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Insomnia and the Performance of US Workers: Results from the America Insomnia Survey

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Study Objectives: To estimate the prevalence and associations of broadly defined (i.e., meeting full ICD-10, DSM-IV, or RDC/ICSD-2 inclusion criteria) insomnia with work performance net of comorbid conditions in the America Insomnia Survey (AIS).

Design/Setting: Cross-sectional telephone survey.

Participants: National sample of 7,428 employed health plan subscribers (ages 18+).

Interventions: None.

Measurements and Results: Broadly defined insomnia was assessed with the Brief Insomnia Questionnaire (BIQ). Work absenteeism and presenteeism (low on-the-job work performance defined in the metric of lost workday equivalents) were assessed with the WHO Health and Work Performance Questionnaire (HPQ). Regression analysis examined associations between insomnia and HPQ scores controlling 26 comorbid conditions based on self-report and medical/pharmacy claims records. The estimated prevalence of insomnia was 23.2%. Insomnia was significantly associated with lost work performance due to presenteeism (χ^2_1 = 39.5, P < 0.001) but not absenteeism (χ^2_1 = 3.2, P = 0.07), with an annualized individual-level association of insomnia with presenteeism equivalent to 11.3 days of lost work performance. This estimate decreased to 7.8 days when controls were introduced for comorbid conditions. The individual-level human capital value of this net estimate was $2,280. If we provisionally assume these estimates generalize to the total US workforce, they are equivalent to annualized population-level estimates of 252.7 days and $63.2 billion.

Conclusions: Insomnia is associated with substantial workplace costs. Although experimental studies suggest some of these costs could be recovered with insomnia disease management programs, effectiveness trials are needed to obtain precise estimates of return-on-investment of such interventions from the employer perspective.

Keywords: Insomnia, epidemiology, employment, absenteeism, presenteeism, comorbidity

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INTRODUCTION

The societal burden of insomnia in the United States is substantial, with an estimated one-third of all US adults experiencing weekly difficulties with nighttime sleep[1] and an estimated 50-70 million people complaining of nighttime sleep loss associated with daytime impairment.[2] As experimental studies increasingly link insomnia with a range of negative effects on functioning, from increased sleepiness and fatigue[3] to reduced psychomotor performance,[4] memory consolidation,[5] and affect regulation,[6] it is unsurprising that insomnia has been associated with significant workplace deficits. Indeed, adverse effects on work performance are consistently ranked among the most prominent components of the overall societal burden of insomnia,[7,8] with estimates of annual insomnia-related workplace costs due to excess sickness absence, reduced work productivity, and workplace accidents-injuries in the US civilian workforce ranging between $15 billion and $92 billion.[9,10]

Although such large effects might justify the implementation of workplace insomnia screening and intervention programs, accurate estimates of the workplace costs of insomnia would be needed to justify such programs. Estimates of this sort currently do not exist, as most available studies are based either on medical/pharmacy claims databases that only study treated insomnia[10,11] or on consumer panels that have very low response rates and suboptimal measures of insomnia.[12] Samples that define insomnia based on treatment risk particularly strong sample bias given epidemiologic evidence that only a small minority of Americans with chronic insomnia symptoms seek formal medical attention[13] and that few insomniacs receive prescription hypnotics[14] or formal diagnoses due to prominent comorbid conditions.[15]

We address the limitations of currently available estimates of the workplace costs of insomnia in the current report by using survey data collected in the America Insomnia Survey (AIS),[1] a national survey of employed subscribers to a very large US national health plan (over 34 million members) who were selected using probability methods that did not oversample subscribers with a diagnosis of or treatment for insomnia. We estimate the associations of insomnia with work performance controlling for a wide range of comorbid conditions. Insomnia was assessed with a clinically validated fully structured diagnostic screening scale.[16] Work performance was assessed with a validated questionnaire that has

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been widely used in studies of health and work performance.[17,18] Comorbid conditions were assessed using both a series of validated self-report screening scales and medical/pharmacy claims data.

METHODS

The Sample

The AIS was carried out between October 2008 and July 2009 in a stratified probability sample of 10,094 adult (ages 18 and older) members of a large (over 34 million members) national US commercial health plan. The sample was restricted to fully insured members enrolled for ≥ 12 months to allow medical and pharmacy claims data to be used in substantive analyses. Sample eligibility was also limited to members who provided the plan with a telephone number, could speak English, and had no impairment that limited their ability to be interviewed by telephone. The sample was selected with stratification to match the US national Census population distribution on the cross-classification of age (18-34, 35-49, 50-64, 65-74 and 75+), sex, urbanicity (Census Standard Metropolitan Statistical Areas [SMSA], non-SMSA urbanized areas, and rural areas), and Census Region (Northeast, South, Midwest, and West). Information about diagnoses or treatment of sleep disorders was ignored in sample selection to make the sample representative of all plan subscribers.

An advance letter was sent to target respondents explaining that the survey was designed "to better understand how health and health problems affect the daily lives of people," that respondents were selected randomly, that participation was voluntary, that responses were confidential, that participation would not affect health care benefits, and that a $20 incentive was offered for participation. A toll-free number was included for respondents who wanted more information or to opt out. Once respondents were contacted by telephone, verbal informed consent was obtained before beginning interviews. The Human Subjects Committee of the New England Institutional Review Board approved these recruitment, consent, and field procedures. The cooperation rate (the rate of survey completion among target respondents with known working telephone numbers, including respondents who were never reached) was 65.0%. The 10,094 interviews were weighted for residual discrepancies between the joint distribution of the sociodemographic and geographic selection criteria in the sample compared to the Census population. A total of 7,428 AIS respondents were either employed or self-employed.

In addition to assessing insomnia, the AIS included many questions about the correlates of insomnia. In order to reduce respondent burden, some questions were administered only to probability subsamples. One such set concerned physical and mental conditions found in previous research to be comorbid with insomnia. Self-report questions about these conditions were administered to all AIS respondents reporting any sleep problems plus a random 50% of other respondents. The random subsample was assigned a weight of 2.0 (multiplied by the weight described in the previous paragraph) in the comorbidity sample to adjust for the fact that they represent only half of those without sleep problems in the full sample. A total of 4,991 AIS respondents in this comorbidity subsample were either employed or self-employed.

Measures

Insomnia

Insomnia in the 30 days before interview was assessed with the Brief Insomnia Questionnaire (BIQ), a 32-question fully structured interviewer-administered questionnaire developed for the AIS to generate insomnia diagnoses according to the definitions and inclusion criteria of the 3 major insomnia classification systems: the Diagnostic and Statistical Manual, Fourth Edition, Text Revision (DSM-IV-TR), International Classification of Diseases-10 (ICD-10), and research diagnostic criteria/International Classification of Sleep Disorders-2 (RDC/ICSD-2) systems. The BIQ allows diagnoses to be generated for any one of these systems alone (i.e., ignoring whether or not full inclusion criteria are also met for any of the other systems). It is also possible, as with the analyses reported here, to combine cases that meet criteria for an insomnia diagnosis in any of the 3 systems into a single category of broadly defined insomnia. Since RDC and ICSD-2 general criteria for insomnia were explicitly developed to be identical, excepting that the former are intended for research applications and the latter are reserved for clinical assessments,[19] we refer to RDC/ICSD-2 criteria throughout this report. The full text of the BIQ along with diagnostic algorithms is available at (http://www.hcp.med.harvard.edu/wmh/affiliated_studies.php).

As noted above, the BIQ was designed to operationalize inclusion criteria of DSM-IV-TR, ICD-10, and RDC/ICSD-2 diagnoses of general insomnia. The cases considered here, hereafter referred to as *broadly defined insomnia* or *insomnia,* meet full inclusion criteria in at least one of these systems, all of which required respondents to report one or more nighttime symptom(s) (difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, or non-restorative sleep) in addition to daytime distress/impairment and other criteria that vary across systems. The operational definitions of criteria across systems were harmonized to require that nighttime symptoms occur ≥ 3 times per week, continue for ≥ 30 min (with the exception of non-restorative sleep [NRS]), and persist for a minimum duration of one month.

Due to familiar difficulties involved with distinguishing primary insomnia from insomnia comorbid with physical/mental disorders or substance/medication use, no attempt was made in the BIQ to operationalize diagnostic hierarchy or organic exclusion rules in DSM-IV-TR Criteria C-E or to distinguish DSM-IV-TR Primary Insomnia, RDC/ICSD Insomnia Disorder or ICD-10 Non-organic Insomnia from other insomnia phenotypes. This decision is consistent with the most recent recommendations of the task force revising the DSM criteria.[20] However, medical and pharmacy claims data for the 12 months before interview were obtained from the health plan for all AIS respondents to study the effects of diagnosed and treated comorbid conditions on correlates of insomnia. The AIS interview also obtained self-report assessments of chronic conditions known to be associated with insomnia for the same purpose (see below). These were introduced as controls in regression analyses to adjust for the effects of comorbid conditions. This approach is consistent with the recommendations of both the 2005 NIH State-of-the-Science Conference[21] and the 2006 Recommendations for Research Assessment of Insomnia.[22]

A clinical reappraisal study was carried out with a subsample of AIS respondents that oversampled those who screened positive in the BIQ. Blinded clinical interviewers who were highly experienced sleep medicine experts carried out semi-structured clinical interviews to make diagnoses of insomnia according to the definitions and criteria of the 3 systems considered here. Psychometric analyses documented good individual-level concordance of diagnoses based on the BIQ with these independent hierarchy-free clinical diagnoses.[16] Sensitivity of BIQ diagnoses based on any of the diagnostic systems (i.e., meeting criteria either for a DSM-IV, ICD-10, or RDC/ICSD-2 diagnosis) compared to clinical diagnoses was 72.6%, specificity was 98.9%, and area under the receiver operating characteristic curve (a measure of classification accuracy insensitive to disorder prevalence) was 0.86. Cohen's κ was 0.77, a value at the upper end of the range conventionally judged to represent *substantial* agreement with clinical diagnoses.[23] A more detailed description of the BIQ, its validation, and the qualifications of the clinical interviewers is presented elsewhere.[16]

Other Physical and Mental Disorders

As noted above, medical and pharmacy claims data for the 12 months before interview along with self-report data on untreated conditions were obtained for disorders and syndromes documented in the literature to be associated with elevated rates of insomnia.[24] A total of 26 such disorders were considered. These included cardiometabolic disorders (congestive heart failure, diabetes, hypertension), musculoskeletal conditions (chronic back or neck pain, osteoarthritis, rheumatoid arthritis), respiratory disorders (chronic obstructive pulmonary disease, seasonal allergies, chronic bronchitis, emphysema, or other) digestive disorders (gastroesophageal reflux disease, irritable bowel syndrome, urinary or bladder problems), other sleep disorders (sleep apnea, restless leg syndrome), neuropathic pain, other chronic pain, migraine, other frequent or severe headaches, emotional disorders (major depression, generalized anxiety disorders, and a summary measure of any other emotional disorder), obesity, and climacteric symptoms common to perimenopausal women. Diagnoses were obtained from ICD-9 codes in medical claims and inferred from pharmacy claims. Diagnoses based on self-reports were obtained in 2 ways. First, a chronic conditions checklist was used based on the list in the US National Health Interview Survey[25] (http://www.hcp.med.harvard.edu/ncs/replication.php). Such checklists have been widely used in epidemiological studies and yield more complete and accurate reports than estimates derived from responses to open-ended questions.[26] Methodological studies have documented good concordance between such checklists and medical records.[27-29] Second, a series of validated disorder-specific self-report scales was used to detect untreated symptom-based conditions.[30-34]

Absenteeism and work performance

Work performance was assessed with the WHO Health and Work Performance Questionnaire (HPQ).[17,18] The HPQ uses self-reports about absenteeism (missed days of work) and presenteeism (low performance while at work transformed to lost workday equivalents) to generate measures of lost workdays in the month before the interview. Absenteeism was defined on a 0-100 scale for percent of workdays the respondent missed in the past 30 days, while presenteeism was defined on a separate 0-100 scale, where 0 means doing no work at all on days at work and 100 means performing at the level of a top worker. Information about salary was used to transform the measures of lost work performance from a time metric to a salary metric for purposes of estimating human capital loss associated with insomnia. Salary was incremented by 30% to estimate fringe benefits. Validation studies have documented significant associations (r = 0.61-0.87) of HPQ absenteeism reports with employer payroll records[18] and significant associations of HPQ work performance reports with both supervisor assessments (r = 0.52)[17] and other administrative indicators of performance (0.58-0.72).[18]

Employment and other sociodemographic variables

All AIS respondents were asked if they were employed, self-employed, unemployed and looking for work, a student, homemaker, retired, or something else. All respondents who reported they were either employed or self-employed (henceforth referred to as *employed*) were asked how many hours they were supposed to work (or, if self-employed, how many hours were necessary to complete their work) in a typical week. Respondents who reported that the number of hours varied from week to week were asked for an average. Respondents who reported they were expected to work as many or few hours as necessary to complete their work were asked the average number of hours it takes to get their work done in a typical week. Additional sociodemographics used as controls included respondent age, sex, and years of education.

Analysis Methods

Linear regression analysis was used to estimate associations of insomnia with work performance controlling for sociodemographics and comorbid conditions. Given that the outcome variables are highly skewed with a large proportion of respondents having 0 values (i.e., reporting no absenteeism and no decrements in work performance), 2-part models and generalized linear models (GLMs) were used to investigate a number of different functional forms and error structures.[35] Standard model comparison procedures were used to select a best-fitting model.[36] (Detailed results are available on request.) The best-fitting model to predict absenteeism was the GLM that assumed a square root link function and a constant error variance, while the best-fitting model to predict presenteeism was the GLM that assumed a square root link function and a gamma error distribution.

Simulation was used to estimate the individual-level association of insomnia with the outcomes from the GLM models. This was required as the GLM model coefficients have no obvious substantive interpretation. The simulation was carried out by estimating the predicted values of the outcomes twice: once based on the parameters from the model and considering the actual characteristics of the respondents, and the second time based on the assumption that no one had insomnia. Individual-level differences between these 2 estimates were then transformed into the metrics of either days or dollars (daily salary plus fringe multiplied by days) and then averaged across all respondents with insomnia to obtain

Table 1—Prevalence and sociodemographic distribution of BIQ/broadly defined insomnia[1] among employed AIS respondents (n = 7,428)

	Insomnia Prevalence		Bivariate		Multivariate	
	%	(SE)	OR	(95% CI)	OR	(95% CI)
Age						
18-29	23.9	(1.1)	1.9*	(1.4-2.5)	1.4*	(1.2-1.6)
30-44	24.2	(0.8)	1.9*	(1.5-2.5)	1.5*	(1.3-1.7)
45-64	23.5	(0.8)	1.8*	(1.4-2.4)	1.4*	(1.2-1.6)
65+	14.3	(1.5)	1.0		1.0	
χ^2_3			25.0*		27.5*	
Sex						
Male	19.7	(0.6)	1.0		1.0	
Female	27.1	(0.7)	1.5*	(1.4-1.7)	1.5*	(1.3-1.6)
χ^2_1			57.1*		59.5*	
Education						
Less than high school	19.9	(4.4)	0.9	(0.5-1.6)	1.2	(0.8-1.7)
High school	25.3	(0.9)	1.2*	(1.1-1.4)	1.2*	(1.1-1.4)
Some college	26.4	(1.5)	1.3*	(1.1-1.5)	1.3*	(1.1-1.5)
College graduate	21.5	(0.6)	1.0		1.0	
χ^2_3			18.0*		22.0*	
Total	23.2	(0.5)				

*Significant association between insomnia and the sociodemographic variable at the 0.05 level, 2-sided test. [1]The Brief Insomnia questionnaire (BIQ) is a validated self-report measure of insomnia.[16] BIQ/broadly defined insomnia includes cases meeting full criteria for insomnia in the BIQ according to ≥ 1 of the following 3 diagnostic systems: DSM-IV, ICD-10, and RDC/ICSD-2. Diagnoses were made without organic exclusions or diagnostic hierarchy rules. See the text for more details.

Table 2—Distributions of HPQ absenteeism and presenteeism[1] scores among employed AIS respondents (n = 7,428)

	Absenteeism		Presenteeism	
	Est	(SE)	Est	(SE)
Mean	7.1	(0.3)	14.2	(0.2)
Median	0.5	(1.0)	17.7	(0.2)
Percentile scores				
99	−20.0		0.0	
75	−10.0	(0.6)	9.9	(0.2)
50	0.5	(1.0)	17.7	(0.2)
25	6.4	(1.0)	26.2	(0.3)
0	100.0		100.0	

[1]The WHO Health and Work Performance Questionnaire (HPQ) is a validated self-report measure of work performance.[17,18] HPQ absenteeism is a continuous 0-100 scale.

estimates of the individual-level associations of insomnia with the outcomes.

In an effort to obtain a rough approximation of the population-level implications of the individual-level results, the individual-level estimates were then multiplied by the estimated number of US workers with insomnia, which we defined as the prevalence of insomnia estimated in the AIS multiplied by the number of workers in the US civilian labor force reported in the most recent (August 2010) US Bureau of Labor Statistics Current Population Survey (www.bls.gov/cps). Although we have no way of knowing if the implicit assumption in making these calculations that the AIS results apply to the total US labor force are correct, we nonetheless believe that this exercise is useful in providing a societal perspective on the meaning of the results. We then examined the population attributable risk proportion (PARP) of insomnia predicting work performance, which is defined as the incremental (i.e., controlling for all comorbid conditions) proportion of observed decrements in work performance that would not have occurred under the regression model if insomnia were eradicated and the insomnia coefficient were due to causal effects of insomnia. So, for example, a PARP of 0.07 would mean that 7% of all the work impairment observed in the population would be predicted not to occur if all cases of insomnia were effectively treated. PARP was calculated using the same simulation methods described above for estimating the individual-level effects of insomnia, except that the mean of the discrepancy of predicted HPQ scores is divided by the mean in the unrestricted model among people with insomnia to define PARP. Statistical significance was consistently evaluated using 0.05-level 2-sided tests. As the AIS data are weighted, the design-based Taylor series method[37] implemented in a SAS macro[38] was used to estimate standard errors and evaluate statistical significance.

RESULTS

Prevalence and Sociodemographic Correlates of Insomnia

The estimated prevalence of insomnia in the total AIS subsample of working people was 23.2%. (Table 1) Insomnia prevalence was significantly lower among working people who were aged 65+ (14.3%) than those who were younger (23.5-24.2%; $\chi^2_3 = 25.0$, $P < 0.001$), higher among women than men (27.1% vs. 19.7%; $\chi^2_1 = 57.1$, $P = 0.001$), and higher among respondents with high school (25.3%) or some college (26.4%) education than those either with less than high school education (19.9%) or college graduates (21.5%; $\chi^2_3 = 18.0$, $P < 0.001$). These associations all persisted in multivariate analyses.

Distributions and Sociodemographic Correlates of Absenteeism and Presenteeism

Absenteeism has a mean value of 7.1% and an inter-quartile range (IQR; 25th-75th percentiles) between −10.0% and 6.4%. The mean of 7.1% is equivalent to somewhat less than one and a half days of absence in a 20-day work month. The negative value at the lower end of the IQR represents the fact that some workers work *more* hours than required by their job description. Comparable values for presenteeism are a mean of 14.2% and an IQR between 9.9% and 26.2% (Table 2). That the mean is higher for presenteeism than absenteeism suggests that the majority of lost work performance in the US civilian workforce

actually occurs during days when workers are on the job instead of absent. If we think of the presenteeism score as a percentage of lost work performance, then overall lost work performance in the sample as a whole is 20.3%, which is the sum of 7.1% due to absenteeism and 13.2% (i.e., 14.2 × [100 – 7.1]) due to presenteeism. This means that presenteeism accounts for about two-thirds of all lost work performance and absenteeism for about one-third.

Absenteeism was significantly higher and presenteeism significantly lower among workers aged 65+ than those aged 18-64 (10.5% vs. 5.8% to 7.7%; $F_{3,7424} = 4.1$, P = 0.006 for absenteeism; 11.8% vs. 12.9% to 16.4%, $F_{3,7424} = 29.1$, P < 0.001 for presenteeism) (Table 3). Women had slightly higher absenteeism but lower presenteeism than men (7.8% vs. 6.5%, $F_{1,7426} = 3.3$, P = 0.07 for absenteeism; 13.4% vs. 15.0%, $F_{1,7426} = 29.4$, P < 0.001 for presenteeism). Absenteeism was higher for workers with no more than a high school education (8.7% to 9.3%) compared to those with at least some college education (5.5% to 6.7%, $F_{3,7424} = 3.5$, P = 0.015). Conversely, presenteeism was lower among workers with less than a high school education compared to those with at least a high school education (10.0% vs. 13.1% to 14.5%, $F_{3,7424} = 7.8$, P < 0.001).

Associations of Insomnia with Work Performance

Individual-level associations

As noted above in the section on analysis methods, examination of GLM models with a variety of link functions and error distributions showed that the best functional forms to describe the joint associations of insomnia and sociodemographic variables in predicting absenteeism and presenteeism were a square root link function for both outcomes, a normal error distribution for absenteeism, and a gamma error distribution for presenteeism. (A table of detailed model comparison statistics is available on request.) Results for these best-fitting models showed that the net association of insomnia with presenteeism ($\chi^2_1 = 39.5$, P < 0.001), but not absenteeism ($\chi^2_1 = 3.2$, P = 0.07), was significant after controlling comorbid conditions.

Interaction analyses found no significant interactions of insomnia with any of the sociodemographics in predicting absenteeism ($\chi^2_3 = 4.3$-7.4, P = 0.06-0.23 for age and education; $\chi^2_1 = 0.3$, P = 0.59 for sex) and no significant interactions of insomnia with either age ($\chi^2_3 = 3.3$, P = 0.34) or sex ($\chi^2_1 = 1.2$, P = 0.28) in predicting presenteeism. A significant interaction was found between insomnia and education in predicting presenteeism ($\chi^2_3 = 11.8$, P = 0.008), but inspection of this interaction showed that it was due to a substantively implausible nonlinear specification in which the association of insomnia with presenteeism was weaker among workers with a high school education than among workers with either more or less than a high school education. (Detailed results of the interactive models are available on request.) Based on the implausibility of this interaction, we chose to focus on the additive specification in further analyses (Table 4). The annualized individual-level association of insomnia with the composite HPQ measure controlling for sociodemographics was 11.3 days of lost work performance for each worker with insomnia before controlling for comorbidity and 7.8 days after controlling for comorbidity. These individual-level decrements in work performance had human capital values of $3,274 before controlling for comorbidity and $2,280 after controlling for comorbidity.

Societal-level associations

The population-level projections of the individual-level coefficients amount to annual losses in work performance associ-

Table 3—Associations of sociodemographics with absenteeism and presenteeism among AIS employed respondents (n = 7,428)

	Absenteeism				Presenteeism			
	Mean		Median		Mean		Median	
	Est	(SE)	Est	(SE)	Est	(SE)	Est	(SE)
Age								
18-29	7.7	(0.8)	1.0	(1.1)	16.4	(0.4)	20.3	(0.6)
30-44	5.8	(0.5)	0.6	(1.1)	14.9	(0.3)	18.7	(0.3)
45-64	7.4	(0.6)	0.8	(1.6)	12.9	(0.2)	16.1	(0.3)
65+	10.5	(1.4)	0.6	(3.3)	11.8	(0.7)	13.2	(0.9)
$F_{3,7424}$	4.1*				29.1*			
Sex								
Male	6.5	(0.5)	0.7	(0.9)	15.0	(0.2)	18.6	(0.3)
Female	7.8	(0.5)	0.5	(1.3)	13.4	(2.0)	16.8	(0.3)
$F_{1,7426}$	3.3				29.C4*			
Education								
0-11	9.3	(3.2)	0.9	(8.7)	10.0	(1.2)	12.5	(2.3)
12	9.3	(0.7)	0.0	(1.3)	15.5	(0.3)	17.5	(0.4)
13-15	5.5	(0.9)	1.0	(1.7)	13.1	(0.4)	16.6	(0.5)
16+	6.7	(0.5)	0.5	(1.1)	14.5	(0.2)	18.1	(0.2)
	$F_{3,7424} = 3.5$*				$F_{3,7426} = 7.8$*			

*Significant association between mean scores of either absenteeism or presenteeism across categories of the sociodemographic variable and at the 0.05 level, 2-sided test.

Table 4—Associations of BIQ/broadly defined insomnia with annualized work loss days due to presenteeism with and without controls for comorbidity among employed AIS respondents in the comorbidity subsample (n = 4,991)

	Individual Level				Aggregate Level (Total US Labor Force)[1]			
	Days/year		Dollars/year		Million days/year		Million dollars/year	
	Est	(SE)	Est	(SE)	Est	(SE)	Est	(SE)
Without control	11.3*	(0.1)	3,274*	(66)	367.0*	(4.2)	91,733.2*	(8,967)
With controls	7.8*	(0.1)	2,280*	(48)	252.7*	(3.0)	63,157.9*	(10,001)

*Significant at the 0.05 level, 2-sided test. [1]These results are based on a projection to the total civilian US labor force from population estimates in the August 2010 Current Population Survey (www.bls.gov/cps).

ated with insomnia equal to 367.0 million days and $91.7 billion before controlling for comorbidity, and 252.7 million days and $63.2 billion after controlling for comorbidity. (Table 4) If we assume that these associations represent causal effects of insomnia, then complete eradication of insomnia would lead to proportional reductions of between 5.4% (0.2) and 7.8% (0.2) (standard errors of estimated proportions in parentheses) of all the population-level lost work performance due to presenteeism. The lower of these 2 PARP estimates is based on the assumption that indirect associations of insomnia with presenteeism associated with comorbid conditions are completely due to spurious effects of the comorbid conditions or their causes on insomnia and work performance. The higher of the two proportions is based on the assumption that indirect associations of insomnia with presenteeism associated with comorbid conditions are completely due to indirect causal effects of insomnia through the comorbid conditions. Using AIS data, we cannot determine which of these two assumptions is the more accurate.

DISCUSSION

Given the enormous personal and health care policy implications associated with insomnia among workers, it is important to establish accurate estimates of insomnia occurrence and consequences in the workplace. Unfortunately, there has been little consensus among previous epidemiological studies regarding these estimates. The AIS results are consequently valuable in providing estimates based on validated measures used in a national sample of workers. Results suggest that insomnia is both very common in the US workforce and that insomnia is associated with substantial lost work performance even after controlling for a wide range of comorbid conditions. Before taking these results at face value, though, they have to be evaluated in comparison to previous results in the insomnia epidemiology literature.

Insomnia Prevalence

The most striking discrepancy is that the AIS insomnia prevalence estimate is much higher than most prevalence estimates found in previous reviews of published literature.[39-42] The fact that clinical sleep medicine experts independently evaluated a subsample of AIS respondents and confirmed the accuracy of our prevalence estimate strongly suggests that this estimate is accurate. If that is so, though, what accounts for the much lower prevalence estimates in previous epidemiological surveys?

We do not have a definitive answer to this question, as no single epidemiological study, including the AIS, ever assessed insomnia with the full range of methods used in the most authoritative previous studies, thus making it impossible to link proportional differences in prevalence estimates across studies to major differences in assessment methods. However, four observations together provide the outlines of a plausible answer.

(i) The high AIS overall insomnia prevalence estimate is due to high prevalence of DSM-IV-TR insomnia (21.8%). As shown in an earlier AIS report, the proportions of respondents meeting ICD-10 (3.6%) and RDC/ICSD-2 (14.0%) criteria are considerably lower.[1] This finding is consistent with a considerable amount of previous research showing that seemingly minor differences in criteria across diagnostic systems can lead to enormous differences in prevalence estimates for a wide range of DSM-IV compared to ICD-10 disorders.[43-45] These differences are due to the extreme sensitivity of categorical diagnoses to threshold decisions, which occur even when the dimensional symptom scores underlying the categorical diagnoses in the different diagnostic systems are strongly correlated.[46]

A similar concern has been raised about differences in criteria for insomnia across diagnostic systems.[47] As described in a previous AIS report,[1] the much lower estimated prevalence of insomnia based on ICD-10 than DSM-IV criteria in the AIS is due largely to ICD Criterion C (preoccupation with and excessive concern over consequences of sleep problems at night and during the day), which is endorsed by only a small minority of DSM-IV-TR cases. Endorsement of RDC/ICSD-2 Criterion B (sleep difficulty despite adequate opportunity and circumstance) was also relatively low among DSM-IV cases in the AIS, leading to the lower prevalence of insomnia based on RDC/ICSD-2 than DSM-IV-TR criteria.

(ii) With this extreme sensitivity of prevalence estimates to seemingly minor differences in diagnostic criteria in mind, it is noteworthy that among the 50+ epidemiological studies included in the numerous reviews of the literature on insomnia prevalence,[39-42] only seven are described as meeting full DSM-IV criteria.[39-41,48-51] All seven of these studies used the Sleep-EVAL interview.[39,52]

(iii) An analysis of symptom profiles in the major Sleep-EVAL studies reported that 27.2% of respondents pooled across samples reported symptoms of either difficulties initiating sleep (DIS), difficulties maintaining sleep (DMS), early morning awakening (EMA), or non-restorative sleep (NRS) that met DSM-IV criteria for a diagnosis of insomnia.[53] This estimate does not differ markedly from the proportion of AIS respondents who reported these symptoms. However, although often described as operationalizing DSM-IV criteria, the Sleep-EVAL also requires a number of much more restrictive ICSD-90[54] criteria, such as dreading sleep or being dissatisfied with sleep latency for a designation of DIS and either difficulty falling back to sleep or "bad" sleep or hyperarousal for a designation of DMS/EMA. The requirements of these vestigial ICSD-90 criteria reduced the prevalence estimate of nighttime insomnia symptoms from 27.2% to 16.8% in the Sleep-EVAL studies. This proportion was them reduced further to 11.1% when additional requirements were imposed for sleep disturbance lasting at least one month and for clinically significant distress-impairment.

(iv) The underestimation of DSM-IV inclusion criteria in the Sleep-EVAL is compounded by invoking DSM-IV diagnostic hierarchy rules to exclude cases due to other physical or mental disorders or to side effects of medication or drug use. This is done in the Sleep-EVAL by asking respondents if they believe that their sleep problems would improve if their other physical or mental health problems improved. This exclusion reduced the estimated prevalence of DSM-IV insomnia in the Sleep-EVAL studies examined from 11.1% to 6.1%. It is important to note, though, that this use of hierarchy rules is contrary to the currently accepted recommendation to diagnose insomnia without organic exclusions and then to use controls to adjust for effects of comorbid conditions in statistical analyses of the consequences of insomnia. This recommendation is based on the fact that the vast majority of people with insomnia also carry at

least one diagnosis of a comorbid disorder and the fact that it is extremely difficult to make a definitive distinction between primary and secondary insomnia in the presence of comorbidity. The 2005 NIH State-of-the-Science Conference Statement on chronic insomnia,[21] the 2006 Recommendations for Research Assessment of Insomnia,[22] and the DSM-IV insomnia task force[20] all made the recommendation to diagnose insomnia without hierarchy exclusions based on these facts. Our decision not to use hierarchy rules in making diagnoses was based on this consistent recommendation.

We are aware of only one other general population survey of insomnia prevalence among US workers that has been carried out in the last decade using operationally defined diagnostic criteria: the 2008 National Sleep Foundation *Sleep in America Poll (SAP)*.[55] Although based on a non-probability quota sample (n = 1,000) and having an extremely low response rate (17%), it is nonetheless interesting to note that the 11.0% RDC/ICSD-2 insomnia prevalence estimate in the SAP is quite similar to the 14.0% RDC/ICSD-2 insomnia prevalence estimate in the AIS. The higher prevalence in the AIS might be due to the wider variety of daytime impairments assessed in the AIS than in the SAP. We know of only one other large (n = 12,778) population-based epidemiological survey that estimated insomnia prevalence among workers. That study, which was carried out in a French general population sample,[56] estimated the prevalence of insomnia among mid-level executives, white collar workers, and blue collar workers using DSM-IV inclusion criteria to be 18.4%, 20.8% and 17.9.%, respectively. These estimates are quite similar to the 22.1% prevalence estimate of DSM-IV-TR insomnia among workers in the AIS.

Based on the above considerations we conclude that good reason exists to consider the possibility that the high prevalence estimate of broadly defined insomnia among workers in the AIS is accurate. In summary: (i) Prevalence estimates of a wide range of DSM-IV and ICD-10 disorders have been shown to be extremely sensitive to seemingly minor variations in criteria. (ii) The AIS prevalence estimate was validated by a team of experienced and blinded clinical experts in sleep medicine. (iii) The much lower prevalence estimates of DSM-IV insomnia cited in reviews of the previous insomnia literature are based almost entirely on studies with a perhaps seriously flawed diagnostic interview schedule. (iv) Other recent epidemiological studies that diagnosed insomnia without diagnostic hierarchy rules generated prevalence estimates very similar to the AIS estimate.

Sociodemographic Correlates of Insomnia

The AIS results regarding the associations of insomnia with sociodemographic variables (age and gender) were generally consistent with those reported in previous studies.[56-58] However, our finding of low insomnia prevalence among older workers is at odds with studies that found age-related increases in insomnia,[57] although that pattern has been inconsistent in the literature.[59,60] As reported elsewhere,[61] we carried out a decomposition to investigate this issue and found that sleep problems increase with age in the AIS, but that the proportion of people with sleep problems who also report clinically significant distress or impairment (a requirement for a diagnosis of insomnia) decreases with age, resulting in a low prevalence of insomnia diagnoses among older people. Ohayon and Reynolds[42] reported a similar specification and suggested, based on this finding, that current diagnostic criteria for insomnia might be inadequate for geriatric populations.

The Association of Insomnia with Work Performance

Although our finding that insomnia is associated with significantly reduced work performance is broadly consistent with previous studies,[7,9-12,55] we are aware of only one previous US study that examined the association between insomnia and work performance using a broadly representative sample, validated measures of insomnia and work performance, and controls for comorbidity.[62] That study was like the AIS in being based on a telephone survey carried out in a health plan sample. However, the sample frame was a small Midwestern regional plan rather than the large national plan used in the AIS, and the sample was much smaller than the AIS (n = 1,329 working respondents). Furthermore, the survey oversampled subscribers with evidence of treatment of sleep disorders that included benzodiazepine hypnotics and antidepressant prescriptions that in some unknown proportion of cases were prescribed to treat anxious insomniacs and depression rather than sleep problems without adding a post-stratification weight to adjust for this sample bias. This sampling scheme might have undermined the representativeness of the subsample of insomniacs. The response rate was also quite low (19.6% of subscribers with a sleep disorder diagnosis; 25.0% of other subscribers). The study used the same measure as the AIS (the HPQ) to assess lost work performance and controlled for comorbidity (but only treated comorbid conditions), but differed from the AIS in using the Insomnia Severity Index (ISI)[63] rather than the BIQ to assess insomnia. The annualized individual-level estimate of lost work performance due to insomnia was $726 in direct salary, which is equivalent to $943 including the 30% fringe benefits estimate used in the AIS. This estimate is considerably smaller than the $2,280-3,274 AIS estimate. We are aware of only one other study, carried out in Quebec, that made a comparable estimate.[7] That study estimated insomnia with the ISI and presenteeism with a simple self-report measure of work performance and concluded that the annual individual-level insomnia-related work loss due to presenteeism was C$4,164. This estimate is higher than the AIS estimate, but that could have been due to the absence of controls for comorbid conditions.

We are aware of four other contemporary US epidemiological studies that assessed the costs of insomnia. Two of these studies used medical or prescriptions claims to define insomnia and administrative records to define absenteeism and did not study presenteeism.[10,11] Benzodiazepines were included in the list of qualifying medications in both these studies even though this doubtlessly led to a confounding of treated insomnia with treated anxiety. The use of administrative records to define absenteeism in these two studies probably led to underestimation of sporadic absenteeism among white collar workers, as we know that the occasional absences of white collar workers are often not recorded. The third recent US epidemiological study also focused on treated insomnia, but obtained information about treatment from self-reports rather than claims data and also assessed absenteeism and presenteeism with self-reports.[12] This third study was based on a non-probability sample from a

consumer panel, making it an inappropriate source from which to extrapolate results to the general population. The fourth US study was the 2008 National Sleep Foundation *Sleep in America Poll*.[55] Although the SAP examined associations between self-reported sleep problems and self-reported work impairments and found significant associations of insomnia with both absenteeism and presenteeism, the extremely low response rate (17%) and coarse measures of absenteeism and presenteeism make precise comparisons of SAP results with AIS results impossible.

A number of other international studies of insomnia and work performance have been carried out that have consistently found insomnia to be related to either short-term absenteeism,[64-66] presenteeism,[7,67] or disability,[68] but did not monetize results. A large (n = 37,302) prospective Norwegian study is especially noteworthy in that it calculated the PARP of baseline insomnia predicting subsequent disability pension claims controlling for a number of comorbid conditions. The PARP estimate (6.7%) was roughly similar in magnitude to the AIS PARP for presenteeism (5.4%).

A number of these previous studies examined the relative importance of insomnia in predicting presenteeism and absenteeism.[7,12,67] They uniformly found, consistent with the AIS, that insomnia is much more strongly related to presenteeism than absenteeism. This means that workers with insomnia generally put in the same number of work hours as other workers, but that their on-the-job performance is lower than other workers. This finding is consistent with a larger literature showing that the majority of lost work performance occurs during days when workers are on the job rather than off work.[69,70]

Our estimate of $59.8 billion annual lost productivity in the US due to insomnia-related lost work performance has no valid comparator. Two highly-cited US estimates of the societal costs of insomnia are decades old.[9] Estimate of the societal costs of insomnia based on more recent data[10] were generated using medical-pharmacy claims data to measure insomnia, which dramatically underestimate prevalence due to the low proportion of insomnias in treatment. The AIS estimate needs to be interpreted with caution because the national sample on which the AIS is based is limited to managed care subscribers.

The AIS results are limited by two sampling issues. First, the low cooperation rate (65.0%) might have distorted estimates of prevalence and correlates. Second, the fact that all respondents were members of a large national commercial health plan means that results may not generalize to the roughly 15% of the US population that lacks health insurance or to segments of the population with insurance not provided by commercial health plans.

The AIS measures also have limitations. Insomnia was assessed with the fully structured BIQ rather than with clinical interviews, which could introduce imprecision into the measurement of insomnia, although this concern is somewhat lessened by the fact that the AIS clinical reappraisal study found good concordance between diagnoses based on the BIQ and diagnoses based on blinded clinical reappraisal interviews.[16] A related issue discussed above was that diagnostic hierarchy and organic exclusion rules were not applied to insomnia diagnoses, but we controlled for comorbid conditions to correct for any inflation in the estimated effects of insomnia introduced by failing to make these diagnostic exclusions. Another potential limitation related to measurement is that work performance was assessed with the HPQ rather than with objective audits of absenteeism or presenteeism. Concern about this limitation is reduced somewhat, though, by the fact that validation studies have found strong associations between the HPQ and objective administrative records of absenteeism and presenteeism.[17,18]

These limitations notwithstanding, the AIS findings add important new information about the prevalence and associations of insomnia with work performance. The $2,280-3,274 individual-level estimate of the value to the employer of performance loss due to insomnia is especially striking. Cost estimates as high as these lead inevitably to the question whether workplace screening and treatment programs for workers with insomnia would be cost-effective from an employer perspective. Although numerous controlled studies have been carried out to document the effectiveness of pharmacologic[71] and behavioral[72] treatments of insomnia, very few have studied the cost-effectiveness of treatment from an employer perspective.[73,74] Given the low proportion of insomniacs who are in treatment,[8] the evidence for treatment effectiveness from available controlled studies, and the high value of lost work performance due to insomnia in relation to the costs of treatment, it would be valuable to carry out controlled workplace effectiveness trials to obtain accurate estimates of the return-on-investment of such interventions from the employer perspective.

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