of Justice.

Online-Only Material: The eMethods, 10 eTables, and Author Video Interview are available at http://www.jama.com.

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REFERENCES

1. National Center on Sleep Disorders. *Research: NIH Sleep Disorders Research Plan.* Bethesda, MD: National Institutes of Health; 2011. NIH publication 11-7820. http://www.nhlbi.nih.gov/health/prof/sleep/sleep_splan.htm. Accessed November 28, 2011.

2. American Academy of Sleep Medicine. *International Classification of Sleep Disorders: An Unmet Public Health Problem. Revised: Diagnostic and Coding Manual.* 2nd ed. Westchester, IL: AASM; 2005.

3. Institute of Medicine of the National Academies. *Sleep Disorders and Sleep Deprivation.* Washington DC: National Academies Press; 2006.

4. Faccenda JF, Mackay TW, Boon NA, Douglas NJ. Randomized placebo-controlled trial of continuous positive airway pressure on blood pressure in the sleep apnea-hypopnea syndrome. *Am J Respir Crit Care Med*. 2001;163(2):344-348.

5. Punjabi NM, Caffo BS, Goodwin JL, et al. Sleep-disordered breathing and mortality: a prospective cohort study. *PLoS Med*. 2009;6(8):e1000132.

6. Redline S, Yenokyan G, Gottlieb DJ, et al. Obstructive sleep apnea-hypopnea and incident stroke: the sleep heart health study. *Am J Respir Crit Care Med*. 2010;182(2):269-277.

7. Yaffe K, Laffan AM, Harrison SL, et al. Sleep-disordered breathing, hypoxia, and risk of mild cognitive impairment and dementia in older women. *JAMA*. 2011;306(6):613-619.

8. Tregear S, Reston J, Schoelles K, Phillips B. Obstructive sleep apnea and risk of motor vehicle crash: systematic review and meta-analysis. *J Clin Sleep Med*. 2009;5(6):573-581.

9. Buysse DJ, Angst J, Gamma A, Ajdacic V, Eich D, Rössler W. Prevalence, course, and comorbidity of insomnia and depression in young adults. *Sleep*. 2008;31(4):473-480.

10. Gangwisch JE, Malaspina D, Posner K, et al. Insomnia and sleep duration as mediators of the relationship between depression and hypertension incidence. *Am J Hypertens*. 2010;23(1):62-69.

11. Kessler RC, Berglund PA, Coulouvrat C, et al. Insomnia and the performance of US workers: results from the America insomnia survey. *Sleep*. 2011;34(9):1161-1171.

12. Drake CL, Roehrs T, Richardson G, Walsh JK, Roth T. Shift work sleep disorder: prevalence and consequences beyond that of symptomatic day workers. *Sleep*. 2004;27(8):1453-1462.

13. Ohayon MM, Lemoine P, Arnaud-Briant V, Dreyfus M. Prevalence and consequences of sleep disorders in a shift worker population. *J Psychosom Res*. 2002;53(1):577-583.

14. Vila B. Impact of long work hours on police officers and the communities they serve. *Am J Ind Med*. 2006;49(11):972-980.

15. Czeisler CA. Medical and genetic differences in the adverse impact of sleep loss on performance: ethical considerations for the medical profession. *Trans Am Clin Climatol Assoc*. 2009;120:249-285.

16. Neylan TC, Metzler TJ, Best SR, et al. Critical incident exposure and sleep quality in police officers. *Psychosom Med*. 2002;64(2):345-352.

17. Garbarino S, De Carli F, Nobili L, et al. Sleepiness and sleep disorders in shift workers: a study on a group of Italian police officers. *Sleep*. 2002;25(6):648-653.

18. The American Association for Public Opinion Research. *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys.* 7th ed. 2011. http://www.aapor.org/AM/Template.cfm?Section=Standard_Definitions2&Template=/CM/ContentDisplay.cfm&ContentID=3156. Accessed November 29, 2011.

19. Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med*. 1999;131(7):485-491.

20. Soldatos CR, Dikeos DG, Paparrigopoulos TJ. Athens Insomnia Scale: validation of an instrument based on *ICD-10* criteria. *J Psychosom Res*. 2000;48(6):555-560.

21. Allen RP, Walters AS, Montplaisir J, et al. Restless legs syndrome prevalence and impact: REST general population study. *Arch Intern Med*. 2005;165(11):1286-1292.

22. Anic-Labat S, Guilleminault C, Kraemer HC, Meehan J, Arrigoni J, Mignot E. Validation of a cataplexy questionnaire in 983 sleep-disorders patients. *Sleep*. 1999;22(1):77-87.

23. Johns MW. Sensitivity and specificity of the multiple sleep latency test (MSLT), the maintenance of wakefulness test and the epworth sleepiness scale: failure of the MSLT as a gold standard. *J Sleep Res*. 2000;9(1):5-11.

24. Maslach C, Jackson SE, Leiter MP. *Maslach Burnout Inventory Manual.* 3rd ed. Palo Alto, CA: Consulting Psychologists Press; 1996.

25. Barger LK, Cade BE, Ayas NT, et al; Harvard Work Hours, Health, and Safety Group. Extended work shifts and the risk of motor vehicle crashes among interns. *N Engl J Med*. 2005;352(2):125-134.

26. Lockley SW, Cronin JW, Evans EE, et al; Harvard Work Hours, Health and Safety Group. Effect of reducing interns' weekly work hours on sleep and attentional failures. *N Engl J Med*. 2004;351(18):1829-1837.

27. Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika*. 1986;73:13-22.

28. Anderson AB, Basilevsky A, Hum DPJ. Missing data: a review of the literature. In: Rossi PH, Wright JD, Anderson AB, eds. *Handbook of Survey Research.* New York, NY: Academic Press; 1983:415-492.

29. Ayas NT, Barger LK, Cade BE, et al. Extended work duration and the risk of self-reported percutaneous injuries in interns. *JAMA*. 2006;296(9):1055-1062.

30. Barger LK, Ayas NT, Cade BE, et al. Impact of extended-duration shifts on medical errors, adverse events, and attentional failures. *PLoS Med*. 2006;3(12):e487.

31. Bureau of Labor Statistics. Current Population Survey (CPS): annual averages—household data. 2007; ftp://ftp.bls.gov/pub/special.requests/lf/aa2007/aat11.txt. Accessed February 18, 2011.

32. Kapsimalis F, Kryger M. Sleep breathing disorders in the U.S. female population. *J Womens Health (Larchmt)*. 2009;18(8):1211-1219.

33. Howard ME, Desai AV, Grunstein RR, et al. Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. *Am J Respir Crit Care Med*. 2004;170(9):1014-1021.

34. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med*. 1993;328(17):1230-1235.

35. Sherry B, Blanck HM, Galuska DA, Pan L, Dietz WH, Balluz L. State-specific obesity prevalence among adults—United States, 2009. *MMWR Morb Mort Wkly Rep*. 2010;59(30):951-955.

36. National Law Enforcement Memorial Fund. Research bulletin: law enforcement officer deaths: preliminary 2010. http://www.nleomf.org/assets/pdfs/reports/2010_Law_Enforcement_Fatalities_Report.pdf. Accessed May 5, 2011.

37. Drake C, Roehrs T, Breslau N, et al. The 10-year risk of verified motor vehicle crashes in relation to physiologic sleepiness. *Sleep*. 2010;33(6):745-752.

38. AAA Foundation for Traffic Safety. Survey of US and Canadian police officers about the public's drowsy driving behavior. 2004; http://www.aaafoundation.org/pdf/PoliceDD.pdf. Accessed October 4, 2011.

39. Yoo SS, Gujar N, Hu P, Jolesz FA, Walker MP. The human emotional brain without sleep--a prefrontal amygdala disconnect. *Curr Biol*. 2007;17(20):R877-R878.

40. Franke WD, Kohut ML, Russell DW, Yoo HL, Ekkekakis P, Ramey SP. Is job-related stress the link between cardiovascular disease and the law enforcement profession? *J Occup Environ Med*. 2010;52(5):561-565.

41. Joseph PN, Violanti JM, Donahue R, et al. Endothelial function, a biomarker of subclinical cardiovascular disease, in urban police officers. *J Occup Environ Med*. 2010;52(10):1004-1008.

42. Budhiraja R, Budhiraja P, Quan SF. Sleep-disordered breathing and cardiovascular disorders. *Respir Care*. 2010;55(10):1322-1332, discussion 1330-1332.

43. Botros N, Concato J, Mohsenin V, Selim B, Doctor K, Yaggi HK. Obstructive sleep apnea as a risk factor for type 2 diabetes. *Am J Med*. 2009;122(12):1122-1127.

44. Scheer FA, Hilton MF, Mantzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. *Proc Natl Acad Sci U S A*. 2009;106(11):4453-4458.

45. Hampton SM, Morgan LM, Lawrence N, et al. Postprandial hormone and metabolic responses in simulated shift work. *J Endocrinol*. 1996;151(2):259-267.

46. Toshihiro M, Saito K, Takikawa S, Takebe N, Onoda T, Satoh J. Psychosocial factors are independent risk factors for the development of Type 2 diabetes in Japanese workers with impaired fasting glucose and/or impaired glucose tolerance. *Diabet Med*. 2008;25(10):1211-1217.

47. Knutsson A, Hallquist J, Reuterwall C, Theorell T, Akerstedt T. Shiftwork and myocardial infarction: a case-control study. *Occup Environ Med*. 1999;56(1):46-50.

48. Violanti JM, Burchfiel CM, Hartley TA, et al. Atypical work hours and metabolic syndrome among police officers. *Arch Environ Occup Health*. 2009;64(3):194-201.

49. Violanti JM, Vena JE, Petralia S. Mortality of a police cohort: 1950-1990. *Am J Ind Med*. 1998;33(4):366-373.

50. Fahrenkopf AM, Sectish TC, Barger LK, et al. Rates of medication errors among depressed and burnt out residents: prospective cohort study. *BMJ*. 2008;336(7642):488-491.

51. Rosen IM, Gimotty PA, Shea JA, Bellini LM. Evolution of sleep quantity, sleep deprivation, mood disturbances, empathy, and burnout among interns. *Acad Med*. 2006;81(1):82-85.

52. Kapur VK, Redline S, Nieto FJ, Young TB, Newman AB, Henderson JA; Sleep Heart Health Research Group. The relationship between chronically disrupted sleep and healthcare use. *Sleep*. 2002;25(3):289-296.

53. Redline S, Kapur VK, Sanders MH, et al. Effects of varying approaches for identifying respiratory disturbances on sleep apnea assessment. *Am J Respir Crit Care Med*. 2000;161(2 Pt 1):369-374.

54. Raj R, Hirshkowitz M. Effect of the new Medicare guideline on patient qualification for positive airway pressure therapy. *Sleep Med*. 2003;4(1):29-33.

55. Komada Y, Inoue Y, Hayashida K, Nakajima T, Honda M, Takahashi K. Clinical significance and correlates of behaviorally induced insufficient sleep syndrome. *Sleep Med*. 2008;9(8):851-856.

A Piece of My Mind

"The central determinants of health care costs are physician habits, attitudes, and behaviors. In every clinical encounter, multiple decisions are made with significant financial consequences." From "Fix It!"

SEE PAGE 2544

Medical News & Perspectives

The recent recommendation by the US Preventive Services Task Force advising against prostate-specific antigen–based screening for prostate cancer has provoked considerable debate in the medical community.

SEE PAGE 2549

Commentaries

Accelerating identification and approval of cancer drugs

SEE PAGE 2608

Homocysteine lowering: the role of subgroup analyses

SEE PAGE 2610

Placebo effect in clinical practice

SEE PAGE 2612

Author in the Room Teleconference

Join Harold C. Sox, MD, on Wednesday, January 18, at 2 PM eastern time to discuss the new American Cancer Society process for creating trustworthy cancer screening guidelines. To register, go to http://www.ihi.org/AuthorintheRoom.

Editor's Audio Summary

Dr Bauchner summarizes and comments on this week's issue.

www.jama.com

Readers Respond

How would you manage care for a house officer with a needlestick injury? Go to www.jama.com to read the case. Submit your response by January 1.

JAMA Patient Page

For your patients: Information about frostbite.

SEE PAGE 2633

Sleep Disorders in Police Officers

Police officers—who often work extended shifts—may experience chronic sleep deficiency or have untreated sleep disorders, which may adversely affect their health and safety. In a cross-sectional survey of 4957 North American police officers and prospective follow-up surveys completed by 3545 officers, Rajaratnam and colleagues found that 40% of the respondents screened positive for a sleep disorder, which was associated with increased risk of self-reported adverse health and job-related administrative errors and safety violations. In an editorial, Grandner and Pack discuss health and safety implications of sleep deprivation and untreated sleep disorders for individuals and society.

SEE PAGE 2567 AND EDITORIAL ON PAGE 2616 AND AUTHOR VIDEO INTERVIEW AT www.jama.com

Heart Rate, Ischemic Heart Disease, and Mortality

High resting heart rate is a recognized predictor of cardiovascular morbidity and mortality, but whether temporal changes in resting heart rate influence the risk of death from ischemic heart disease is not known. Nauman and colleagues analyzed data from a prospective cohort study of 29 325 apparently healthy individuals who had resting heart rate measured on 2 occasions approximately 10 years apart. The authors report that an increase in resting heart rate over the 10-year period was associated with an increased risk of ischemic heart disease–related death.

SEE PAGE 2579

Chlorthalidone Treatment and Long-term Survival

In the Systolic Hypertension in the Elderly Program trial, in which 4736 older patients with isolated systolic hypertension were randomly assigned to chlorthalidone-based stepped-care therapy or placebo for 4.5 years, antihypertensive therapy resulted in a lower rate of cardiovascular events but effects on mortality were not significant. At a 22-year follow-up of the study participants, Kostis and colleagues found that 4.5 years' treatment with chlorthalidone-based therapy was associated with a gain in life expectancy free from cardiovascular death—corresponding to approximately 1 day gained for each month of treatment received.

SEE PAGE 2588

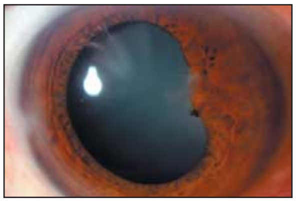
Immunosuppression in Sepsis

Some evidence suggests that in severe sepsis, an early hyperinflammatory response is followed by immunosuppression. In a study that involved postmortem spleen and lung tissue harvested from 40 patients who died with sepsis, 29 control spleens from critically ill patients without sepsis, and 20 control lungs from transplant donors or lung cancer resections, Boomer and colleagues assessed the association of sepsis with changes in host immunity. The authors report biochemical, flow cytometric, and immunohistochemical findings consistent with immunosuppression in tissue obtained from the patients who died with sepsis that were not observed in the control tissues. In an editorial, Ward discusses evidence for the development of immunosuppression in patients with sepsis. In a commentary Angus calls for a reevaluation of current modes of treating sepsis.

SEE PAGE 2594 CME AND EDITORIAL ON PAGE 2618 AND COMMENTARY ON PAGE 2614

CLINICIAN'S CORNER

JAMA Clinical Challenge



A patient who experienced the sensation of an object striking his right eye, without acute pain or change in vision, presented to the emergency department 9 days later for evaluation of increasingly blurred vision. What would you do next?

SEE PAGE 2606

Supplementary Online Content

Rajaratnam SMW, Barger L, Lockley SW, et al. Sleep disorders, health, and safety in police officers. *JAMA*. 2011;306(23):2567-2578.

This supplementary material has been provided by the authors to give readers additional information about their work.

eMethods.

Questionnaire instruments

Obstructive Sleep Apnea (OSA)

The Berlin Questionnaire[1] revised as a part of the Cleveland Sleep Habits Questionnaire (iONSLEEP LLC, Shaker Heights, OH),[2] was used to screen participants for OSA. Positive screening for OSA based on the Berlin predicted a respiratory disturbance index (RDI) greater than 5 with a sensitivity of 86% and a specificity of 77%.[1] The Berlin Questionnaire assesses known risk factors and symptoms of OSA: snoring and pauses in breathing, daytime sleepiness, and history of high blood pressure and/or body mass index (BMI) greater than 30. Participants with scores ≥ 2 in at least two of the three symptom categories were deemed to have high pre-test probability for OSA, and categorized as positive for OSA.

Insomnia

The Athens Insomnia Scale[3] was used to assess risk for insomnia. This self-administered psychometric instrument was developed to assess the severity of insomnia based on ICD-10 diagnostic criteria. The instrument consists of eight items assessing sleep disturbance (difficulty with sleep induction, awakenings during the night, early morning awakening, total sleep time, and overall quality of sleep) and daytime consequences (problems with sense of well-being, functioning, and sleepiness during the day). These items are summed to create a final score; highest possible score is 24.When using a score of six or above to identify those at risk of insomnia, the scale has 93% sensitivity and 85% specificity against ICD-10 diagnosis (90% overall correct case identification).[4] For the present study, only moderate to severe cases were deemed to be positive for insomnia, defined by a score of 10 or above on the scale. In order to differentiate insomnia from shift work disorder, where insomnia symptoms are associated with the work schedule, we required a score of 10 or above on the same scale when referencing "the most recent week during which you had a vacation (at least 3 consecutive days off)."

Shift Work Disorder

As there was no validated instrument available to screen for shift work disorder, one was developed for the purposes of the present study. The instrument was based on the International Classification of Sleep Disorders-2 (ICSD-2) diagnostic criteria for shift work disorder.[5] We also assessed the risk of moderate to severe shift work disorder defined as a report of both insomnia and excessive wake time sleepiness that are temporally associated with a recurring work schedule that overlaps the usual sleep time. Participants who reported in the past month working three or more night shifts, defined as any 8- to 10-hour shifts between 10 pm and 8 am or any 12-hour shift between 7 pm and 9 am), were deemed to be night shift workers and were screened for shift work disorder.

For the excessive sleepiness component of shift work disorder, we used a series of questions assessing the following: (i) difficulties with sleepiness while on a night shift schedule vs. while on vacation or days off (response choices none, mild, considerable or intense); (ii) likelihood of dozing off or falling asleep while driving after a night shift vs. while driving after at least two days off from work; and (iii) likelihood of dozing or falling asleep while at work during a night shift vs. during a day or evening shift (response choices would never doze, slight chance of dozing, moderate chance of dozing or high chance of dozing). To be deemed positive for excessive sleepiness associated with shift work participants were required to show a lower score for difficulties with sleepiness or likelihood of dozing during periods of night shift work compared to periods of vacation/days off or day/evening work in at least one of the three groups of questions.

To assess the insomnia component of shift work disorder, we presented participants with two separate versions of the Athens Insomnia Scale[3] to evaluate their experiences while attempting to sleep after night shift work and during periods of vacation or days off from work, respectively. To be deemed positive for the insomnia component of shift work disorder, participants were required to have a score of six or above for the insomnia scale during periods of night work and a score below six for the insomnia scale during periods of vacation or days off from work.

Restless Legs Syndrome

We used the questionnaire from the Restless Legs Syndrome Epidemiology, Symptoms, and Treatment (REST) program.[6] The questionnaire comprises 10 items with diagnostic questions for restless legs syndrome and questions about the frequency and nature of restless legs syndrome symptoms and the degree of associated distress. In a study in primary care, the questionnaire showed sensitivity of 82.3% and specificity of 89.9%.[7]

Narcolepsy with cataplexy

For a positive narcolepsy screening result, participants needed to satisfy criteria for excessive sleepiness and cataplexy. The Epworth Sleepiness Scale (ESS)[8] was used to assess excessive sleepiness (see below), with a score ≥ 13 used as the criterion for identifying those positive for narcolepsy. ESS score ≥ 13 shows high sensitivity (90.4%) and specificity (84.6%) for narcolepsy-cataplexy versus population based samples of adults (written communication, E. Mignot, MD, PhD, August 10, 2011). To assess cataplexy symptoms, a modified version of the questions proposed by Anic-Labat et al. (sensitivity 92.1% and specificity 95.3%, calculated from published data)[9] was used, in which participants were asked about the frequency of muscle weakness in their legs and/or buckling of their knees when laughing, angry or telling/hearing a joke. Those participants who reported “sometimes (at least once a month but less than once per week)” or “often (at least once per week)” were deemed positive for cataplexy.

Excessive sleepiness

The Epworth Sleepiness Scale (ESS)[8] was used to assess excessive sleepiness. Participants rated their likelihood of dozing or falling asleep in eight different situations. The total ESS score was calculated, with higher scores reflecting higher sleepiness level. Excessive sleepiness as a dichotomous variable was defined as ESS score ≥ 11, shown to have high sensitivity (93.5%) and high specificity (100%),[10] and is consistent with the original validation study of the instrument.[11]

Burnout

Maslach Burnout Inventory, a 22-item validated questionnaire, was used to for measuring burnout.[12] Burnout describes emotional exhaustion related to occupational stress. The Maslach Burnout Inventory has three subscales: emotional exhaustion, depersonalization, and personal achievement. We analysed only emotional exhaustion and depersonalization as personal achievement is reported to be an independent scale.[12] Burnout as a dichotomous variable was defined as high emotional exhaustion and depersonalization scores (≥ 27 and ≥ 13, respectively) compared to low to moderate scores. Reliability of the scales has been estimated by Cronbach’s alpha of 0.90 for emotional exhaustion and 0.79 for depersonalization, and test-retest reliability coefficients of 0.82 for emotional exhaustion and 0.60 for depersonalization.[12]

Assessment and scoring of sleep stages, arousals, respiratory events, and leg movements

Polysomnographic sleep studies were performed at Sleep HealthCenters (MA), which is accredited by the American Academy of Sleep Medicine. Data were sampled at 100 Hz and stored on a computer using a digital data acquisition system (Alice software versions 3 and 4, Respironics, Murrysville, PA). Scoring was performed by registered polysomnographic technologists.

Data included sleep stages (using 4 electroencephalograms, 2 electrooculograms, and a submental electromyogram), arterial oxyhemoglobin saturation (SaO_2 from pulse oximeter), airflow (snoring microphone, nasal pressure transducer, oronasal thermistors), abdominal and thoracic breathing movements (strain gauges wrapped around the thorax and abdomen), electrocardiography, and periodic limb movements (surface electromyography of anterior tibialis activity of both legs).

Sleep stages, apneas, hypopneas, arousals, and leg movements were scored visually from the computer screen using Alice software versions 3 and 4. Sleep stages were scored according to standard criteria.[13] Arousals were detected from 3-second or longer changes in electroencephalography and electromyography using standardized criteria.[14] Respiratory events were scored based on the recommendations of the Task Force of the American Academy of Sleep Medicine (the “Chicago Criteria”).[15] Thus, apnea was scored when cessation of airflow for 10 seconds or longer was observed. Apneas were further classified as obstructive or central depending on the presence or absence of chest-wall breathing movements. Hypopneas were identified based on a discernible decrease in breathing for at least 10 seconds (observed in the respiratory strain gauge, nasal pressure, or thermistor recordings), followed by either arterial oxyhemoglobin desaturation of at least 3% or an arousal. Hypopneas were not categorized as obstructive or central events. These events were quantified as the respiratory disturbance index (RDI, number of respiratory disturbances per hour of sleep). As there are differences in scoring criteria used by varied laboratories, where available we also report the apnea-hypopnea index (AHI, number of apneas plus hypopneas per hour of sleep). The AHI is usually slightly lower than the RDI because the definition for hypopnea is more conservative than the definition of a respiratory disturbance, i.e., scored hypopneas require a >50% reduction in breathing effort [rather than a ‘discernible reduction’] and a 4% reduction in SaO_2 [rather than a 3% reduction]. Quality control data for this laboratory revealed the interscorer reliability is greater than 90% for scoring respiratory events and for sleep staging. The resting, awake, and supine baseline SaO_2 was recorded, as was the minimum SaO_2 overnight during sleep. Periodic limb movements were scored when at least 4 consecutive bursts of anterior tibialis activity (> 25% of the calibration activity with a duration of 0.5-5 seconds) occurred within 5 to 90 seconds. The total number of individual leg movements was recorded. If leg movements accompanied arousals at the termination of a Chicago Criteria-defined respiratory event, then these events were classified as respiratory disturbances, and, in such cases, the accompanying leg movements were not counted in the periodic limb movements of sleep index (PLMI). The nasal-pressure tracing, the results of the snoring-detection microphone on the neck, and alterations in the phase relationship between thoracic and abdominal breathing motions (e.g., paradoxical motion) were used qualitatively to help identify airflow limitation. If a leg movement caused an arousal with accompanying larger breaths and there were subsequent smaller unobstructed breaths at sleep onset, then these events were classified as leg movements and counted in the PLMI, rather than the respiratory disturbance index (RDI). After being scoring by a registered polysomnographic technologist, as occurs in most accredited laboratories, all records were reviewed by a sleep specialist, who confirmed the adequacy of the scoring (adjusting scoring where necessary was < 2% of events).

There are several possible classification schemes for severity of OSA based on polysomnography results, but there is not a universally accepted single threshold RDI or AHI to reliably distinguish between ‘normal’ and ‘mild’ OSA, partly because AHI and RDI are greatly affected by body posture and amount of REM versus non-REM sleep which can vary considerably from night to night, and choice of devices used (e.g., nasal thermistors versus nasal pressure), and scoring criteria (e.g., AHI versus RDI) also affect results. Moreover, long term health outcome data are not yet available for such thresholds before and after therapeutic intervention. The classifications of moderately severe and severe OSA are less controversial as people in these categories have more night-to night consistency in test results, and the benefit of therapy is clearer in these groups. Given this background, the following criteria were applied by a sleep specialist to classify general OSA severity:

- Normal to mild: RDI < 10/hour of sleep and AHI < 5/hour of sleep and minimum saturation above 85% (unless saturation was stable and low, as may occur with lung disease and obesity);
- Mild to moderate: RDI ≥10 and <25/hour of sleep, or >5 with associated desaturation to <85%;
- Moderate to severe: RDI ≥ 25 and < 35/hour of sleep;
- Severe: RDI ≥ 35/hour of sleep.

It should be noted that in this group, all polysomnographic records classified as Normal also had AHI < 5/hour of sleep, and three subjects were classified as Mild based on desaturation below 85%, and in each case, RDI was between 5-10/hour but with notable desaturation in REM sleep.

eReferences

1. Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med.* Oct 5 1999;131(7):485-491.

2. Mustafa M, Erokwu N, Ebose I, Strohl K. Sleep problems and the risk for sleep disorders in an outpatient veteran population. *Sleep Breath.* Jun 2005;9(2):57-63.

3. Soldatos CR, Dikeos DG, Paparrigopoulos TJ. Athens Insomnia Scale: validation of an instrument based on ICD-10 criteria. *J Psychosom Res.* Jun 2000;48(6):555-560.

4. Soldatos CR, Dikeos DG, Paparrigopoulos TJ. The diagnostic validity of the Athens Insomnia Scale. *J Psychosom Res.* Sep 2003;55(3):263-267.

5. American Academy of Sleep Medicine. *International Classification of Sleep Disorders, Revised: Diagnostic and Coding Manual*. 2nd ed. Westchester, Illinois: AASM; 2005.

6. Allen RP, Walters AS, Montplaisir J, et al. Restless legs syndrome prevalence and impact: REST general population study. *Arch Intern Med.* Jun 13 2005;165(11):1286-1292.

7. Nichols DA, Allen RP, Grauke JH, et al. Restless legs syndrome symptoms in primary care: a prevalence study. *Arch Intern Med.* Oct 27 2003;163(19):2323-2329.

8. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep.* Dec 1991;14(6):540-545.

9. Anic-Labat S, Guilleminault C, Kraemer HC, Meehan J, Arrigoni J, Mignot E. Validation of a cataplexy questionnaire in 983 sleep-disorders patients. *Sleep.* Feb 1 1999;22(1):77-87.

10. Johns MW. Sensitivity and specificity of the multiple sleep latency test (MSLT), the maintenance of wakefulness test and the Epworth sleepiness scale: Failure of the MSLT as a gold standard. *Journal of Sleep Research.* 2000;9(1):5-11.

11. Johns M, Hocking B. Daytime sleepiness and sleep habits of Australian workers. *Sleep.* 1997;20(10):844-849.

12. Maslach C, Jackson SE, Leiter MP. *Maslach burnout inventory manual*. 3rd ed. ed. Palo Alto CA: Consulting Psychologists Press; 1996.

13. Rechtschaffen A, Kales A. *A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects.* Washington DC: US Government Printing Office; 1968.

14. American Sleep Disorders Association. EEG arousals: scoring rules and examples: a preliminary report from the Sleep Disorders Atlas Task Force of the American Sleep Disorders Association. *Sleep.* Apr 1992;15(2):173-184.

15. American Academy of Sleep Medicine Task Force. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep.* Aug 1 1999;22(5):667-689.

16. Rajaratnam S, Barger L, Lockley S, et al. Screening for sleep disorders in North American police officers. *Sleep.* 2007;30(Abstract supplement):A209.

eTable 1. Comparison of demographic characteristics between municipal police department survey respondents and those of the entire police department

Characteristic	**Municipal police department survey respondents (n=659)**	**Municipal police department (all officers) (n=3,726)**
Age, *y*		
Mean ± SD	36.9 ± 8.3	38.3 ± 8.6
Age distribution, *n (%) (95% CI)*		
20-29 y	132 (20.2) (17.1-23.3)	637 (17.1)
30-39 y	303 (46.4) (42.6-50.2)	1,590 (42.7)
40-49 y	155 (23.7) (20.5-27.0)	1,029 (27.6)
50+ y	60 (9.2) (7.0-11.4)	470 (12.6)
Not known	9 (n/a)	-
Sex, *n (%) (95% CI)*		
Women	168 (25.6) (22.3-28.9)	1,017 (27.3)
Men	488 (74.4) (71.1-77.7)	2,709 (72.7)
Not known	3 (n/a)	-
Rank, *n (%)(95% CI)*		
Patrol Officer	471 (88.4) (85.6-91.1)	3,251 (87.3)
Sergeant	44 (8.3) (5.9-10.6)	286 (7.7)
Lieutenant or higher	15 (2.8) (1.4-4.2)	189 (5.1)
Other	3 (0.6) (0.0-1.2)	-
Not known	126 (n/a)	-

eTable 2. Comparison of demographics and sleep disorder risk of police officers who participated in the follow-up survey and officers who did not participate in the follow-up survey

Demographic characteristic	**Participated in follow-up**	**Did not participate in follow-up**
N (%)	3,545 (71.5)	1,412 (28.5)
Age, *y*		
Mean ± SD *(range)*	38 ± 8.3 (20-64)	38.8 ± 8.3 (20-77)
Sex, *n (%)(95% CI)*		
Women	600 (16.9)(15.7-18.2)	261 (18.5)(16.5-20.5)
Men	2,935 (82.8)(81.6-84.0)	1,144 (81.0)(79.0-83.1)
Not known	10 (0.3)	7 (0.5)
Body mass index, *kg/m²*		
Mean ± SD *(range)*	28.7± 4.6 (15.8-56.5)	28.7 ± 4.8 (17.8-47.5)
Health (subjective), *n (%)(95% CI)*		
Poor	8 (0.2)(0.1-0.4)	3 (0.2)(0.0-0.5)
Fair	165 (4.7)(4.0-5.3)	82 (5.8)(4.6-7.0)
Good	1,274 (35.9)34.4-37.5)	505 (35.8)(33.3-38.3)
Very good	1,481 (41.8)(40.2-43.4)	618 (43.8)(41.2-46.4)
Excellent	591 (16.7)(15.4-17.9)	193 (13.7)(11.9-15.5)
Not known	26 (0.7)	11 (0.8)
Employer type, *n (%)(95% CI)*		
Municipal	2,180 (61.5)(59.9-63.1)	960 (68.0)(65.6-70.4)
County	523 (14.8)(13.6-15.9)	322 (22.8)(20.6-25.0)
State	732 (20.6)(19.3-22.2)	63 (4.5)(3.4-5.5)
Federal	51 (1.4)(1.0-1.8)	39 (2.8)(1.9-3.6)
University/College/School	18 (0.5)(0.3-0.7)	8 (0.6)(0.2-1.0)
Transit and railroad	0 (0.0)(n/a)	2 (0.1)(0.0-0.3)
Security	2 (0.1)(0.0-0.1)	2 (0.1)(0.0-0.3)
Other	20 (0.6)(0.3-0.8)	10 (0.7)(0.3-1.1)
Not known	19 (0.5)	6 (0.4)
Primary activity, *n (%)(95% CI)*		
First-line supervisors/managers of police and detectives	525 (14.8)(13.6-16.0)	218 (15.4)(13.6-17.3)
Detectives and criminal investigators	246 (6.9)(6.1-7.8)	162 (11.5)(9.8-13.1)
Police and sheriff's patrol officers	2,394 (67.5)(66.0-69.1)	904 (64.0)(61.5-66.5)
Other	362 (10.2)(9.2-11.2)	126 (8.9)(7.4-10.4)
Not known	18 (0.5)	2 (0.1)
Sleep disorder risk	**Participated in follow-up**	**Did not participate in follow-up**

N for OSA and SWD (%)	3,545 (71.5)	1,412 (28.5)
N for other sleep disorders (%)	2,886 (67.1)	1,412 (32.9)
OSA, *n (%)(95% CI)*		
Positive	1,162 (32.8)(31.2-34.3)	504 (35.7)(33.2-38.2)
Negative	2,342 (66.1)(64.5-67.6)	863 (61.1)(58.6-63.7)
Not known	41 (1.2)	45 (3.2)
Insomnia (moderate to severe), *n (%)(95% CI)*		
Positive	176 (6.1)(5.2-7.0)	105 (7.4)(6.1-8.8)
Negative	2,683 (93.0)(92.0-93.9)	1,214 (86.0)(84.2-87.8)
Not known	27 (0.9)	93 (6.6)
SWD[†], *n (%)(95% CI)*		
Positive	193 (5.4)(4.7-6.2)	79 (5.6)(4.4-6.8)
Negative	1,053 (29.7)(28.2-31.2)	488 (34.6)(32.1-37.0)
Unknown/Not a shift worker	2,299 (64.9)(63.3-66.4)	845 (59.8)(57.3-62.4)
RLS, *n (%)(95% CI)*		
Positive	44 (1.5)(1.1-2.0)	26 (1.8)(1.1-2.5)
Negative	2,803 (97.1)(96.5-97.7)	1,260 (89.2)(87.6-90.9)
Not known	39 (1.4)	126 (8.9)
Narcolepsy, *n (%)(95% CI)*		
Positive	10 (0.3)(0.1-0.6)	6 (0.4)(0.1-0.8)
Negative	2,854 (98.9)(98.5-99.3)	1,304 (92.4)(91.0-93.7)
Not known	22 (0.8)	102 (7.2)
Any sleep disorder, *n (%)(95% CI)*		
Positive	1,386 (39.1)(37.5-40.7)	617 (43.7)(41.1-46.3)
Negative or not known	2,159 (60.9)(59.3-62.5)	795 (56.3)(53.7-58.9)

eTable 3. Self-reported characteristics of participants screening positive vs. those screening negative for sleep disorders, and those screening positive for obstructive sleep apnea vs. those screening negative for obstructive sleep apnea

	Any sleep disorder			**Obstructive sleep apnea**		
	Positive screening	**Negative screening**	**P[a]**	**Positive screening**	**Negative screening**	**P[a]**
N (%)	2,003 (40.4)	2,954 (59.6)		1,666	3,205	
Age, *y*						
Mean ± SD *(range)*	39.9 ± 8.3 *(20 – 66)*	37.5 ± 8.3 *(20 – 77)*	<0.001	40.6 ± 8.3 *(22 – 66)*	37.3 ± 8.1 *(20 – 77)*	<0.001
Employed in police work, *y*						
Mean ± SD *(range)*	14.2 ± 8.2 *(0 – 40)*	11.6 ± 8.0 *(0 – 41)*	<0.001	14.8 ± 8.2 *(0 – 40)*	11.6 ± 7.9 *(0 – 41)*	<0.001
Sex, *n (%) (95% CI)*						
Women	250 (12.5) (11.0-13.9)	611 (20.7) (19.2-22.1)	<0.001	168 (10.1) (8.6-11.5)	669 (20.9) (19.5-22.3)	<0.001
Men	1,753 (87.5) (86.1-89.0)	2,326 (78.7) (77.3-80.2)		1,498 (89.9) (88.5-91.4)	2,528 (78.9) (77.5-80.3)	
Not known	0 (0)	17 (0.6)		0 (0) (n/a)	8 (0.3)	
Body mass index, *n (%) (95% CI)*[†]						
< 25 kg/m^2	209 (10.4) (9.1-11.8)	785 (26.6) (25.0-28.2)	<0.001	98 (5.9) (4.8-7.0)	880 (27.5) (25.9-29.0)	<0.001
≥ 25 and < 30 kg/m^2	603 (30.1) (28.1-32.1)	1,664 (56.3) (54.5-58.1)		419 (25.2) (23.1-27.2)	1,823 (56.9) (55.2-58.6)	
≥ 30 and < 35 kg/m^2	827 (41.3) (39.1-43.4)	392 (13.3) (12.0-14.5)		791 (47.5) (45.1-49.9)	410 (12.8) (11.6-13.9)	
≥ 35 kg/m^2	359 (17.9) (16.2-19.6)	85 (2.9) (2.3-3.5)		354 (21.2) (19.3-23.2)	80 (2.5) (2.0-3.0)	
Not known	5 (0.2) (0.0-0.5)	28 (0.9)		4 (0.2)	12 (0.4)	
< 30 kg/m^2	812 (40.5) (38.4-42.7)	2,449 (82.9) (81.5-84.3)	<0.001	517 (31.0) (28.8-33.3)	2,703 (84.3) (83.1-85.6)	<0.001
≥ 30 kg/m^2	1,186 (59.2) (57.1-61.4)	477 (16.1) (14.8-17.5)		1,145 (68.7) (66.5-71.0)	490 (15.3) (14.0-16.5)	

Not known	5 (0.2) (0.0-0.5)	28 (0.9)		4 (0.2)	12 (0.4)	
Body mass index, *kg/m²*						
Mean ± SD *(range)*	30.9 ± 4.9 *(15.8 – 56.5)*	27.1 ± 3.7 *(17.0 – 49.4)*	<0.001	31.9 ± 4.7 *(19.4 – 56.5)*	27.0 ± 3.6 *(15.8 – 49.4)*	<0.001

[a] Independent samples t-test or chi-squared test.

eTable 4. Variables included in models used to examine associations between comorbidities and adverse health outcomes and positive sleep disorder screening (or positive OSA screening)[a]

	Any sleep disorder (Complete-case)	**Any sleep disorder (Missing-indicator method)**	**OSA (Complete-case)**	**OSA (Missing-indicator method)**
Diabetes	Age, BMI, Smoking, Hypertension	Age, BMI, Smoking, Hypertension	Age, BMI, Smoking, Hypertension	Age, BMI, Smoking, Hypertension, Shift length
Cardiovascular disease	Age, Hypertension	Age, Hypertension	Age, Hypertension	Age, Hypertension
Gastrointestinal disorder	Age, Smoking, Hypertension	Age, Sex, Hypertension, Smoking, Shift length	Age, Hypertension, Night shift	Age, Sex, Hypertension, Night shift
Depression	Sex, Hypertension	Age, Sex, Hypertension	Age, Sex, Hypertension	Age, Sex, Hypertension
Anxiety disorder	Sex, alcohol, Hypertension	Sex, Smoking, alcohol, Hypertension	Sex, Smoking, alcohol, Hypertension, Second job	Sex, Smoking, alcohol, Hypertension
Pharmacotherapy for insomnia	Sex, BMI, Hypertension	Sex, BMI, Hypertension	Sex, BMI, Hypertension, Night shift	Sex, BMI, Hypertension, Night shift
Caffeine consumption	Smoking, Shift length	Smoking	Age, Smoking, Night shift Primary activity, Shift length	Age, BMI, Smoking, Primary activity, Night shift
Health status	Age, BMI, Smoking, Hypertension, Primary activity,	Age, Sex, BMI, Smoking, Hypertension, Shift length	Age, Sex, BMI, Smoking, Hypertension, Primary activity, Shift length	Age, Sex, BMI, Smoking, Hypertension, Shift length
Fall asleep while driving after work	Smoking, Night shift, Second job, Shift length	Age, BMI, Smoking, Second job,	Sex, Smoking, Night shift, Second job, Shift length	Sex, BMI, Smoking, Night shift Second job, Shift length
Burnout – emotional exhaustion	Sex, BMI, Shift rotation	Sex, BMI, Shift rotation	Sex, BMI, alcohol, Shift rotation	Sex, BMI, Primary activity, Shift rotation
Burnout – depersonalization	Age	Age	Age, alcohol, Second job, Primary activity, Shift length	Age, alcohol, Hypertension, Primary activity, Second job, Shift length

[a] See Table 3.

eTable 5. Variables included in models used to examine associations between performance and safety outcomes and attentional failures (dichotomized variables) and positive sleep disorder screening[a]

	Variables included in the multiple regression models in addition to sleep disorder (Complete-case)	**Variables included in the multiple regression models in addition to sleep disorder (Missing-indicator method)**
Administrative error – actual	Age, Primary activity, Nightshift, Mean work hours, Sleep	Age, Primary activity, Nightshift, Mean work hours
Fall asleep while driving	Age, Sex, Nightshift, Sleep	Age, Sex, Sleep
Error or safety violation – attributed to fatigue	Primary activity, Nightshift, Mean work hours, Sleep	Primary Activity, Nightshift, Mean work hours, Sleep
Occupational Injury	Primary Activity, Nightshift	Primary Activity, Nightshift
Uncontrolled anger towards suspect/citizen	Age, Primary Activity, Nightshift, Mean work hours, Sleep	Age, Primary Activity, Nightshift, Mean work hours, Sleep
Citizen complaints	Age, Second job, Primary Activity, Mean work hours	Age, Second job, Primary Activity, Mean work hours
Commendations	Age, Mean work hours, Sleep	Age, Mean work hours, Sleep
Administrative error – near-miss	BMI, Nightshift Mean work hours, Sleep	BMI, Nightshift, Mean work hours, Sleep
Absenteeism (all cause sickness absence)	Sex, BMI, Primary Activity, Mean work hours	Sex, BMI, Primary Activity, Mean work hours
Error or safety violation – not attributed to fatigue	BMI, Primary Activity, Mean work hours	Primary Activity, Mean work hours
Fall asleep during meetings at the police department	Mean work hours, Sleep	Mean work hours, Sleep
Fall asleep on the telephone	Mean work hours, Sleep	Mean work hours, Sleep
Fall asleep while stopped in traffic	BMI, Nightshift, Sleep	Age, Second job, Sleep

[a] See Table 4.

eTable 6. Self-reported performance and safety outcomes and attentional failures (continuous variables) associated with positive sleep disorder screening (n=3,545)

(n=15,735 total person months)	**OR (95% CI) Unadjusted**	**OR (95% CI) Adjusted[a]**	**OR (95% CI) Adjusted[a]** (Missing-indicator method)
Primary outcomes			
Serious administrative error – actual	1.32 (1.09-1.60) P=0.005	2.02 (1.40-2.91) P<0.001	1.43 (1.15-1.79) P=0.001
Fall asleep while driving	1.75 (1.34-2.28) P<0.001	1.54 (1.18-2.00) P=0.001	1.67 (1.28-2.17) P<0.001
Error or safety violation – attributed to fatigue	1.16 (1.07-1.25) P<0.001	1.10 (1.00-1.21) P=0.05	1.19 (1.09-1.29) P<0.001
Occupational Injury	1.28 (1.05-1.57) P=0.02	1.25 (0.99-1.57) P=0.06	1.27 (1.04-1.54) P=0.02[b]
Secondary outcomes			
Uncontrolled anger towards suspect/citizen	1.14 (0.98-1.32) P=0.09	1.20(1.02-1.42) P=0.03	1.21(1.05-1.40) P=0.008
Citizen complaints	1.21 (1.00-1.46) P<0.05	1.29 (1.07-1.56) P=0.007	1.29 (1.07-1.56) P=0.007
Commendations	1.02 (0.90-1.16) P=0.72	1.02(0.88-1.18) P=0.81	1.01(0.89-1.14) P=0.94
Serious administrative error – near-miss	1.61(1.33-1.96) P<0.001	1.56 (1.23-1.97) P<0.001	1.70 (1.39-2.10) P<0.001
Absenteeism (all cause sickness absence)	1.46 (1.26-1.70) P<0.001	1.35 (1.14-1.59) P<0.001	1.57 (1.33-1.85) P<0.001
Error or safety violation – not attributed to fatigue	1.16 (0.98-1.37) P=0.08	1.15 (0.98-1.35) P=0.09	1.16 (0.98-1.37) P=0.08
Fall asleep during meetings at the police department	2.18 (1.53-3.10) P<0.001	2.12(1.38-3.28) P<0.001	2.15(1.53-3.02) P<0.001
Fall asleep on the telephone	1.84 (1.09-3.11) P=0.02	1.61 (0.92-2.84) P=0.01	1.65 (0.98-2.78) P=0.06
Fall asleep while stopped in traffic	1.74 (1.32-2.29) P<0.001	1.67 (1.25-2.24) P<0.001	1.61 (1.23-2.11) P<0.001*

Positive screening result for sleep disorders was defined as meeting criteria for any of the sleep disorders assessed. For shift work disorder, positive result required both wake time drowsiness and insomnia (mild, moderate or severe), with wake time drowsiness defined as moderate to high chance of falling asleep while driving after working nights compared to never or slight chance during days off, and moderate to high chance of falling asleep during night shift compared to never or slight chance during day shift. No positive sleep disorder screening was defined as not meeting criteria for any of the sleep disorders assessed.

[a] Odd ratios were adjusted for sex, age, BMI, primary police activity, shift rotation, second job, number of night shifts worked, mean total work hours per week, and monthly sleep.

[b] Not significant when significance level is adjusted for multiple comparisons (P=0.0125).

eTable 7. Variables included in models used to examine associations between performance and safety outcomes and attentional failures (continuous variables) and positive sleep disorder screening[a]

	Variables included in the multiple regression models in addition to sleep disorder (Complete-case)	**Variables included in the multiple regression models in addition to sleep disorder (Missing-indicator method)**
Administrative error – actual	BMI, Nightshift, Mean work hours	BMI, Nightshift, Mean work hours
Fall asleep while driving	Sex, Nightshift, Sleep	Age, Sex, monthly sleep
Error or safety violation – attributed to fatigue	Nightshift	BMI, Nightshift, Sleep
Occupational Injury	Primary Activity, Nightshift	Primary Activity, Nightshift
Uncontrolled anger towards suspect/citizen	Age, Primary Activity, Mean work hours, Sleep	Age, Primary Activity, Mean work hours, Sleep
Citizen complaints	Age, Second job, Primary Activity	Age, Primary Activity
Commendations	Age, Mean work hours, Sleep	Age, Nightshift, Mean work hours, Sleep
Administrative error – near-miss	BMI, Nightshift Mean work hours, Sleep	BMI, Nightshift Mean work hours, Sleep
Absenteeism (all cause sickness absence)	Sex, Shift rotation, Primary Activity, Mean work hours	Sex, Shift rotation, Second job, Primary Activity, Nightshift, Mean work hours
Error or safety violation – not attributed to fatigue	Second job, Sleep	Second job, Sleep
Fall asleep during meetings at the police department	Mean work hours, Sleep	Mean work hours, Sleep
Fall asleep on the telephone	Primary Activity, Mean work hours, Sleep	Primary Activity, Mean work hours, Sleep
Fall asleep while stopped in traffic	BMI, Nightshift, Sleep	Sleep

[a] See eTable 6.

eTable 8. Self-reported performance and safety outcomes and attentional failures (dichotomous variables) associated with risk of sleep disorders in police officers who completed one year of monthly surveys (n=459)

(n=5,508 person-months)	**Positive Outcome in person months with positive screen for sleep disorder n (%)[a]**	**Positive Outcome in person months with negative screen for sleep disorder n (%)[a]**	**OR (95% CI) Unadjusted**		**OR (95% CI) Adjusted[b]** Missing-indicator method	
Serious administrative error – actual	259 (11.2)	239 (7.5)	1.59 (1.14-2.23)	P=0.007	1.62 (1.16-2.26)	P=0.005
Fall asleep while driving	210 (9.1)	218 (6.8)	1.23 (0.80-1.89)	P=0.35	1.26 (0.82-1.94)	P=0.29
Error or safety violation – attributed to fatigue	406 (17.6)	410 (12.8)	1.47 (1.13-1.91)	P=0.004	1.75 (1.32-2.32)	P<0.001
Occupational injury	90 (3.9)	116 (3.6)	1.23 (1.01-1.51)	P=0.04	1.18 (0.92-1.70)	P=0.38

Positive screening result for sleep disorders was defined as meeting criteria for any of the sleep disorders assessed. For shift work disorder, positive result required both wake time drowsiness and insomnia (mild, moderate or severe), with wake time drowsiness defined as moderate to high chance of falling asleep while driving after working nights compared to never or slight chance during days off, and moderate to high chance of falling asleep during night shift compared to never or slight chance during day shift.[16] No positive sleep disorder screening was defined as not meeting criteria for any of the sleep disorders assessed. Sex, Age, BMI, Primary activity, Shift rotation, Second job, Amount of shift work, Average monthly work hours, Monthly hours of sleep.

[a] Missing data and negative outcomes for these variables are not shown.

[b] Odd ratios were adjusted for sex, age, BMI, primary police activity, shift rotation, second job, number of night shifts worked, mean total work hours per week, and monthly sleep. Only those variables that were significant ($P < 0.05$) were included in the final model (see Methods)

eTable 9. Comparison between questionnaire (Berlin) questionnaire outcome or body mass index and classification of OSA severity from polysomnography

	Polysomnographic classification of OSA severity n (%)				**Mild to moderate, Moderate to severe, or Severe**			**Moderate to severe or Severe**		
	Normal to mild	**Mild to moderate**	**Moderate to severe**	**Severe**	**n**	**PPV**	**NPV**	**n**	**PPV**	**NPV**
Questionnaire outcome[a]	**n=42**	**n=38**	**n=11**	**n=23**						
Negative (n=60)	32 (53.3)	17 (28.3)	4 (6.7)	7 (11.7)	28	81.5	53.3	11	42.6	81.7
Positive (n=54)	10 (18.5)	21 (38.9)	7 (13.0)	16 (29.6)	44			23		
BMI[†]	**n=43**	**n=39**	**n=10**	**n=23**						
< 25 kg/m^2 (n=15)	10 (66.7)	3 (20.0)	1 (6.7)	1 (6.7)	5	67.0	66.7	2	31.0	86.7
≥ 25 kg/m^2 (n=100)	33 (33.0)	36 (36.0)	9 (9.0)	22 (22.0)	67			31		
< 30 kg/m^2 (n=71)	34 (47.9)	20 (28.2)	9 (12.7)	8 (11.3)	37	79.5	47.9	17	36.4	76.1
≥ 30 kg/m^2 (n=44)	9 (20.5)	19 (43.2)	1 (2.3)	15 (34.1)	35			16		
< 35 kg/m^2 (n=103)	42 (40.8)	37 (35.9)	9 (8.7)	15 (14.6)	61	91.7	40.8	24	75.0	76.7
≥ 35 kg/m^2 (n=12)	1 (8.3)	2 (16.7)	1 (8.3)	8 (66.7)	11			9		

BMI body mass index; PPV positive predictive value; NPV negative predictive value

Definitions of polysomnographic classifications:

Normal to Mild: RDI < 10/hour and AHI < 5/hour of sleep and minimum saturation above 85% (unless saturation was stable and low, as may occur with lung disease and obesity);

Mild to Moderate: RDI ≥10 and <25/hour of sleep, or >5 with associated desaturation to <85%;

Moderate to Severe: RDI ≥ 25 and < 35/hour of sleep;

Severe: RDI ≥ 35/hour of sleep.

[a] Questionnaire screening result (Berlin) was unknown for two participants and BMI was unknown for one participant due to insufficient information provided by them in the survey.

eTable 10. Participants reporting symptoms consistent with shift work disorder as a percentage of those providing sufficient information to determine risk in all three definitions applied

	n	Percentage of respondents reporting at least one night shift and with complete responses for all definitions of shift work disorder
1. Excessive waketime sleepiness and insomnia	268	16.1%
Excessive waketime sleepiness	561	33.7%
Insomnia	679	40.8%
2. Excessive waketime sleepiness or insomnia	972	58.4%
3. Waketime drowsiness[a] and insomnia	47	2.8%

[a] Participants were required to meet the following criteria for waketime drowsiness: moderate to high chance of falling asleep while driving after working nights compared to never or slight chance during days off, and moderate to high chance of falling asleep during night shift compared to never or slight chance during day shift.[16]

The frequency of shift work disorder was found to be consistent with the figures reported in Table 2 when the same criteria are applied only in those individuals who had sufficient data for all definitions of shift work disorder that we considered.

Percentages represent the number of individuals reporting the symptom(s) divided by the number of individuals who reported working at least one night shift during the one month prior to completing the survey, and who provided sufficient information to determine risk according to all three definitions of SWD (n=1,664). Night shift was defined as work hours that included at least 6 hours between 10 PM and 8 AM.