Trouble Sleeping Associated With Lower Work Performance and Greater Health Care Costs

Longitudinal Data From Kansas State Employee Wellness Program

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Objective: To examine the relationships between employees' trouble sleeping and absenteeism, work performance, and health care expenditures over a 2-year period. **Methods:** Utilizing the Kansas State employee wellness program (EWP) data set from 2008 to 2009, multinomial logistic regression analyses were conducted with trouble sleeping as the predictor and absenteeism, work performance, and health care costs as the outcomes. **Results:** EWP participants ($N = 11,698$ in 2008; 5636 followed up in 2009) who had higher levels of sleep disturbance were more likely to be absent from work (all $P < 0.0005$), have lower work performance ratings (all $P < 0.0005$), and have higher health care costs ($P < 0.0005$). Longitudinally, more trouble sleeping was significantly related to negative changes in all outcomes. **Conclusions:** Employees' trouble sleeping, even at a subclinical level, negatively impacts on work attendance, work performance, and health care costs.

Learning Objectives

- Become familiar with previous research on how sleep disturbances affect occupational outcomes, including absenteeism and decreased productivity.
- Summarize the new findings on associations between sleep quality and work attendance, performance, and health care costs.
- Discuss the implications for incorporating sleep improvement intervention into employee wellness programs.

Sleep is an important area of focus in occupational medicine. Previous studies have shown associations between employees' sleep disturbances and a wide variety of negative occupational outcomes, including (1) absenteeism, (2) decreased productivity or presenteeism, (3) accidents and injuries, and (4) increased health care costs. According to a recent World Economic Forum report emphasizing chronic disease prevention at worksites as a strategy to enhance workforce wellness and performance, insufficient sleep is one of the eight major employee behaviors that employers should invest resources to address, to significantly reduce health care cost and increase productivity.[1] In the United States, employees' insufficient sleep caused an estimated $150 billion in indirect costs (combined costs of absenteeism, presenteeism, and workplace accident or injuries).[1]

Strong evidence from previous studies shows sleep disturbances are important factors of absenteeism; for instance, a study by Sivertsen et al[2] examined data from the Hordaland Health Study, and showed that insomnia and sleep apnea were both predictive of subsequent sick leave. These findings were echoed in the study by Bultmann et al,[3] who found that in the Danish Work Environment Cohort Study, sleep disturbances and fatigue significantly predicted sickness absence. Rahkonen et al[4] examined data from employees of the City of Helsinki, and found that frequent sleep problems were associated with increased sickness absences, both short and long in duration. Rajaratnam et al[5] found that police officers with probable sleep disorders were more likely to miss work as well. These and other studies suggest that poor sleep quality is associated with greater absenteeism.

Regarding decreased productivity at work (ie, presenteeism) because of sleep problems, several studies have assessed these effects in varying ways. For example, Kessler et al[6] examined data from the American Insomnia Survey, and found that poor sleep quality was significantly associated with lost work performance because of presenteeism. Swanson et al[7] found that self-reported symptoms of insomnia, sleep apnea, restless legs syndrome, and other sleep disorders were consistently associated with presenteeism. McKibben et al[8] found that sleep disturbances were associated with a 3-fold risk of impaired work performance and a 5-fold risk of limited day-to-day function among employees of the Florida Department of Health. In a landmark study, Rosekind et al[9] examined data from several US companies, and found that for a typical good sleeper, the cost of decreased productivity because of insufficient sleep per year (based on salary) was $1293 per employee. This was increased to $2319 among those at risk for insufficient sleep, $2796 for those with insufficient sleep, and $3156 for those with insomnia. In addition, this study found that the lost productivity was attributed to several domains, including impaired ability to meet time management demands, mental and interpersonal demands, output demands, and physical job demands.

Regarding increased accidents and injuries in occupational settings, many studies have showed that employees' sleep disturbances are significant risk factors. These findings have been reported across numerous professions, including physicians,[10,11] nurses,[12–14] police officers,[5] truck drivers,[15–19] bus drivers,[20] factory workers,[21] and others.[22] Furthermore, Shahly et al[23] found that self-reported poor sleep quality was associated with costly workplace accidents and errors. These studies focused on varying sleep factors (eg, sleep apnea, sleep deprivation, shift work), but they show that, overall, trouble sleeping is an important risk factor for accidents and injuries.

In addition, employers incur substantial direct health care costs because of insufficient sleep of their employees. Strong evidence has shown that sleep deficiency or poor sleep quality is related to many chronic diseases such as coronary heart disease, diabetes, hypertension, overweight and obesity, and chronic stress and psychological problems.[24]

Only a few studies to date have examined the potential impact of poor sleep on health care costs. This is an important

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consideration, given that health care costs are rising dramatically and this is a key expenditure for employers. Most of the studies in this domain have focused on sleep apnea, showing that screening for, diagnosing, or both treating sleep apnea can significantly reduce health care expenditures in occupational settings[25–27]; however, there have been a number of studies showing how ameliorating sleep problems can potentially reduce health care costs.[28,29] These studies show that untreated sleep disorders, such as insomnia and sleep apnea, can profoundly increase health care expenditures. Despite these findings, previous studies have typically not examined the role of trouble sleeping in general, which may or may not meet criteria for a sleep disorder but may, still, impact health.

Moreover, not only does poor sleep directly contribute to chronic diseases, it may be indirectly contributing to their development through unhealthy behaviors,[24] as previous studies indicated that sleep deficiency and/or poor sleep quality are associated with a number of behavioral risk factors of chronic diseases such as smoking,[30] alcohol abuse,[31] high stress,[32–34] low level of physical activities,[35] and poor nutrition.[35,36]

Despite the fact that sleep disturbances are contributing to numerous negative occupational outcomes and that having sufficient and quality sleep is an important health behavior,[37,38] the increasingly popular employee wellness programs (EWP) in the United States currently still lack a sleep improvement component to promote employee overall health. Among the employers offering a lifestyle management program in their EWP, most of them target nutrition/weight management (79%), smoking (77%), and fitness (72%).[39]

Taken together, the existing literature suggests that trouble sleeping may have an impact in a number of occupational demands, including absenteeism, presenteeism, accidents/injuries, and health care expenditures, but employers are not investing sufficient resources to alleviate these problems. Generalizability of previous studies on the relation between sleep and occupational outcomes may be limited by a number of factors. For example, existing studies tended to focus on specific occupations (eg, truck drivers), focus on specific sleep disorders (rather than general sleep problems), and focus on cross-sectional analyses (because of unavailability of longitudinal data). One possible avenue for an analysis that addresses some of these issues would be to examine data from an EWP in an organization large enough to include many different professions (increasing generalizability), using a measure of general sleep disturbance (to capture subclinical problems), and making use of follow-up data (to examine longitudinal relationships).

Accordingly, to bring greater awareness to employers about the significance of addressing sleep problems in the employee population, and establish a generalizable, quantified longitudinal effect of sleep disturbance on work performance and health care costs, the current study utilized a large Kansas State EWP data set to examine the relationships between trouble sleeping and absenteeism, work performance, and health care expenditures over a 2-year period. This allowed us to investigate relationships between changes in trouble sleeping and changes in these important workplace-related outcomes.

METHODS

Data Source

The data for the current study were obtained through a data use agreement between the University of Kansas Medical Center and the Kansas Health Policy Authority in 2010. Data included basic personnel data of all Kansas state employees enrolled in the state health plans, as well as the complete individual-level responses of all health risk assessment (HRA) participants across 2008 and 2009. The personnel data in this data set included the health plan members' age and total health care expenses (sum of expenses in medical care, prescription drugs, and dental care) in the year for both years. These employees were eligible to participate in the Kansas State EWP, of which the online HRA was a major component. Each individual in these data had a unique alphanumerical identifier. Because the coding of the numerical identifier was unknown to the authors, these data were not considered as personally identifiable, and it was deemed exempt by the Human Subjects Committee at the University of Kansas Medical Center.

Measures

All measures of sleep disturbance, absenteeism, and work performance were self-reported responses to the online HRA questionnaire in both 2008 and 2009. Online HRA is a gateway component of virtually all EWP, which collects information on employees' personal, familial, lifestyle, and emotional risk factors of common chronic diseases. Employees were given $50 gift card to complete their online HRA and onsite biometric screening yearly.

Sleep disturbance was assessed with the question, ''During the past 4 weeks, how often have you been bothered by any of the following problems?'' with ''Trouble Sleeping'' as one item. The response choices were ''Never,'' ''Seldom,'' ''Sometimes,'' ''Often,'' and ''Always.''

Absenteeism was assessed by two questions: (1) in past 4 weeks, number of days you missed an entire workday because of problems with your physical or mental health (only include days missed for your own health, not someone else's health), and (2) in past 4 weeks, number of days you missed part of a workday because of problems with your physical or mental health (only include days missed for your own health, not someone else's health).

Self-rated work performance was assessed by the question, ''On scale from 0 (worst) to 10 (best), how would you rate your overall job performance on the days you worked during the past 4 weeks (28 days)?''. Others' work performance was assessed by the question, ''On scale from 0 (worst) to 10 (best), how would you rate the usual performance of most workers in a job similar to yours?''. Relative work performance score in our analysis was obtained by subtracting the others' work performance rating from the self work performance rating.

Health care costs data were collected from the health services claims processed by the state employee health plans offered by the former Kansas Health Policy Authority (now subsumed in the Division of Health Care Finance, Kansas Department of Health and Environment). Covariates included age, sex, race/ethnicity, highest education level achieved, total household income, and self-rated health. These were included because they are associated with both sleep quality and occupational factors in the literature.

Statistical Analyses

To examine relationships between trouble sleeping and baseline absenteeism, multinomial logistic regression analyses used absenteeism as outcome (0 days as reference, relative to 1 to 2, 3 to 6, and 7 or more days). Trouble sleeping was included as a categorical variable (reference = ''never''). To investigate linear trends, the ordinal trouble sleeping variable was also assessed as a pseudo-continuous variable. To examine relationships between trouble sleeping and baseline self-rated performance, relative performance, and health care costs, these were input as continuous outcomes in multiple linear regression analyses. Trouble sleeping was again assessed as a categorical variable and a pseudo-continuous variable. Analyses were performed with and without covariates. To examine longitudinal changes in outcomes relative to longitudinal changes in trouble sleeping, change scores for all variables were computed by subtracting 2008 from 2009 data. (Thus, positive values mean an increase over 1 year.) Change scores for all variables were computed, including absenteeism variables which were treated

TABLE 1. Characteristics of the Baseline Sample ($N = 11,698$)

Variable	Category	Total Sample	2008 Data Only	2008 and 2009 Data
N		11,698	6,062	5,636
Age	Mean ± SD	44.60 ± 11.50	43.87 ± 12.02	45.39 ± 10.86
Sex	Female	63.93%	63.43%	64.46%
Race/ethnicity	Non-Hispanic White	86.53%	85.43%	87.70%
	Black/African American	4.51%	5.51%	3.44%
	Hispanic/Latino	3.42%	3.70%	3.12%
	Native American	2.62%	3.10%	2.11%
	Asian/Other	2.92%	2.26%	3.62%
Education	Postgraduate	25.58%	25.26%	25.92%
	College graduate	33.63%	31.92%	35.47%
	Some college	27.00%	27.52%	26.44%
	High school	13.17%	14.42%	11.83%
	Less than high school	0.62%	0.89%	0.34%
Income	$100,000+	2.14%	2.46%	1.79%
	$85,001–$100,000	1.89%	2.14%	1.61%
	$55,001–$85,000	14.17%	13.30%	15.12%
	$35,001–$55,000	39.61%	36.75%	42.67%
	$20,001–$35,000	34.90%	36.19%	33.52%
	$0–$20,000	7.29%	9.16%	5.29%
Health	Excellent	11.56%	11.38%	11.75%
	Very good	42.02%	40.91%	43.20%
	Good	38.74%	38.98%	38.48%
	Fair	7.27%	8.23%	6.23%
	Poor	0.42%	0.49%	0.34%
Absenteeism (missed full days in the past 4 wks)	0 d	72.61%	71.61%	73.69%
	1–2 d	22.06%	22.29%	21.82%
	3–6 d	4.50%	5.13%	3.81%
	≥7d	0.83%	0.97%	0.67%
Absenteeism (missed part days)	0 d	76.39%	77.17%	75.55%
	1–2 d	20.28%	19.28%	21.34%
	3–6 d	2.80%	3.04%	2.54%
	≥7 d	0.54%	0.51%	0.57%
Absenteeism (missed total days)	0 d	61.17%	61.33%	61.00%
	1–2 d	27.42%	26.71%	28.19%
	3–6 d	9.39%	9.72%	9.03%
	≥7 d	2.02%	2.24%	1.77%
Work performance (subjective)	perf_r	8.32 ± 1.35	8.30 ± 1.38	8.33 ± 1.32
Work performance (relative)	perf_d1	0.89 ± 1.57	0.89 ± 1.60	0.88 ± 1.55
Health care costs	Mean ± SD	5,016.65 ± 11,691.27	5,199.46 ± 13,689.51	4,820.03 ± 9,060.05
Trouble sleeping	Never	44.05%	43.60%	44.54%
	Seldom	22.00%	20.69%	23.40%
	Sometimes	22.11%	23.00%	21.15%
	Often	8.60%	8.91%	8.27%
	Always	3.25%	3.81%	2.64%
Absenteeism (missed full days) change	Mean ± SD	−0.09 ± 1.98		
Absenteeism (missed part days) change	Mean ± SD	−0.01 ± 2.03		
Absenteeism (missed total days) change	Mean ± SD	−0.10 ± 3.23		
Work performance (subjective) change	Mean ± SD	−0.07 ± 1.41		
Work performance (relative) change	Mean ± SD	0.06 ± 1.76		
Trouble sleeping category change	4 categories improved	15.83%		
	3 categories improved	4.61%		
	2 categories improved	0.77%		
	1 category improved	0.14%		
	No change	51.42%		
	1 category worse	19.83%		
	2 categories worse	6.24%		
	3 categories worse	1.00%		
	4 categories worse	0.16%		

as continuous for this calculation. Linear regression analyses examined trouble sleeping change scores as predictor of change scores for outcome variables, controlling for their baseline. All analyses were repeated after adjustment for covariates. *P* values <0.05 were considered significant. All analyses were performed using STATA 12.0 software (College Station, TX).

RESULTS

Sample Characteristics

The sample consisted of $N = 11,698$ participants assessed in 2008 and $N = 5636$ who were followed up in 2009. The participation rates in the online HRA were 26% and 19% in the 2 years,

TABLE 2. Results of Multinomial Logistic Regression Analyses Investigating Associations Between Trouble Sleeping (Reference = Never) and Absenteeism (Reference = 0 Days)

	1–2 d			3–6 d			≥7 d		
Trouble Sleeping Category	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***
				Unadjusted					
				Missed Full Days					
Never		Reference			Reference			Reference	
Seldom	1.40	1.25–1.58	<0.0005	1.30	0.99–1.70	0.054	1.41	0.73–2.71	0.301
Sometimes	1.66	1.48–1.87	<0.0005	2.33	1.84–2.95	<0.0005	2.52	1.42–4.44	0.001
Often	2.55	2.18–2.97	<0.0005	4.50	3.42–5.91	<0.0005	6.53	3.59–11.88	<0.0005
Always	2.71	2.13–3.43	<0.0005	6.48	4.53–9.26	<0.0005	11.52	5.75–23.09	<0.0005
Linear trend†	*1.31*	*1.26–1.36*	*<0.0005*	*1.63*	*1.52–1.75*	*<0.0005*	*1.88*	*1.61–2.20*	*<0.0005*
				Missed Partial Days					
Never		Reference			Reference			Reference	
Seldom	1.45	1.29–1.64	<0.0005	1.64	1.19–2.26	0.002	2.90	1.22–6.90	0.016
Sometimes	1.74	1.54–1.96	<0.0005	2.18	1.61–2.94	<0.0005	5.32	2.43–11.65	<0.0005
Often	2.20	1.88–2.58	<0.0005	3.94	2.49–5.56	<0.0005	11.46	5.04–26.04	<0.0005
Always	2.76	2.19–3.49	<0.0005	5.81	3.73–9.07	<0.0005	10.38	3.45–31.23	<0.0005
Linear trend†	*1.30*	*1.25–1.35*	*<0.0005*	*1.55*	*1.42–1.70*	*<0.0005*	*1.93*	*1.59–2.34*	*<0.0005*
				Missed Days Total					
Never		Reference			Reference			Reference	
Seldom	1.37	1.23–1.53	<0.0005	1.64	1.37–1.97	<0.0005	1.68	1.09–2.58	0.018
Sometimes	1.60	1.44–1.78	<0.0005	2.36	1.99–2.80	<0.0005	3.43	2.37–4.97	<0.0005
Often	2.12	1.81–2.47	<0.0005	4.54	3.68–5.59	<0.0005	8.43	5.66–12.55	<0.0005
Always	2.15	1.67–2.78	<0.0005	7.17	5.40–9.52	<0.0005	12.91	7.86–21–19	<0.0005
Linear trend†	*1.25*	*1.21–1.30*	*<0.0005*	*1.63*	*1.55–1.72*	*<0.0005*	*1.98*	*1.79–2.20*	*<0.0005*
				Adjusted*					
				Missed Full Days					
Never		Reference			Reference			Reference	
Seldom	1.30	1.16–1.47	<0.0005	1.16	0.88–1.52	0.296	1.20	0.62–2.32	0.583
Sometimes	1.45	1.29–1.64	<0.0005	1.78	1.39–2.26	<0.0005	1.78	0.99–3.18	0.053
Often	1.95	1.66–2.29	<0.0005	1.76	2.07–3.68	<0.0005	3.70	1.99–6.90	<0.0005
Always	1.92	1.50–2.45	<0.0005	3.40	2.33–4.96	<0.0005	5.58	2.69–11.59	<0.0005
Linear trend†	*1.21*	*1.16–1.26*	*<0.0005*	*1.39*	*1.29–1.50*	*<0.0005*	*1.56*	*1.32–1.85*	*<0.0005*
				Missed Partial Days					
Never		Reference			Reference			Reference	
Seldom	1.36	1.20–1.54	<0.0005	1.49	1.08–2.05	0.016	2.38	1.00–5.69	0.051
Sometimes	1.54	1.36–1.74	<0.0005	1.78	1.31–2.42	<0.0005	3.86	1.74–8.55	0.001
Often	1.74	1.47–2.05	<0.0005	2.62	1.83–3.76	<0.0005	6.76	2.90–15.76	<0.0005
Always	2.03	1.59–2.58	<0.0005	3.42	2.15–5.47	<0.0005	5.37	1.72–16.70	0.004
Linear trend†	*1.21*	*1.16–1.26*	*<0.0005*	*1.36*	*1.24–1.50*	*<0.0005*	*1.64*	*1.33–2.01*	*<0.0005*
				Missed Days Total					
Never		Reference			Reference			Reference	
Seldom	1.28	1.14–1.43	<0.0005	1.46	1.22–1.76	<0.0005	1.44	0.94–2.23	0.097
Sometimes	1.42	1.27–1.58	<0.0005	1.87	1.57–2.23	<0.0005	2.48	1.69–3.62	<0.0005
Often	1.67	1.42–1.97	<0.0005	2.94	2.36–3.66	<0.0005	4.69	3.09–7.12	<0.0005
Always	1.60	1.24–2.08	<0.0005	4.08	3.03–5.50	<0.0005	6.02	3.57–10.14	<0.0005
Linear trend†	*1.17*	*1.12–1.21*	*<0.0005*	*1.42*	*1.35–1.50*	*<0.0005*	*1.64*	*1.47–1.82*	*<0.0005*

CI, confidence interval; OR, odds ratio. *Adjusted for age, sex, race/ethnicity, education, income, and overall health.
P values <0.05 are considered significant.
†Evaluating trouble sleeping as a pseudo-continuous ordinal variable; effects for one-category increase.

respectively. Characteristics of the sample are shown in Table 1, which displays demographic and socioeconomic covariates, health status, occupational outcome variables (absenteeism, work performance, and health care costs), and trouble sleeping.

Table 1 also displays differences between the complete sample and those that provided longitudinal data. Although only 48% of respondents provided follow-up data, this group did not differ from the full sample or those that only provided the first-year

TABLE 3. Associations Between Trouble Sleeping, Work Performance, and Health Care Costs

	Subjective Performance (0–10)			Relative Performance (Self/Other)			Health Care Costs ($)		
Trouble Sleeping Category	***B***	**95% CI**	***P***	***B***	**95% CI**	***P***	***B***	**95% CI**	***P***
					Unadjusted				
Never		Reference			Reference				
Seldom	−0.16	−0.23 to −0.10	<0.0005	−0.11	−0.18 to −0.03	0.005	$551.05	$1.52–$1,100.58	0.049
Sometimes	−0.23	−0.29 to −0.16	<0.0005	−0.12	−0.19 to −0.04	0.002	$1,943.71	$1,395.11–$2,492.32	<0.0005
Often	−0.51	−0.60 to −0.42	<0.0005	−0.31	−0.41 to −0.20	<0.0005	$3,639.55	$2,854.87–$4,424.22	<0.0005
Always	−0.48	−0.62 to −0.34	<0.0005	−0.31	−0.47 to −0.14	<0.0005	$5,206.07	$3,995.97–$6,416.17	<0.0005
Linear trend†	*−0.14*	*−0.16 to −0.12*	*<0.0005*	*−0.08*	*−0.11 to −0.06*	*<0.0005*	*$1,166.70*	*$981.73–$1,351.66*	*<0.0005*
					Adjusted‡				
Never		Reference			Reference				
Seldom	−0.15	−0.21 to −0.09	<0.0005	−0.10	−0.17 to −0.02	0.011	−$13.38	−$560.54 to $533.77	0.962
Sometimes	−0.21	−0.28 to −0.15	<0.0005	−0.11	−0.18 to −0.03	0.005	$1,027.34	473.18–$1,581.50	<0.0005
Often	−0.42	−0.51 to −0.33	<0.0005	−0.25	−0.36 to −0.15	<0.0005	$2,337.19	$1,541.31–$3,133.07	<0.0005
Always	−0.36	−0.50 to −0.22	<0.0005	−0.24	−0.41 to −0.08	0.004	$3,461.89	$2,242.13–$4,681.64	<0.0005
Linear trend†	*−0.11*	*−0.14 to −0.09*	*<0.0005*	*−0.07*	*−0.09 to −0.04*	*<0.0005*	*$725.15*	*$532.98–$917.33*	*<0.0005*

CI, confidence interval.
†Adjusted for age, sex, race/ethnicity, education, income, and overall health.
‡Evaluating trouble sleeping as a pseudo-continuous ordinal variable; effects for one-category increase.

data in any clinically meaningful way. For example, age, sex, race/ethnicity, income, and other factors were similarly distributed.

Absenteeism

Results of analyses assessing absenteeism at baseline are shown in Table 2. These include multinomial logistic regression analyses with absenteeism as outcome (odds of 1 to 2, 3 to 6, and 7 or more days, relative to 0 days) and trouble sleeping as predictor. When trouble sleeping was assessed as a categorical variable, higher levels of trouble sleeping were associated with greater likelihood of absenteeism. This was consistent for missed full days, missed partial days, and total missed days. In addition, in all cases, a significant linear trend was found, demonstrating increased likelihood of each absenteeism category associated with increasing levels of trouble sleeping. This pattern was maintained for both unadjusted and adjusted analyses.

Work Performance

Results of analyses assessing trouble sleeping associated with work performance measured at baseline are shown in Table 3. Regarding self-rated recent work performance, trouble sleeping was consistently associated with lower self-ratings of work performance. In addition, trouble sleeping was consistently associated with a greater discrepancy between self-reported recent work performance and self-reported average performance of a worker in their job. Although workers typically rated themselves as above average, the degree to which they reported themselves to be above average depended on trouble sleeping. A linear trend between trouble sleeping and work productivity was also found. This was consistent for both unadjusted and adjusted analyses.

Health Care Costs

Results of analyses assessing sleep disturbance at baseline with total health care costs for that year are also shown in Table 3. More trouble sleeping was, in general, associated with greater health care costs. For example, workers who report that they ''always'' experience trouble sleeping were associated with a mean $5206 in health care expenditures above those who ''never'' have problems; after adjusting for covariates, including overall health, this discrepancy was maintained but attenuated, representing an increased cost of $3461. In addition, a linear trend was found, such that in adjusted analyses, each category increase in the variable measuring trouble sleeping was associated with an additional $725 cost.

Longitudinal Change

Table 4 describes relationships between change in trouble sleeping and change in absenteeism, work performance, and health care costs over 1 year. Linear relationships between changes in trouble sleeping and changes in all outcomes were detected in both adjusted for baseline only and adjusted for baseline and covariates analyses. For example, in adjusted for baseline and covariates analysis, every 1-unit worsening in trouble sleeping over 1 year

TABLE 4. Associations Between Changes in Trouble Sleeping and Changes in Absenteeism, Work Performance, and Health Care Costs

	Adjusted for Baseline			Adjusted for Baseline and Covariates		
Absenteeism (full days)	0.14	0.09–0.19	<0.0005	0.12	0.08–0.18	<0.0005
Absenteeism (partial days)	0.15	0.10–0.21	<0.0005	0.14	0.08–0.19	<0.0005
Absenteeism (total)	0.28	0.21–0.36	<0.0005	0.26	0.19–0.36	<0.0005
Subjective performance	−0.08	−0.12 to −0.05	<0.0005	−0.08	−0.12 to −0.05	<0.0005
Relative performance	−0.08	−0.13 to −0.04	<0.0005	−0.06	−0.12 to −0.03	0.001
Healthcare costs	$411.15	$224.02–$598.29	<0.0005	$340.45	$152.60$528.30	<0.0005

was associated with missing approximately 0.26 days (including 0.12 full and 0.14 partial days), a 8% decline in self-rated work performance, an 6% decline in relative work performance, and an increase of $340 in health care expenditures.

DISCUSSION

The current study investigated the relationships between employees' sleep disturbance and work attendance, work performance, and health care costs over a 2-year period, using a large Kansas State EWP participants' HRA data. Our analyses found that cross-sectionally, higher levels of sleep disturbance were associated with greater likelihood of absenteeism (either full days or partial days), greater likelihood of lower self-ratings of work performance (either self only or relative to other workers). In terms of health care costs, our cross-sectional analyses also found significant association between more frequent trouble sleeping and higher health care costs. More importantly, in our longitudinal analyses, we found that worsening of sleep disturbance over 1 year was associated with further absenteeism, low work productivity, and higher health care costs. These findings suggest that trouble sleeping of employees, even at a subclinical level, have significant negative impact on work performance and health care costs, which are important occupational outcomes to employers.

Previous studies on the relation between sleep disorders (eg, insomnia, sleep apnea, etc) or sleep disturbances (eg, disrupted, insufficient sleep) variables and absenteeism reported that workers with these sleep problems are more likely to be absent from work,[7,40,41] and hence loss of productivity. This is detrimental to both the employee and employer. Our results are consistent with the literature with additional findings on the missed full days versus partial days. After adjusting for potential covariates, we found that the employees who indicated even ''seldom'' had trouble sleeping were significantly associated with up to 6 missed days total. This association was stronger, and the number of missed days total was higher as the level of trouble sleeping increased. This highlights the potential absenteeism consequence of even low frequency of trouble sleeping.

Perhaps more concerning to employers is the relation between trouble sleeping and presenteeism or lower work performance on the job. Several studies have found significant associations between sleep disturbances and lower work performance, more errors at work, more work disabilities, or more accidents at work.[6–9,42–46] The presenteeism problem is more serious than the absenteeism one, as it is more costly to the employers. Not only the employers are paying the employees for being present at work, they are also more likely to pay for longer work time to complete a task or any compensation because of errors or disabilities caused by the fatigued (cognitively or physically) employees. Our results again confirmed the previous literature in this relation, in that even ''seldom'' had trouble sleeping was associated with lower subjective and relative work performance ratings. Our data added new insight into relative work performance, suggesting higher level of trouble sleeping is related to lesser degree of above average work performance. The correlation between trouble sleeping and lower productivity at work is alarming, and the fact that over half of our sample (56%) reported some level of sleep disturbance calls for development and implementation of effective intervention to monitor and improve employees' sleep health.

Regarding the relation between trouble sleeping and health care expenditure, literature is limited in this area, but the available studies suggest the increased health care service utilization[42] and increased medical and prescription costs[40] among employees with insomnia, as opposed to those without. Very few studies have been able to analyze actual health care expenses, rather they made estimated economic costs of workplace productivity loss associated with poor sleep.[6,9] Our findings provided concrete evidence that each unit of increased sleep disturbance is associated with progressively higher total health care expense. This linear relation was true for employees whose sleep disturbance may not have met the diagnostic criteria of insomnia as well. The implications of this finding could be that as sleep disturbance increases, the employee either actually experienced more illnesses that need health care, or perceived to experience ill health and sought more health care services. These phenomena are likely because of the various negative physiological or mental health effects of sleep disturbances. Either way, the poor health status caused by trouble sleeping among employees directly costs employers' business outcome, especially most employers are still paying for a large portion of their employees' health insurance in the United States.

A few strengths of the current study should be noted. Our HRA participants' sample was large and occupationally diverse. It encompasses Kansas state employees from many industries (eg, education, transportation, health care, administration, etc); the data from the present study are likely to be generalizable to multiple industries. Our data set also included objective data on the health care expenses, which allowed us to examine the actual dollars spent associated with different degrees of trouble sleeping. Another unique aspect of our data is that we had the longitudinal HRA responses data across 2 years, which allowed us to examine the association between worsening trouble sleeping and abstenteeism, work performance, and health care costs outcomes. Last but not least, our sample included employees who had sleep disturbances that might not have met diagnoses of sleep disorders, so we could examine the relation between subclinical sleep problems and important occupational outcomes.

Limitations

The single-item measure of sleep quality is problematic for several reasons. Most importantly, this question has not been specifically validated against any standard sleep measure; thus, it is unclear to what degree the construct captured by this item represents better-validated measures of sleep. Second, self-reported, single-item, retrospective sleep items are not ideal for assessing sleep. Objective measures, such as actigraphy, and prospective measures, such as sleep diary, would be ideal. Nonetheless, single-item sleep quality measures have proven useful in many previous studies.[24] The HRA responses data we used were self-reported, so we cannot know the actual respondents' absenteeism and work performance. The significant linear trends and associations found were from the cross-sectional data at baseline, and causal inference cannot be made. Our sample was also geographically limited to the Kansas State.

Finally, the low HRA participation rate could potentially have resulted in a sample biased on one of the measures of interest. This HRA participation rate (approximately 20%) is typical among EWP,[39] and because the participation rate in the present study is in line with that of most other studies, the data are likely to be at least as representative as is the standard in the literature. Previous studies reported that when participation rates are lower than 30%, female workers are more likely to participate in worksite health promotion programs, though no other systematic demographic differences (eg, age, race/ethnicity, marital status, education, income level) between participants and nonparticipants were consistently found[47,48] using chi-square, *t* tests, or meta-analysis techniques (eg, Cohen d). This was also the case in our study population.

Further studies will be needed to address the weaknesses of this study, such as using more objective and standard subjective measures of sleep disturbance and objective measures of absenteeism, and work performance. It would also be more desirable to have longitudinal data with longer follow-up time to confirm the trend we found between the 2 years. The longer follow-up longitudinal data will also allow investigation of whether improved sleep over time

may reverse the negative effect of absenteeism, work performance, and health care costs.

CONCLUSIONS

The present study demonstrated that trouble sleeping was associated with a greater likelihood of missed workdays, lower work performance (either subjective or relative), and higher overall health care costs. Longitudinal data analyses across 2 years also demonstrated that each unit of worsening trouble sleeping over time was associated with more missed workdays, decline in work performance, and increased health care costs over time. These results indicate that it is important for employers to incorporate sleep improvement intervention as one of the essential lifestyle change interventions offered in EWP to promote health and productivity of the large employee population.

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REFERENCES

1. World Economic Forum. *The New Discipline of Workforce Wellness: Enhancing Corporate Performance by Tackling Chronic Disease*. Geneva, Switzerland: World Economic Forum; 2010.
2. Sivertsen B, Bjornsdottir E, Overland S, Bjorvatn B, Salo P. The joint contribution of insomnia and obstructive sleep apnoea on sickness absence. *J Sleep Res*. 2013;22:223–230.
3. Bultmann U, Nielsen MB, Madsen IE, Burr H, Rugulies R. Sleep disturbances and fatigue: independent predictors of sickness absence? A prospective study among 6538 employees. *Eur J Public Health*. 2013;23:123–128.
4. Rahkonen O, Lallukka T, Kronholm E, Vahtera J, Lahelma E, Laaksonen M. Sleep problems and sickness absence among middle-aged employees. *Scand J Work Environ Health*. 2012;38:47–55.
5. Rajaratnam SM, Barger LK, Lockley SW, et al. Sleep disorders, health, and safety in police officers. *JAMA*. 2011;306:2567–2578.
6. Kessler RC, Berglund PA, Coulouvrat C, et al. Insomnia and the performance of US workers: results from the America insomnia survey. *Sleep*. 2011;34:1161–1171.
7. Swanson LM, Arnedt JT, Rosekind MR, Belenky G, Balkin TJ, Drake C. Sleep disorders and work performance: findings from the 2008 National Sleep Foundation Sleep in America poll. *J Sleep Res*. 2011;20:487–494.
8. McKibben JB, Fullerton CS, Ursano RJ, et al. Sleep and arousal as risk factors for adverse health and work performance in public health workers involved in the 2004 Florida hurricane season. *Disaster Med Public Health Prep*;. 2010;(4 suppl 1):S55–62.
9. Rosekind MR, Gregory KB, Mallis MM, Brandt SL, Seal B, Lerner D. The cost of poor sleep: workplace productivity loss and associated costs. *J Occup Environ Med*. 2010;52:91–98.
10. Mansukhani MP, Kolla BP, Surani S, Varon J, Ramar K. Sleep deprivation in resident physicians, work hour limitations, and related outcomes: a systematic review of the literature. *Postgrad Med*. 2012;124:241–249.
11. Reed DA, Fletcher KE, Arora VM. Systematic review: association of shift length, protected sleep time, and night float with patient care, residents' health, and education. *Ann Intern Med*. 2010;153:829–842.
12. Dorrian J, Paterson J, Dawson D, Pincombe J, Grech C, Rogers AE. Sleep, stress and compensatory behaviors in Australian nurses and midwives. *Rev Saude Publica*. 2011;45:922–930.
13. Scott LD, Hwang WT, Rogers AE, Nysse T, Dean GE, Dinges DF. The relationship between nurse work schedules, sleep duration, and drowsy driving. *Sleep*. 2007;30:1801–1807.
14. Chang YS, Wu YH, Hsu CY, Tang SH, Yang LL, Su SF. Impairment of perceptual and motor abilities at the end of a night shift is greater in nurses working fast rotating shifts. *Sleep Med*. 2011;12:866–869.
15. Sharwood LN, Elkington J, Meuleners L, Ivers R, Boufous S, Stevenson M. Use of caffeinated substances and risk of crashes in long distance drivers of commercial vehicles: case-control study. *BMJ*. 2013;346:f1140.
16. Zhang C, Berger M, Malhotra A, Kales SN. Portable diagnostic devices for identifying obstructive sleep apnea among commercial motor vehicle drivers: considerations and unanswered questions. *Sleep*. 2012;35:1481–1489.
17. Verster JC, Taillard J, Sagaspe P, Olivier B, Philip P. Prolonged nocturnal driving can be as dangerous as severe alcohol-impaired driving. *J Sleep Res*. 2011;20:585–588.
18. Gurubhagavatula I, Nkwuo JE, Maislin G, Pack AI. Estimated cost of crashes in commercial drivers supports screening and treatment of obstructive sleep apnea. *Accid Anal Prev*. 2008;40:104–115.
19. Pack AI, Maislin G, Staley B, et al. Impaired performance in commercial drivers: role of sleep apnea and short sleep duration. *Am J Respir Crit Care Med*. 2006;174:446–454.
20. Razmpa E, Sadegh Niat K, Saedi B. Urban bus drivers' sleep problems and crash accidents. *Indian J Otolaryngol Head Neck Surg*. 2011;63:269–273.
21. Aderaw Z, Engdaw D, Tadesse T. Determinants of occupational injury: a case control study among textile factory workers in Amhara Regional State, Ethiopia. *J Trop Med*. 2011;2011:657275.
22. Salminen S, Oksanen T, Vahtera J, et al. Sleep disturbances as a predictor of occupational injuries among public sector workers. *J Sleep Res*. 2010;19(1 pt 2):207–213.
23. Shahly V, Berglund PA, Coulouvrat C, et al. The associations of insomnia with costly workplace accidents and errors: results from the America Insomnia Survey. *Arch Gen Psychiatry*. 2012;69:1054–1063.
24. Grandner MA. Addressing sleep disturbances: An opportunity to prevent cardiometabolic disease? *Int Rev Psychiatry*. 2014;26:155–176.
25. Mar J, Rueda JR, Duran-Cantolla J, Schechter C, Chilcott J. The cost-effectiveness of nCPAP treatment in patients with moderate-to-severe obstructive sleep apnoea. *Eur Respir J*. 2003;21:515–522.
26. Tan MC, Ayas NT, Mulgrew A, et al. Cost-effectiveness of continuous positive airway pressure therapy in patients with obstructive sleep apnea-hypopnea in British Columbia. *Can Respir J*. 2008;15:159–165.
27. Ayas NT, FitzGerald JM, Fleetham JA, et al. Cost-effectiveness of continuous positive airway pressure therapy for moderate to severe obstructive sleep apnea/hypopnea. *Arch Intern Med*. 2006;166:977–984.
28. Wade AG. The societal costs of insomnia. *Neuropsychiatr Dis Treat*. 2010;7:1–18.
29. Leger D, Bayon V. Societal costs of insomnia. *Sleep Med Rev*. 2010;14:379–389.
30. de Leeuw R, Eisenlohr-Moul T, Bertrand P. The association of smoking status with sleep disturbance, psychological functioning, and pain severity in patients with temporomandibular disorders. *J Orofac Pain*. 2013;27:32–41.
31. Chaput JP, McNeil J, Despres JP, Bouchard C, Tremblay A. Short sleep duration is associated with greater alcohol consumption in adults. *Appetite*. 2012;59:650–655.
32. Okamura H, Tsuda A, Yajima J, et al. Short sleeping time and psychobiological responses to acute stress. *Int J Psychophysiol*. 2010;78:209–214.
33. Lauterbach D, Behnke C, McSweeney LB. Sleep problems among persons with a lifetime history of posttraumatic stress disorder alone and in combination with a lifetime history of other psychiatric disorders: a replication and extension. *Compr Psychiatry*. 2011;52:580–586.
34. Kompier MA, Taris TW, van Veldhoven M. Tossing and turning—insomnia in relation to occupational stress, rumination, fatigue, and well-being. *Scand J Work Environ Health*. 2012;38:238–246.
35. Grandner MA, Jackson N, Gerstner JR, Knutson KL. Dietary nutrients associated with short and long sleep duration. Data from a nationally representative sample. *Appetite*. 2013;64:71–80.
36. Grandner MA, Jackson N, Gerstner JR, Knutson KL. Sleep symptoms associated with intake of specific dietary nutrients. *J Sleep Res*. 2014;23:22–34.
37. Colten HR, Altevogt BM. Institute of Medicine Committee on Sleep Medicine and Research. *Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem*. Washington, DC: Institute of Medicine: National Academies Press; 2006.
38. Zee PC, Badr MS, Kushida C, et al. Strategic opportunities in sleep and circadian research: report of the joint task force of the sleep research society and american academy of sleep medicine. *Sleep*. 2014;37:219–227.
39. Mattke S, Liu H, Caloyeras JP, et al. *Workplace Wellness Programs Study: Final Report*. Santa Monica, CA: RAND Corporation; 2013.
40. Kleinman NL, Brook RA, Doan JF, Melkonian AK, Baran RW. Health benefit costs and absenteeism due to insomnia from the employer's perspective: a retrospective, case-control, database study. *J Clin Psychiatry*. 2009;70:1098–1104.
41. Godet-Cayre V, Pelletier-Fleury N, Le Vaillant M, Dinet J, Massuel MA, Leger D. Insomnia and absenteeism at work. Who pays the cost? *Sleep*. 2006;29:179–184.

42. Rosekind MR, Gregory KB. Insomnia risks and costs: health, safety, and quality of life. *Am J Manag Care*. 2010;16:617–626.
43. Yumang-Ross DJ, Burns C. Shift work and employee fatigue: implications for occupational health nursing. *Workplace Health Saf*. 2014;62:256–261. quiz 262.
44. Omachi TA, Claman DM, Blanc PD, Eisner MD. Obstructive sleep apnea: a risk factor for work disability. *Sleep*. 2009;32:791–798.
45. Douglas NJ. Sleep, performance and the European Working Time Directive. *Clin Med*. 2005;5:95–96.
46. Niu SF, Chung MH, Chen CH, Hegney D, O'Brien A, Chou KR. The effect of shift rotation on employee cortisol profile, sleep quality, fatigue, and attention level: a systematic review. *J Nurs Res*. 2011;19:68–81.
47. Lewis RJ, Huebner WW, Yarborough III CM. Characteristics of participants and nonparticipants in worksite health promotion. *Am J Health Promot*. 1996;11:99–106.
48. Robroek SJ, van Lenthe FJ, van Empelen P, Burdorf A. Determinants of participation in worksite health promotion programmes: a systematic review. *Int J Behav Nutr Phys Act*. 2009;6:26.