

# The Prevalence of Short Sleep Duration by Industry and Occupation in the National Health Interview Survey

Sara E. Luckhaupt, MD, MPH; SangWoo Tak, ScD, MPH; Geoffrey M. Calvert, MD, MPH

Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, OH

**Study Objectives:** To explore whether employment in industries likely to have non-standard work schedules (e.g., manufacturing and service) and occupations with long work-weeks (e.g., managerial/ professional, sales, and transportation) is associated with an increased risk of short sleep duration.

**Design:** Cross-sectional epidemiologic survey.

**Setting:** Household-based face-to-face survey of civilian, non-institutionalized US residents.

**Participants:** Sample adults interviewed for the National Health Interview Survey in 1985 or 1990 (N = 74,734) or between 2004 and 2007 (N = 110,422). Most analyses focused on civilian employed workers interviewed between 2004 and 2007 (N = 66,099).

**Interventions:** N/A

**Measurements and Results:** The weighted prevalence of self-reported short sleep duration, defined as  $\leq 6$  h per day, among civilian employed workers from 2004-2007 was 29.9%. Among industry categories, the prevalence of short sleep duration was greatest for management of companies and enterprises (40.5%), followed by transportation/warehousing (37.1%) and manufacturing (34.8%). Occupational categories with the highest prevalence included production occupations in the transportation/warehousing industry, and installation, maintenance, and repair occupations in both the transportation/warehousing industry and the manufacturing industry. In the combined sample from 1985 and 1990, 24.2% of workers reported short sleep duration; the prevalence of short sleep duration was significantly lower during this earlier time period compared to 2004-2007 for 7 of 8 industrial sectors.

**Conclusions:** Self-reported short sleep duration among US workers varies by industry and occupation, and has increased over the past two decades. These findings suggest the need for further exploration of the relationship between work and sleep, and development of targeted interventions for specific industry/occupation groups.

**Keywords:** Sleep duration, occupational groups, work

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THE NATIONAL SLEEP FOUNDATION (NSF) RECOMMENDS THAT HEALTHY ADULTS SLEEP 7-9 H/DAY; BUT EPIDEMIOLOGICAL STUDIES SUGGEST THAT mean sleep duration among American adults has decreased substantially over time, with an increased percentage of adults who report an average sleep duration of  $\leq 6$  h/day.<sup>1,2</sup> Recent surveys indicate that American workers average 6.7 to 7.6 h of sleep per workday.<sup>3,4</sup>

Both short and long habitual sleep time have been found to be associated with increased risks of mortality,<sup>5,6</sup> hypertension,<sup>7,8</sup> coronary heart disease,<sup>9</sup> and diabetes.<sup>10</sup> In addition, short sleep duration has been found to be associated with self-rated poor health<sup>11</sup> and elevated body mass index (BMI).<sup>12</sup> Among workers, insufficient sleep can affect job performance and workplace safety, which are important occupational health considerations.<sup>13-15</sup>

In addition to understanding the effects of sleep duration, it is important to study determinants that predict or influence an individual's sleep duration.<sup>16</sup> This issue is important because: 1) understanding the primary determinants of sleep duration will

allow for the design of studies that can appropriately control for confounders and effect modifiers; and 2) knowledge of the determinants of sleep duration will allow for identification of subgroups at highest risk for sleep related morbidity, so that these subgroups can be targeted with appropriate interventions.

Non-occupational factors that have been associated with short sleep duration include demographic factors: being male,<sup>17-20</sup> being non-Hispanic black,<sup>18,21</sup> being divorced or widowed,<sup>18,19</sup> low levels of education,<sup>7,18,19</sup> and urban residence.<sup>18</sup> Some studies have found a U-shaped relationship between age and short sleep duration, with lower prevalence of short sleep duration among young adults and older adults, compared to middle-aged adults<sup>2,17</sup>; while other studies have suggested a more linear increase in prevalence of short sleep duration with age.<sup>7</sup> High self-reported stress,<sup>18</sup> smoking,<sup>18,20,22,23</sup> activity limitations and leisure-time physical inactivity,<sup>18,23</sup> and alcohol consumption<sup>18,22,23</sup> have also been associated with short sleep duration. Employed persons tend to have a higher prevalence of short sleep duration than unemployed persons<sup>18</sup>; and, with regard to work schedules, early morning start times,<sup>24</sup> rotating shifts,<sup>25</sup> night shifts,<sup>26</sup> and long work hours<sup>17</sup> are associated with short sleep duration.

## Relationships between Work and Sleep

Decreases in mean sleep duration have been attributed, in part, to the expanded possibilities of nighttime activities that accompanied the introduction of electric light and other technologies, and to the more recent trend toward expansion of both manufac-

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Address correspondence to: Sara E. Luckhaupt, MD, MPH, 4676 Columbia Parkway, MS R-17, Cincinnati, OH 45226; Tel: (513) 841-4123; Fax: (513) 841-4489; E-mail: SLuckhaupt@cdc.gov

turing and service sectors to 24-h/day operations.<sup>1</sup> In addition, cell phones, beepers, and other communication devices have had the effect of putting some workers in a perpetual “on-call” status, increasing the likelihood that sleep will be interrupted for rapid decision-making or other duty-related tasks. The increasing role of computing and the internet in work may also influence sleep patterns, as people literally bring their laptops, and thus work, to bed with them. Observational studies have suggested that work may impact both quantity and quality of sleep as a result of long working hours,<sup>3,17</sup> shift work,<sup>3,24-26</sup> and job stress.<sup>27-30</sup> Although the effects of work may remain important after adjusting for many potential confounders.<sup>25,30</sup>

Worldwide, annual working hours for most workers have gradually declined from the latter part of the 19th century until recently, when they began increasing again. The US now has the longest annual working hours of any of the wealthy industrialized countries,<sup>31</sup> although data from the US Bureau of Labor Statistics indicate that the average length of the American work week has changed little, and possibly even declined since the 1960s-1970s.<sup>32,33</sup> The prevalence of workers who work > 48 h per week has increased, and there is evidence that long working hours vary by occupation, with a high prevalence among managerial and professional, sales, and transportation workers.<sup>32,34</sup>

In addition to the quantity of hours worked affecting the opportunity for sleep, the timing of hours available for sleep affects sleep duration through circadian disruption. Attempts to sleep during daylight hours, when melatonin is falling and body temperature is rising, usually result in shorter sleep episodes and more awakening.<sup>35-37</sup> Thus, working non-traditional shifts, especially night shifts, can negatively affect sleep duration independently of long working hours.

In order to identify groups of workers at increased risk of short sleep duration for targeted interventions and future studies, we used data from the National Health Interview Survey (NHIS) to examine the prevalence of short sleep duration among US workers by industry and occupation. We hypothesized that workers in the manufacturing and service sectors would be at increased risk of short sleep duration due to 24-h/day operations leading to non-standard work schedules; and that, within these industry sectors, managerial and professional, sales, and transportation workers would be at increased risk of short sleep duration due to long work weeks. We also hypothesized that the prevalence of short sleep duration among US workers has increased significantly over time. We defined short sleep duration as a self-reported average  $\leq 6$  h of sleep per 24-h period, based on the NSF recommendation that adults should sleep 7-9 h/day ([http://www.sleepfoundation.org/site/c.huIXKjM0IXf/b.2419131/k.6C23/How\\_Much\\_Sleep\\_is\\_Enough.htm](http://www.sleepfoundation.org/site/c.huIXKjM0IXf/b.2419131/k.6C23/How_Much_Sleep_is_Enough.htm)), and well controlled experimental studies that have shown both neurobehavioral performance and memory impairment with chronic sleep reductions to  $\leq 6$  h.<sup>38,39</sup>

## METHODS

### Study Sample

Publicly available data collected through the National Health Interview Survey (NHIS) were utilized in the present analyses. The NHIS has been conducted annually by the National Cen-

ter for Health Statistics in collaboration with the US Census Bureau since 1957 to monitor the health of the nation, as described elsewhere.<sup>40,41</sup> The target population is the US civilian, non-institutionalized population, and interviews are conducted face-to-face in the participants' homes. A representative sample of households is selected using a multistage cluster sample design. Trained interviewers from the US Census Bureau annually visit 35,000 to 40,000 households across the country and collect data on about 75,000 to 100,000 individuals. A sample adult and sample child are chosen from each family to answer detailed questions. The data used to analyze sleep duration and the relevant SAS program statements are publicly available (<http://www.cdc.gov/nchs/nhis.htm>).

Variables of interest for this study included demographic variables – sex, age, race, ethnicity, marital status, and educational attainment, which have previously been associated with sleep duration. Data on urban vs. rural residence are collected for the NHIS but are not publicly available for recent years. Work-related variables of interest included employment status, industry, occupation, number of current jobs, and total hours worked in the last week. (The latter 2 variables were only available for 2004-2007.) Data on health behaviors (smoking, alcohol consumption, physical inactivity, and obesity) and self-rated health status were also included in some analyses.

Since work hour data were not available in the 1985 or 1990 NHIS, we utilized work hour data from the 1990 Current Population Survey (CPS) to provide a comparison to the 2004-2007 NHIS work hour data. The CPS data was obtained from the website of the National Bureau of Economic Research ([http://www.nber.org/data/cps\\_basic.html](http://www.nber.org/data/cps_basic.html)).

### Study Definitions

The NHIS sample adult questionnaire included a question about the average hours of sleep per day in 1985, 1990, and 2004-2007: “On average, how many hours of sleep do you get in a 24-hour period?” Answers were recorded as whole numbers of hours, so we used the categorical variable “short sleep duration” for all analyses. We defined short sleep duration as  $\leq 6$  h of sleep in a 24-h period, on average.

Employment status in the week prior to the interview was ascertained for all adults. We classified employment status into 5 categories: employed (“working for pay at a job or business” or “with a job or business but not at work”), unemployed (“looking for work”), unpaid worker (“working, but not for pay, at a family-owned job or business”), non-worker (“not working at a job or business and not looking for work”), and unknown.

Verbatim responses were obtained from each employed sample adult ( $\geq 18$  years old) respondent regarding his/her industry (employer's type of business) and occupation (employee's type of work). These responses were reviewed by US Census Bureau coding specialists who assigned 4-digit industry and occupation codes. For data prior to 2004, industry and occupation codes were based on the prevailing versions of the Standard Industrial Classification (SIC) and the Standard Occupational Classification (SOC) systems. For industry and occupation data collected since 2004, the 1997 North American Industrial Classification System (NAICS) and 2000 SOC system were used. Due to concerns that the level of detail contained in the Census codes could compromise respondent confidentiality, detailed industry

and occupation codes are restricted to in-house NHIS data files, and only 2-digit industry and occupation recodes are included in public use data files. Since 2004, the occupation recodes include 94 detailed categories and 23 simple categories, and the industry recodes include 79 detailed categories and 21 simple categories.

### Data Analyses

First, we pooled data from NHIS sample adults interviewed from 2004 through 2007 to analyze the prevalence of short sleep duration by employment status. We excluded respondents coded to the military specific occupation category or the Armed Forces industry category ( $N = 42$ ) from further analyses because the NHIS sample is not designed to provide accurate estimates of persons in the Armed Forces. Next we analyzed the prevalence of short sleep duration among currently employed civilian workers by simple industry categories. Within industry categories with a high prevalence of short sleep duration, we performed additional analyses to identify occupational groups with the highest prevalence of short sleep duration. We also examined the prevalence of short sleep duration by demographic variables, health behaviors, health status, and job characteristics, which are all hypothesized to be potential confounders in the relationship between work and short sleep duration.

Four different models were developed to calculate prevalence ratios (PRs) for industry groups using an industry group with a median prevalence of short sleep duration as a reference group. In the first model, we only adjusted for demographic factors (age, sex, race, ethnicity, marital status, and education), in order to avoid potential “overadjustment” by factors likely to be consequences of short sleep, which could result in underestimation of the relationship between job and sleep duration.<sup>42,43</sup> In the second model, we adjusted for both demographic factors and health behaviors (smoking, alcohol consumption, physical inactivity, and obesity) which have previously been shown to be associated with short sleep duration and vary by industry. In the third model, we added a measure of overall health status that has been shown to be associated with short sleep duration and vary by industry. Finally, in the fourth model, we added job characteristics (long work hours and multiple jobs) hypothesized to affect sleep duration. We used the fourth model for the additional analyses of occupational groups within the high-prevalence industry categories. Results for industry and occupation groups with sample sizes  $< 30$  were not reported because of confidentiality concerns and instability of estimates generated from samples this small.

In order to compare the prevalence of short sleep duration by industry over time, we compared NHIS data from 2004-2007 to NHIS data from 1985 and 1990. Although the differences in the NCHS industry and occupation recode systems used before 2004 and those used since 2004 precluded us from making comparisons with earlier time periods at the level of the 21 simple industry recode categories, we were able to sort the industry codes from each time period into 8 broad industry sectors corresponding to the NIOSH National Occupational Research Agenda (NORA) industrial sectors (See <http://www.cdc.gov/niosh/NORA/>).

We tested the hypothesis that the prevalence of short sleep duration among US workers has increased significantly over

time by comparing NHIS data from 1985 and 1990 to data from 2004-2007 within NORA industry categories using the Wald  $\chi^2$  test. Sleep hour data was available for 1985, 1990, and 2004 to 2007, but was not available between these dates. Weighted mean weekly work hours by industry sector were calculated from 1990 CPS data and 2004-2007 NHIS data.

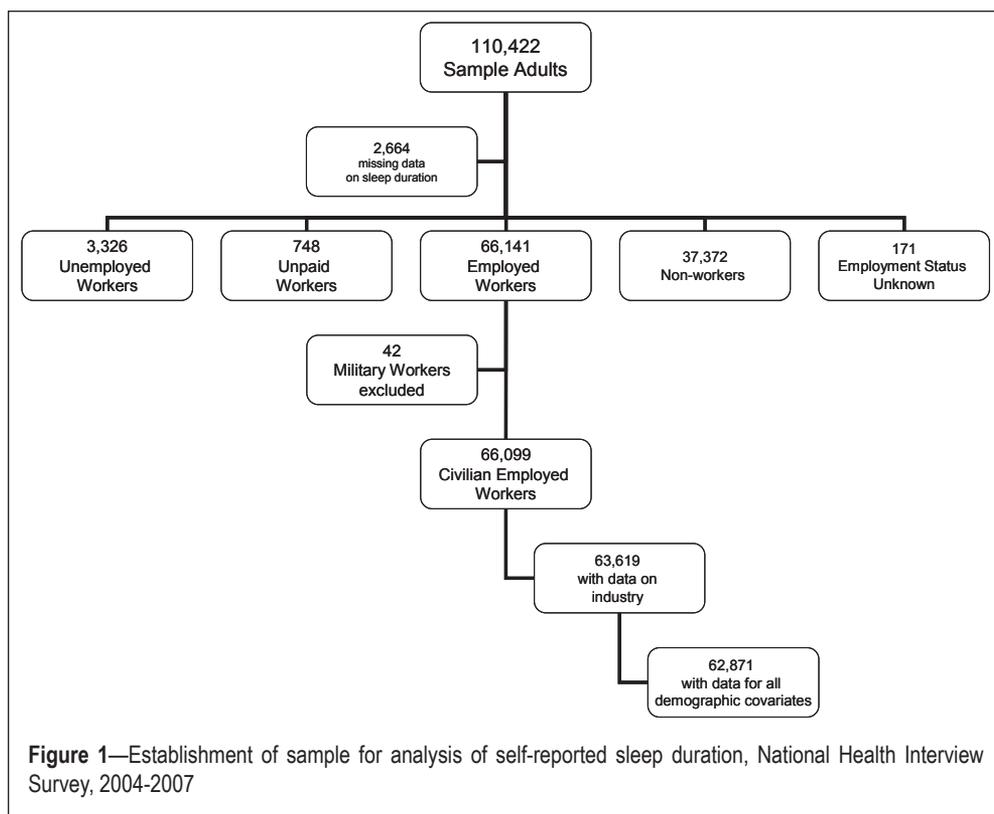
All analyses were completed using the Software for the Statistical Analysis of Correlated Data (SUDAAN v9.0) package to take into account sample weights and design effects due to the complex sample survey design.<sup>44</sup> This allowed us to estimate the total number of employed US civilian workers represented by each individual in the sample. Variance estimates were adjusted for the population survey units, strata, and sampling weights assigned by NCHS.

### RESULTS

Data were available for 110,422 sample adults in the 2004-2007 NHIS, who represent approximately 219 million non-institutionalized US adults per year. We excluded 2,664 respondents with missing data for sleep duration from all analyses (Figure 1). The distribution of hours of self-reported sleep duration by employment status is shown in Figure 2. For each group except employed workers, the highest proportion of respondents reported sleeping an average of 8 h/day. The highest proportion of employed workers reported sleeping an average of 7 h/day. The overall weighted prevalence of short sleep duration ( $\leq 6$  h/day) was 28.3%, and ranged from 16.1% among respondents with unknown employment status to 29.9% among employed workers.

The remainder of the analyses focused on employed civilian workers ( $N = 66,099$ ; representing  $\sim 137$  million workers per year). The overall weighted prevalence of short sleep duration within this group was lower in 2007 than in 2004, 2005, or 2006 (Table 1). The lowest prevalence of short sleep duration occurred among the oldest age group ( $> 65$  years), followed by the youngest age group (18-25 years); and the highest prevalence occurred between the ages of 46 and 55. Females had a lower prevalence of short sleep duration than males; Whites had a lower prevalence of short sleep duration than Blacks or persons of other races; Hispanics had a lower prevalence than non-Hispanics; and married persons had a lower prevalence than non-married persons. Smoking, heavy alcohol use, and obesity were associated with an increased prevalence of short sleep duration. Workers who reported no leisure time physical activity had a decreased prevalence of short sleep duration compared to workers who were physically active during their leisure time. Workers who reported fair or poor health status had a much higher prevalence of short sleep duration than workers with excellent, very good, or good health status. Workers with more than one job and workers who worked  $> 40$  h in the last week had an increased prevalence of short sleep duration compared to other workers.

The analysis of short sleep duration by industry excluded respondents with missing data for age, sex, race/ethnicity, education, marital status, industry and/or occupation, for a final sample of 62,871 workers (Figure 1, Table 2). Among industry categories, the weighted prevalence of short sleep duration was greatest for management of companies and enterprises (40.5%), followed by transportation and warehousing (37.1%),



manufacturing (34.8%), and public administration (33.5%). These prevalences represent approximately 38,000 workers in the management of companies and enterprises industry group, 2 million workers in the transportation and warehousing industry group, 5 million workers in the manufacturing industry group, and 2 million workers in the public administration industry group experiencing short sleep duration each year. The lowest prevalence of short sleep duration (23.1%) occurred among the agriculture, forestry, fishing, and hunting industries (Table 2).

The retail trade industry ranked 10th out of the 20 industry groups in prevalence of short sleep duration (30.1%), and was used as a reference group for calculation of prevalence ratios. Compared to workers in the retail trade industry, workers in the transportation and warehousing (Model 1 PR = 1.15; 95% CI 1.07-1.24) and manufacturing (Model 1 PR = 1.11; 95% CI 1.04-1.18) industries were significantly more likely to report short sleep duration. The significant findings for the prevalence of short sleep duration by industry were the same across the 4 models, with the exception that the PR for public administration became significant in the fourth model (i.e., the PRs for the transportation and manufacturing industries remained elevated across all 4 models). The magnitude of the elevated PRs was slightly attenuated with the addition of health behaviors, health status, and job characteristics to the models (Table 2).

Within the transportation/warehousing, manufacturing, and public administration industry groups, the prevalence of short sleep duration was calculated by occupational group, and the 5 occupational groups with the highest prevalence within each of these industry groups are shown in Table 3. Of the industry-occupation pairs examined, the weighted prevalence of short sleep duration was highest for production occupations in the transportation and warehousing industry (44.9%; representing 37,000 workers with short sleep duration annually), followed

by installation, maintenance, and repair occupations in the transportation and warehousing industry (43.4%; representing 124,000 workers with short sleep duration annually) and transportation and material moving occupations in the public administration industry (43.0%; representing 43,000 workers with short sleep duration annually). Among the industry-occupation pairs examined, the largest numbers of workers with short sleep duration annually were found in production workers within the manufacturing industry (2.6 million) and transportation and material moving occupations within the transportation and warehousing industry group (~960,000).

In the combined sample from 1985 and 1990, 24.2% (SD = 0.3%) of workers reported short sleep duration, significantly less than the overall prevalence of short sleep duration among workers in 2004-

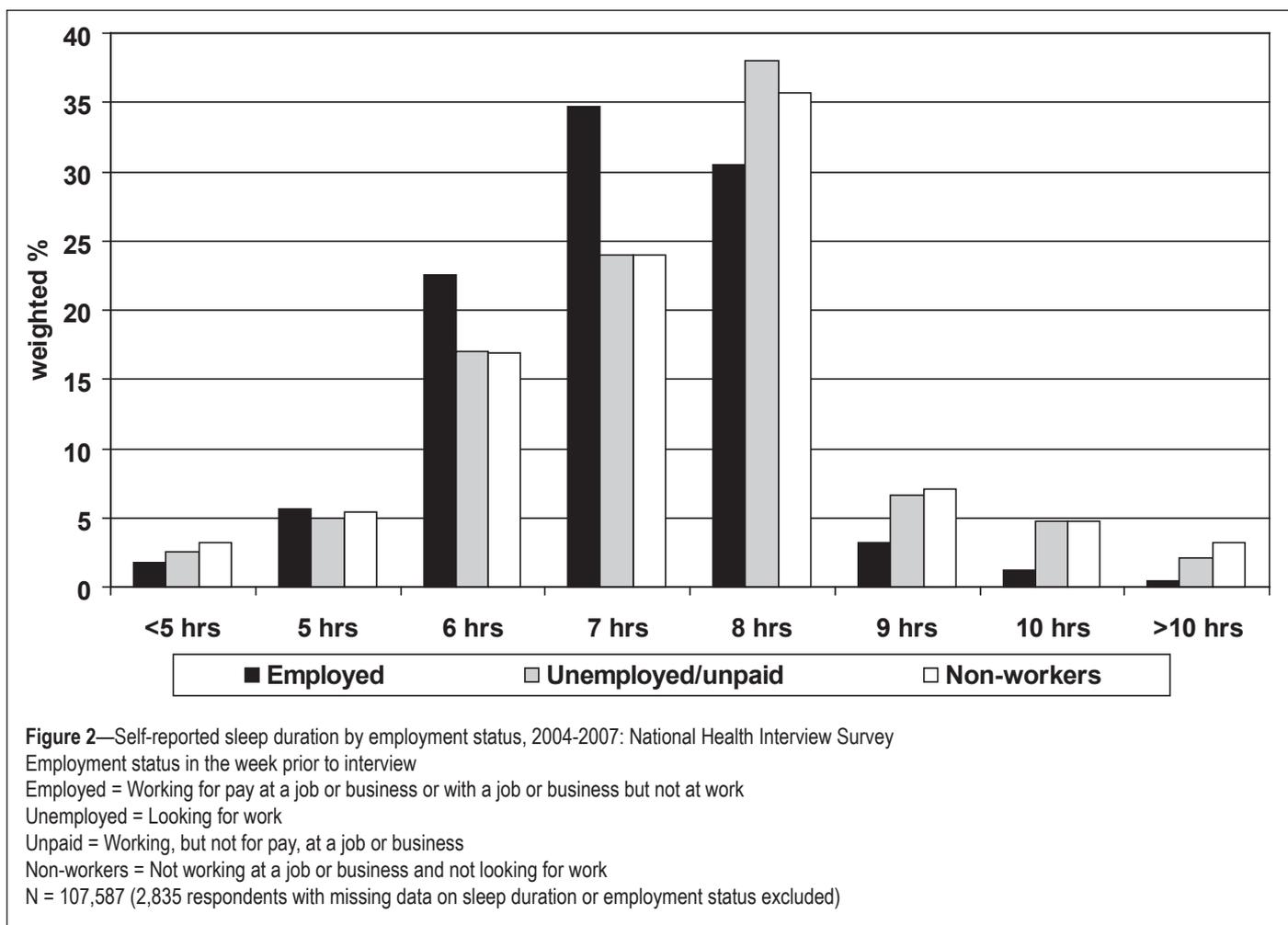
2007 of 30.1% (SD = 0.3%;  $P < 0.0001$ ). Differences between the 2 time periods were significant for each of the 8 NORA sectors except mining (Table 4). In 1985/1990, health care was the industry with the highest prevalence of short sleep duration (28.1%). However, in 2004-2007 it ranked third (31.7%) and was exceeded by transportation, warehousing and utilities (36.0%), and manufacturing (34.7%).

The average work hours for each sector, based on 2004-2007 NHIS data are also shown in Table 4. Work hour data were not collected in the NHIS in 1985 or 1990, but work hour data from the 1990 CPS are shown for comparison. Work hours do not appear substantially different between the 2 time periods overall or within most sectors, but caution is advised when comparing these data from 2 different surveys. Although data on shifts worked are not available from the NHIS, previously published data on the prevalence of shift work by industry from supplements to the CPS in 1985<sup>45</sup> and 2004<sup>46</sup> are shown in Table 4 as a reference.

## DISCUSSION

To the best of our knowledge, this is the first paper to estimate the prevalence of short sleep duration (defined as  $\leq 6$  h of self-reported sleep per day) by occupational category in the US and by industry category in any country. We found that self-reported short sleep duration among US workers currently affects approximately 30% of the working population, approximately 40 million workers annually. Furthermore, we found evidence that the prevalence of short sleep duration among workers has increased over the past two decades, even though the average number of hours worked per week may have decreased slightly.

We found modestly increased prevalence ratios for short sleep duration among workers in certain industry and occupa-



tional groups compared to workers in an industry group with an average (median) prevalence of short sleep duration. Although the PRs were all less than 1.5, they represent substantial numbers of workers with short average sleep duration, who may be at risk for both morbidity and mortality related to short sleep duration and for workplace injuries and impaired work performance. In addition, we found several industry groups (e.g., agriculture, forestry, and fishing; education services; mining) with prevalences of short sleep duration well below the median, suggesting that much better sleep patterns are possible. Differences by industry remained after adjustment for health behaviors, health status, work hours, and multiple jobs.

Among workers currently employed in the civilian sectors, we found the highest prevalence of short sleep duration within the industry group “Management of companies and enterprises,” but the prevalence ratio for this group compared to the median prevalence group (retail industry) was not significantly elevated which may be due to the small sample size (N = 41). This category represents a sector newly added to the 1997 version of NAICS (sector 55), and comprises: 1) business establishments that hold the securities of companies for the purpose of owning a controlling interest or influencing management decisions; and 2) establishments that administer, oversee, and manage their overall company or enterprise (e.g., corporate offices, head offices, and centralized administrative offices which achieve economies of scale by consolidating these services from across other establishments of the company). It has been

suggested that this sector is underrepresented because survey respondents tend not to provide the kind of information needed to distinguish workers in the management establishment of a larger corporation or enterprise from those that work in the production or service-providing establishments of the same company.<sup>47</sup> Our study suggests a need for further study of the health habits and needs of this group of workers.

The industry groups with prevalences of short sleep duration significantly above the median (transportation and warehousing, manufacturing, and public administration) appear to be industries likely to operate on a 24-h/day schedule based on working shifts. A 2004 supplement to the Bureau of Labor Statistics’ Current Population Survey found that wage and salary workers in food services, transportation and warehousing, and nondurable goods manufacturing were among the groups most likely to usually work an alternate (other than regular daytime) shift.<sup>46</sup>

The effects of such work shifts on sleep duration may be exacerbated by excessive work hours in some groups. According to the 2004-2007 NHIS data (Table 4), workers in the manufacturing and transportation industries averaged some of the highest weekly work hours, after mining and agriculture and related industries.

Adverse impacts of long work hours and insufficient sleep and other sleep problems on workplace safety and job performance have been described for truck drivers, medical interns, and Japanese workers in small and medium-scale (mostly man-

**Table 1**—Estimated population prevalence (%) of short sleep duration\* among employed civilian US workers, 2004-2007

Variable	Unweighted sample Size	Estimated annual population (in millions)	Estimated annual cases (in millions)	Weighted prevalence (%; SE <sup>†</sup> )	PR	95% CI
<b>Total</b>	66,099	136.8	40.9	29.9 (0.3)		
2004	18,667	133.1	40.9	30.7 (0.4)	1.08	1.03-1.13
2005	18,875	136.6	41.2	30.2 (0.4)	1.06	1.01-1.12
2006	14,601	138.1	42.1	30.5 (0.5)	1.08	1.03-1.13
2007	13,956	139.3	39.5	28.4 (0.5)	Ref.	
<b>By Demographic Characteristics</b>						
<b>Sex</b>						
Male	32,956	73.9	22.6	30.7 (0.3)	1.06	1.03-1.09
Female	33,143	62.9	18.3	29.0 (0.3)	Ref.	
<b>Age category</b>						
18-25 y	8,751	21.0	5.4	25.9 (0.6)	1.04	0.95-1.15
26-35 y	15,455	30.7	9.1	29.8 (0.5)	1.20	1.10-1.31
36-45 y	16,679	33.8	10.7	31.7 (0.5)	1.28	1.17-1.40
46-55 y	14,989	31.7	10.1	31.9 (0.5)	1.28	1.17-1.40
56-65 y	7,965	15.7	4.5	28.9 (0.6)	1.16	1.06-1.28
> 65 y	2,260	3.9	1.0	24.8 (1.0)	Ref.	
<b>Race</b>						
White	52,058	118.2	36.0	28.8 (0.3)	Ref.	
Black	9,733	15.4	5.8	37.2 (0.7)	1.29	1.24-1.35
Other	4,308	8.7	2.8	31.5 (0.9)	1.10	1.03-1.16
<b>Ethnicity</b>						
Non-Hispanic	53,860	118.2	36.0	30.5 (0.3)	1.15	1.10-1.20
Hispanic	12,239	18.6	4.9	26.4 (0.6)	Ref.	
<b>Marital Status</b>						
Married	35,022	87.8	25.5	29.0 (0.3)	Ref.	
Not married	30,841	48.6	15.4	31.6 (0.4)	1.09	1.06-1.12
<b>Education</b>						
< 16 y	26,066	52.9	16.0	30.3 (0.4)	1.02	0.99-1.05
16 y or more	39,556	82.9	24.7	29.8 (0.3)	Ref.	
<b>By Health Behaviors</b>						
<b>Current smoker</b>						
Yes	14,116	29.2	10.4	35.7 (0.6)	1.26	1.22-1.31
No	51,190	105.9	29.9	28.3 (0.3)	Ref.	
<b>Heavy alcohol user<sup>§</sup></b>						
Yes	15,229	32.8	10.6	32.2 (0.5)	1.11	1.07-1.15
No	50,077	102.3	29.8	29.1 (0.3)	Ref.	
<b>Physically inactive<sup>¶</sup></b>						
Yes	22,793	44.4	13.1	29.5 (0.4)	0.98	0.95-1.01
No	42,513	90.7	27.3	30.1 (0.3)	Ref.	
<b>Obese<sup>**</sup></b>						
Yes	15,972	32.7	11.9	36.2 (0.5)	1.30	1.26-1.34
No	49,334	102.4	28.5	27.9 (0.3)	Ref.	
<b>By Self-reported health status</b>						
Excellent/very good/good	61,878	129.0	37.7	29.2 (0.3)	Ref.	
Fair/poor	4,206	7.7	3.3	42.2 (1.0)	1.45	1.38-1.51

\*Short sleep duration defined as  $\leq 6$  h/24-h period<sup>†</sup>Standard error estimated by SUDAAN (v9.0)<sup>§</sup>Heavy alcohol use defined as having had 5 or more drinks in 1 day in the past year<sup>¶</sup>Physically inactive defined as never engaging in any moderate or vigorous leisure-time physical activity<sup>\*\*</sup>Obese defined as a body mass index  $\geq 30$ *Table 1 continued on following page*

**Table 1** (continued)—Estimated population prevalence (%) of short sleep duration\* among employed civilian US workers, 2004-2007

Variable	Unweighted sample Size	Estimated annual population (in millions)	Estimated annual cases (in millions)	Weighted prevalence (%; SE†)	PR	95% CI
<b>By Work Characteristics</b>						
<b>Number of current jobs</b>						
1	60,410	124.8	36.6	29.3 (0.3)	Ref.	
> 1	5,303	11.2	4.1	37.0 (0.8)	1.26	1.20-1.32
<b>Weekly work hours</b>						
≤ 40	46,872	95.8	26.0	27.1 (0.3)	Ref.	
> 40	18,434	39.3	14.4	36.6 (0.4)	1.35	1.31-1.39

\*Short sleep duration defined as ≤ 6 h/24-h period

†Standard error estimated by SUDAAN (v9.0)

‡Heavy alcohol use defined as having had 5 or more drinks in 1 day in the past year

¶Physically inactive defined as never engaging in any moderate or vigorous leisure-time physical activity

\*\*Obese defined as a body mass index ≥ 30

ufacturing) enterprises.<sup>13-15</sup> Specifically, truck drivers had significantly less sleep (measured by actigraphy) prior to critical incidents (crashes, near-crashes, and crash-relevant conflicts)<sup>13</sup>; medical interns exhibited both decreased sleep and increased attentional failures (validated by electrooculography and polysomnography) during periods with extended work shifts<sup>14</sup>; and, Japanese workers who reported insufficient sleep and other sleep problems were more likely to report any occupational injuries in the past year.<sup>15</sup> Because the consequences of exhaustion and fatigue among truck drivers and railroad workers, and among health care workers may adversely impact public health and safety, there have been efforts to regulate extreme working hours in these two industries.<sup>31</sup> (See <http://www.nts.gov/publication/1999/SR9901.pdf> and <http://www.govtrack.us/congress/bill.xpd?bill=h110-2095> for more information on transportation workers and <http://www.acgme.org/DutyHours/dutyhour-summary2003-04.pdf> for information on medical residents). There is evidence that truck drivers' average sleep duration has increased since stricter regulations were promulgated in 2003,<sup>13</sup> and at least one clinical trial has suggested that reducing work hours has increased sleep duration, as well as decreased attentional failures, among medical interns.<sup>14</sup>

Interestingly, within the transportation and warehousing industry group, we found higher prevalences of short sleep duration among production and installation, maintenance, and repair occupations than among transportation and material moving occupations; but the prevalence of short sleep duration among transportation and material moving occupations in the transportation and warehousing industry was also significantly higher than among the median worker group, suggesting that despite the regulations, both truck drivers and other workers in the transportation industry may continue to experience insufficient sleep.

Early morning start times, night shifts, and rotating shifts may also be a factor in explaining short sleep duration. Unfortunately, the NHIS did not collect data on workers' shift schedules, but other studies, such as the Helsinki Heart Study and the 2004 CPS supplement, have found a high prevalence of irregular schedules among traffic and transportation workers.<sup>26,46</sup>

We found the lowest prevalence of short sleep duration in the agriculture, forestry, fishing, and hunting industry category. Although farmers and others in these categories often work long hours and start working early in the morning, it seems logical that since their work schedules are more attuned to natural light-dark cycles, and may be more flexible compared to the schedules of other workers, work may interfere less with natural sleep habits. According to CPS supplements that measured shift work, approximately 10% of agricultural workers report working non-standard shifts, which is considerably lower than manufacturing or transportation workers, but much higher than construction workers, who were more likely to report short sleep duration in our study.<sup>46</sup> Consistent with the present estimate of 23.1% prevalence of short sleep duration among farmers and related workers, Spengler et al found a prevalence of short sleep duration (≤ 6 h of self-reported daily sleep) among part-time Kentucky farmers of 24.3%.<sup>48</sup>

Most previous studies in which sleep duration or quality were determined by occupation have used very broad categories, compared to the categories presented here.<sup>49,50</sup> Two exceptions are a Finnish study published in 1984, in which differences in the prevalence of difficulty falling asleep, frequent nighttime waking, and early waking among workers in 40 occupational groups were assessed<sup>51</sup> and a recent Norwegian study in which sleep duration was compared among 7 occupational categories.<sup>52</sup> Some of our findings regarding variation in prevalence of short sleep duration by industry and occupation are consistent with findings from these studies, although the former study only addressed sleep quality, and our study only addressed sleep quantity. Specifically, Partinen et al<sup>51</sup> found the highest frequency of complaints of difficulty falling asleep among male bus drivers and the highest frequency of complaints of frequent awakening among male laborers (who might have been similar to production workers in our study). Ursin et al found that craft workers, plant operators, and drivers slept less than their reference group of "leaders" (legislators, senior officials, and managers)<sup>52</sup> Furthermore, Ursin et al found that occupational groups had effects on sleep duration independent of the effects of shift work.

**Table 2**—Estimated prevalence (%) of short sleep duration\* by industry sectors, United States, 2004-2007

Industry sector (NAICS 2002)	Unweighted sample size	Estimated population (in 1000s)	Estimated number of workers with short sleep duration (in 1000s)	Weighted prevalence (%, SE†)	Model 1: industry + demographics PR (95% CI)‡	Model 2: industry + demographics + health behaviors PR (95% CI)††	Model 3: industry + demographics + health behaviors + health status PR (95% CI)**	Model 4: industry + demographics + health behaviors + health status + job characteristics PR (95% CI)‡‡
Management of companies and enterprises (55)	41	93.34	37.80	40.5 (9.4)	1.30 (0.82-2.04)	1.22 (0.73-2.03)	1.24 (0.74-2.06)	1.27 (0.79-2.05)
Transportation and warehousing (48-49)	2,696	5565.43	2064.92	37.1 (1.2)	1.15 (1.07-1.24)	1.13 (1.05-1.21)	1.13 (1.05-1.21)	1.11 (1.03-1.20)
Manufacturing (31-33)	7,026	15162.27	5276.06	34.8 (0.7)	1.11 (1.04-1.18)	1.11 (1.04-1.17)	1.11 (1.04-1.18)	1.09 (1.03-1.16)
Public administration (92)	3,201	6508.39	2179.68	33.5 (1.1)	1.05 (0.98-1.14)	1.05 (0.98-1.13)	1.05 (0.98-1.13)	1.07 (1.03-1.11)
Information (51)	1,589	3367.48	1056.76	31.4 (1.7)	1.01 (0.90-1.13)	1.02 (0.91-1.14)	1.02 (0.92-1.14)	1.03 (0.93-1.15)
Health care and social assistance (62)	8,310	16065.03	5012.83	31.2 (0.6)	1.02 (0.96-1.08)	1.02 (0.96-1.08)	1.02 (0.96-1.08)	1.03 (0.97-1.09)
Administrative support, waste management, and remediation services (56)	2,737	3395.09	1651.37	30.6 (1.1)	0.99 (0.91-1.07)	0.98 (0.90-1.06)	0.97 (0.90-1.06)	0.98 (0.91-1.06)
Utilities (22)	527	1201.86	368.07	30.6 (2.3)	0.97 (0.83-1.13)	0.96 (0.83-1.12)	0.97 (0.83-1.13)	0.99 (0.85-1.15)
Accommodation and food service (72)	3,837	7600.49	2306.50	30.4 (0.9)	1.02 (0.95-1.10)	1.01 (0.94-1.09)	1.01 (0.93-1.09)	1.01 (0.94-1.09)
Retail trade (44-45)	6,447	13821.80	4163.28	30.1 (0.7)	1.00	1.00	1.00	1.00
Arts, entertainment, and recreation (71)	1,199	2485.33	742.06	29.9 (1.7)	0.98 (0.87-1.10)	0.99 (0.88-1.11)	0.99 (0.88-1.11)	0.99 (0.89-1.13)
Wholesale trade (42)	1,898	4162.37	1196.70	28.8 (1.3)	0.93 (0.84-1.02)	0.92 (0.84-1.02)	0.93 (0.84-1.03)	0.91 (0.82-1.00)
Mining (21)	252	605.70	170.87	28.2 (3.2)	0.91 (0.72-1.15)	0.90 (0.71-1.13)	0.90 (0.72-1.14)	0.85 (0.67-1.08)
Construction (23)	4,778	10507.84	2947.89	28.1 (0.9)	0.90 (0.84-0.98)	0.90 (0.83-0.97)	0.90 (0.83-0.97)	0.91 (0.84-0.98)
Finance and insurance (52)	3,001	6233.08	1747.40	28.0 (1.0)	0.92 (0.84-1.00)	0.93 (0.85-1.02)	0.93 (0.86-1.02)	0.94 (0.86-1.02)
Professional, scientific, and technical service (54)	3,811	8272.35	2270.22	27.4 (0.9)	0.89 (0.83-0.96)	0.91 (0.85-0.98)	0.91 (0.85-0.97)	0.91 (0.85-0.98)
Real estate, rental, and leasing (53)	1,369	2856.26	778.01	27.2 (1.5)	0.89 (0.80-1.00)	0.89 (0.79-1.00)	0.89 (0.80-1.00)	0.89 (0.80-1.00)
Other services, except public administration (81)	3,251	6582.17	1772.49	26.9 (0.9)	0.88 (0.81-0.96)	0.89 (0.82-0.96)	0.88 (0.81-0.96)	0.88 (0.81-0.95)
Education services (61)	6,092	12488.11	3330.99	26.7 (0.7)	0.88 (0.82-0.94)	0.90 (0.85-0.97)	0.91 (0.85-0.97)	0.92 (0.86-0.98)
Agriculture, forestry, fishing, and hunting (11)	809	1673.39	387.17	23.1 (1.8)	0.78 (0.66-0.91)	0.78 (0.66-0.91)	0.78 (0.67-0.91)	0.74 (0.63-0.86)
Total	62,871	130647.79	39461.06	30.2 (0.3)				

\*Short sleep duration defined as  $\leq 6$  h/24-h period

†Standard error estimated by SUDAAN (v9.0).

‡In Model 1, prevalence ratios (PR) are adjusted for demographic covariates (age, sex, race, ethnicity, marital status, and education).

††In Model 2, prevalence ratios (PR) are adjusted for demographic covariates and health behaviors (smoking, alcohol consumption, physical inactivity, and obesity)

\*\*In Model 3, prevalence ratios (PR) are adjusted for demographic covariates, health behaviors, and health status

‡‡In Model 4, prevalence ratios (PR) are adjusted for demographic covariates, health behaviors, health status, and job characteristics (long work hours and multiple jobs)

Interestingly, the increase in the prevalence of short sleep duration among workers from 1985/1990 to 2004-2007 does not appear to be explained by substantial increases in work hours nor by changes in shift work. Our analyses and previous analyses of CPS data indicate that average weekly work hours have slightly declined during this time period, while CPS data

indicate that the proportion of workers engaged in shift work has increased.<sup>33</sup> Furthermore, few of the industry sectors with the highest mean weekly work hours or the highest prevalence of shift work in either time period were among the industry groups with the highest prevalence of short sleep duration, suggesting that the relationship between work hours, shift work

**Table 3**—Estimated prevalence (%) of short sleep duration\* by occupation within high-prevalence industries United States, 2004-2007

Industry Sector (NAICS 2002) / Occupation	Unweighted sample size	Estimated population (in 1000s)	Estimated number of workers with short sleep duration (in 1000s)	Weighted prevalence (%; SE <sup>†</sup> )	PR <sup>§</sup>	95 % CI
<b>Transportation and Warehousing (48-49)</b>						
Production occupations	41	82.68	37.09	44.9 (9.2)	1.45	0.94-2.23
Installation, maintenance, and repair occupations	127	285.20	123.87	43.4 (4.9)	1.35	1.08-1.69
Management occupations	186	413.82	168.46	40.7 (4.4)	1.28	1.03-1.58
Building and grounds cleaning and maintenance occupations	31	48.21	18.05	37.4 (9.9)	1.29	0.77-2.16
Transportation and material moving occupations	1,231	2576.64	962.14	37.3 (1.8)	1.12	1.00-1.25
<b>Manufacturing (31-33)</b>						
Installation, maintenance, and repair occupations	289	683.90	281.20	41.1 (3.3)	1.25	1.06-1.48
Production occupations	3,319	6881.85	2606.11	37.9 (1.0)	1.20	1.12-1.29
Building and grounds cleaning and maintenance occupations	88	179.74	65.23	36.3 (6.1)	1.16	0.83-1.61
Transportation and material moving occupations	599	1363.29	485.12	35.6 (2.4)	1.12	0.97-1.29
Architecture and engineering occupations	401	888.45	291.67	32.8 (3.1)	1.02	0.85-1.23
<b>Public Administration (92)</b>						
Transportation and material moving occupations	47	100.36	43.12	43.0 (9.4)	1.37	0.93-2.01
Protective service occupations	781	1671.53	639.11	38.2 (2.1)	1.16	1.03-1.31
Healthcare practitioners and technical occupations	104	200.53	76.34	38.1 (5.1)	1.18	0.91-1.52
Architecture and engineering occupations	77	175.90	65.93	37.5 (6.8)	1.30	0.93-1.82
Computer and mathematical occupations	116	256.67	90.93	35.4 (5.9)	1.16	0.83-1.62

\*Short sleep duration defined as  $\leq 6$  h/24-h period<sup>†</sup>Standard error estimated by SUDAAN (v9.0)<sup>§</sup>Prevalence ratios (PR) are adjusted for demographic covariates (age, sex, race, ethnicity, marital status, and education), health behaviors (smoking, alcohol consumption, physical inactivity, and obesity), health status, and job characteristics (long work hours and multiple jobs); reference group = all workers employed in retail sales industry

and sleep duration may vary by industry sector. Before indulging in speculation about possible predictors of short sleep duration across different industry sectors, we plan to perform more detailed analyses by hours worked, commuting times, other job characteristics, and industry sector.

### Limitations

The large sample size and nationally representative sample design of this study allowed reliable estimates of the prevalence of short sleep duration for various industries and occupations. On the other hand, the NHIS provides data on quantity, but not *quality* of sleep, which may be a limitation; however, duration of sleep has been associated with many aspects of the quality of sleep in other studies that assessed both duration and quality of sleep.<sup>3,29,53</sup> For example, Japanese workers who reported symptoms of insomnia (i.e., non-refreshing sleep, difficulty falling asleep, frequent sleep disruption, and early morning arousal) reported significantly shorter average sleep durations<sup>29</sup>; and clinically diagnosed primary insomniacs have been found to have significantly reduced total sleep time (measured by polysomnography) compared to healthy controls.<sup>53</sup>

Other limitations to the NHIS data are that sleep duration is self-reported, with no distinction made between sleep duration on weekdays (work days) vs. weekends (non-work days), reported average sleep time is rounded to the nearest hour, and there are no data on work shifts. Self-reported habitual sleep

duration has been found to have a modest correlation with sleep duration measured by actigraphy, with higher subjective estimates of sleep duration and variation in the accuracy of self-reported sleep duration by health, sociodemographic, and sleep characteristics.<sup>54</sup>

We analyzed data by simple NCHS industry and occupation recodes rather than detailed recodes to limit problems caused by small numbers. Trend analyses were further limited by the fact that no data on sleep hours were collected by the NHIS between 1990 and 2004, and industry and occupation recode categories changed between 1990 and 2004; thus comparisons could only be made within broad industry categories.

Finally, the present study was not designed to determine how the differential in the distribution of short sleep duration is related to many specific job characteristics (e.g., job stress, irregular or rotating shifts) or to examine how work and non-work demands/activities (e.g. internet, TV, video games) compete for sleep. Differences in the prevalence within broad industry and occupation categories may be due to changes in not only the nature of jobs but also the composition of jobs within these categories. The present analysis did not reveal the reason(s) driving the increase in the number of workers who are not getting enough sleep.

Furthermore, the differences in sleep duration between industry/occupation groups may be influenced by self-selection of job according to sleep needs, which could not be assessed with

**Table 4**—Estimated prevalence of short sleep duration by NORA industry sector, United States, 1985 and 1990 compared to 2004-2007

	1985 and 1990				2004-2007				P-value > F for short sleep duration <sup>‡</sup>
	Unweighted sample size (NHIS)	Weighted prevalence (% of short sleep duration (SE*))	Mean weekly work hours (weighted; from CPS, 1990 <sup>†</sup> )	Prevalence (% of shift work; (from CPS, 1985 <sup>§</sup> )	Unweighted sample size (NHIS)	Weighted prevalence (% of short sleep duration (SE*))	Mean weekly work hours (weighted; from NHIS, 2004-2007 <sup>¶</sup> )	Prevalence (% of shift work; (from CPS, 2004 <sup>**</sup> )	
Agriculture, forestry, fishing, and hunting	1,222	16.9 (1.4)	44.7	10.6 <sup>a</sup>	826	23.1 (1.8)	45.7	9.5	0.0025
Mining	336	25.5 (2.7)	45.9	21.9	252	28.2 (3.2)	49.3	31.5	0.4328
Construction	2,567	22.2 (1.0)	40.9	2.5	4,832	28.0 (0.9)	42.1	2.8	< 0.0001
Manufacturing	8,572	27.0 (0.6)	42.4	17.9	7,108	34.7 (0.7)	43.6	17.7	< 0.0001
Transportation, Warehousing and utilities	3,129	27.3 (1.0)	42.8	20.6	3,252	36.0 (1.0)	43.2	27.8	< 0.0001
Wholesale and retail trade	8,058	23.4 (0.6)	39.9	26.3 <sup>b</sup>	8,423	29.7 (0.6)	39.6	22.0	< 0.0001
Services	17,291	22.7 (0.4)	39.9	38.4 <sup>c</sup>	32,011	28.8 (0.3)	39.0	36.1 <sup>c</sup>	< 0.0001
Health care	3,871	28.1 (0.9)	39.1	27.0 <sup>d</sup>	6,915	31.7 (0.7)	38.8	19.0	0.0012
Total	45,046	24.2 (0.3)	40.7	15.9	63,619	30.1 (0.3)	40.2	17.7	< 0.0001

\*Standard error estimated by SUDAAN (v9.0).

<sup>†</sup>CPS data obtained from the website of the National Bureau of Economic Research ([http://www.nber.org/data/cps\\_basic.html](http://www.nber.org/data/cps_basic.html))

<sup>§</sup>Reference: Mellor EF. Shift work and flexitime: how prevalent are they? Monthly Labor Review. 1986; November:14-21.

<sup>¶</sup>Excludes 1,391 respondents without valid data for mean weekly work hours.

<sup>\*\*</sup>Reference: McMnamin TM. A time to work: Recent trends in shift work and flexible schedules. Monthly Labor Review 2007; December:3-15.

<sup>‡</sup>Compares the prevalence of short sleep duration between 1985, 1990 and 2004-2007 using the Wald  $\chi^2$  test.

<sup>a</sup>Excludes forestry and fishing workers.

<sup>b</sup>Excludes wholesale trade workers

<sup>c</sup>Based on all workers in service occupations, including health care workers; data for all service industries not available

<sup>d</sup>Hospital workers only

this cross-sectional study. People who need a lot of regular sleep might avoid jobs that have irregular schedules and night shifts.

## Conclusions

We found a high prevalence of short sleep duration among workers in the transportation/warehousing, manufacturing, and public administration industries, and identified specific occupational groups within these industries with the highest prevalence of short sleep duration. Additionally, analyses suggest that average sleep duration has generally declined among workers over the last two decades. Further explorations of the relationship between work and sleep and development of targeted interventions (i.e., protective legislation or other policy interventions, education and training materials) for specific industry/occupation groups are needed.

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## DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

## DISCLOSURE STATEMENT

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