The Relationship Between Chronically Disrupted Sleep and Healthcare Use

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Study Objectives: To determine whether chronic sleep deprivation, sleep disruption, sleepiness, insomnia, and OSA are associated with increased healthcare use in a community-based population.
Design: Cross-sectional study.
Setting/Participants: 6440 Sleep Heart Health Study (SHHS) participants recruited from ongoing cohort studies.
Interventions: N/A
Measurements: Polysomnography results (Apnea Hypopnea Index (AHI), percent of sleep time with oxyhemoglobin saturation below 90% (CT90), arousal index) as well as data on sleep related symptoms, medication use, and chronic illness. The indirect measure of predicted healthcare utilization was the modified Chronic Disease Score (CDS) calculated from medication data.
Results: After adjustment for age, gender, BMI and study site, subjects in the highest quartiles of AHI, CT90 and Epworth score had CDS that were 6%-9% higher than the lowest quartiles. The adjusted mean CDS for subjects with sleep apnea was similar to that for subjects with hypertension, chronic bronchitis or asthma and 18% greater than the mean CDS for subjects without sleep apnea. Among subjects who did not have significant sleep-disordered breathing, complaints of insomnia, sleepiness, fatigue, and not getting enough sleep were associated with increased CDS.
Conclusions: This study demonstrated an association between subjective complaints of daytime sleepiness, inadequate sleep time, insomnia as well as objective measures of severity of SDB, and an indirect measure of healthcare utilization in a community-based sample. Though the percent increases in healthcare utilization observed were modest, the prevalence of these factors in the general population is high, and may therefore be associated with a substantial cost burden to the healthcare system.
Key words: Sleep; sleepiness; insomnia; sleep apnea; obstructive sleep apnea; sleep deprivation; healthcare costs; economics; chronic disease

INTRODUCTION

CHRONIC SLEEP DEPRIVATION AND DISRUPTION ARE PREVALENT IN THE GENERAL POPULATION.[1,2] They often cause daytime somnolence, which is estimated to occur in more than 10% of the general population.[3,4] Insomnia and obstructive sleep apnea are two common causes of chronic sleep disruption. The prevalence of self-reported sleep difficulty ranges from 10% to 40% among community residents and primary care patients.[5] Obstructive sleep apnea (OSA) is estimated to occur in 2%-4% of middle-aged adults.[6]

Several studies indicate that OSA is associated with increased healthcare utilization and medical costs.[7,8,9] One study of 238 consecutive OSA patients found twice the medical costs in the year prior to diagnosis compared to age- and gender-matched controls.[7] Further, there was a dose-response relationship between the severity of sleep-disordered breathing (SDB) and medical costs in these patients. A telephone survey of 4,972 people found that individuals with self-reported breathing pauses were more likely to report seeking medical care in the previous year.[9]

Similarly, studies indicate that insomnia is associated with increased healthcare utilization and medical costs.[2,5] A study of primary care patients screened for insomnia found that mean medical costs were approximately 50% higher during the six month period surrounding the date of screening in those complaining of disrupted sleep.[5] A survey of telecommunications employees found that individuals with self-reported sleep difficulties reported poorer overall health and greater use of medical services.[2]

To our knowledge, there are no studies of the relationships of daytime sleepiness and inadequate sleep time to increased healthcare utilization and medical costs. Results of a prospective study that found daytime sleepiness was associated with increased mortality and incident cardiovascular disease in older adults provides support for the hypothesis that sleepiness might be associated with increased healthcare use.[10]

To determine whether chronic sleep deprivation, sleep disruption, sleepiness, insomnia, and OSA are associated with increased healthcare utilization in a community-based population, we used polysomnography results as well as data on sleep related symptoms, medication use, and chronic illness from Sleep Heart Health Study (SHHS) participants. Our indirect mea-

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sure of healthcare utilization was a modified Chronic Disease Score (CDS) calculated from medication data.[11]

METHODS

Study Population

All subjects were participants in the SHHS, a multicenter study of the cardiovascular consequences of SDB that recruited participants from ongoing cohort studies of cardiovascular or respiratory disease in several ethnic groups. The design of the SHHS has been described previously.[12,13] A sample of participants in the parent cohorts meeting inclusion criteria (aged 40 years or older; no history of treatment of sleep apnea; no tracheostomy; no current home oxygen therapy), was invited to participate in the initial examination of the SHHS. Selection and recruitment procedures varied by study site according to logistical considerations and participant's characteristics. Persons with a history of snoring were oversampled from individuals younger than 65 years in order to optimize statistical power by increasing the prevalence of SDB in the younger participants. Among 11,053 participants in the parent cohorts identified as potentially eligible, a total of 6,440 individuals had a successful unattended baseline PSG performed between December, 1995 and February, 1998.

Polysomnography

Participants underwent a single night, unattended polysomnography at the home, using a portable monitor (Compumedics P Series System, Abbotsford, Victoria, Australia). The following channels were recorded: electroencephalogram (C3/A1, C4/A2), electrooculogram (bilateral), electrocardiogram, chin electromyogram, oxyhemoglobin saturation (finger pulse oximetry), chest and abdominal excursion (inductance plethysmography), airflow (oro-nasal thermocouple), body position, and ambient light. Sleep studies were scored at a central reading center. Details of the hook-up procedure, failure rates, scoring of the studies, quality assurance, and quality control have been described elsewhere.[13,14]

An abnormal respiratory event (an apnea or an hypopnea) was defined as a decrease in airflow or chest wall movement to amplitude that was smaller than approximately 25% (an apnea) or 70% (an hypopnea) of the baseline amplitude. A qualifying event lasted at least 10 seconds and was associated with oxyhemoglobin desaturation of 4% or greater compared with baseline. Arousals were identified according to recommendations of the American Academy of Sleep Medicine.[15]

We examined the association of CDS with three polysomnography parameters: average number of abnormal respiratory events per hour of sleep (apnea-hypopnea index, AHI), average number of arousals per hour of sleep (arousal index), and percent of sleep time with oxyhemoglobin saturation below 90% (CT90). For analyses involving the arousal index, only results from studies (n=4756) that could be reliably scored for arousals were included (studies that were assessed by scorers to be unreliable for scoring arousals or for discriminating sleep stages because of excessive EEG artifact were excluded).

Chronic Illness, Medications, and Sleep Symptoms

During the home visit, a study technician administered a questionnaire, which included information on medical history. The interviewer asked if a doctor had ever told the participant that he/she had angina, heart attack, heart failure, stroke, emphysema, chronic bronchitis, chronic obstructive pulmonary disease (COPD), or asthma. Data on self-reported hypertension and diabetes were obtained from parent studies. An "unsure" response was allowed for each data item. The prevalence of each chronic illness was defined as the percentage of "yes" responses out of the total of "yes" and "no" responses for that data item. Absence of chronic disease was defined as either "no" or "unsure" response for all of the above items.

The interviewer also recorded both prescribed and selected non-prescribed medications taken within the two-week period prior to home visit. The interviewer transcribed information from the medication container onto the data collection form including medication name, strength, and number prescribed per time period. Participants completed a Sleep Habits Questionnaire. This instrument asked about trouble falling asleep, waking up during the night and having difficulty getting back to sleep, feeling unrested during the day no matter how many hours slept, feeling excessively sleepy during the day, and not getting enough sleep. Responses included never (0), rarely (1/month or less), sometimes (2-4/month), often (5-15/month), and almost always (16-30/month). These responses were recoded into binary variable that contrasted "often" and "almost always" responses versus the other responses ("often" vs. "not often"). Sleep apnea and insomnia profiles were created to identify participants with these conditions. The sleep apnea profile consisted of often feeling sleepy and having an AHI in the highest quartile (>11.0). Subjects meeting both these criteria were categorized as having sleep apnea syndrome. The insomnia profile consisted of often having trouble falling asleep, waking up during the night, or waking up early. Subjects that had any of these three complaints were categorized as having insomnia.

Physician diagnosis of sleep apnea was assessed by the response to a question in the Sleep Habits Questionnaire which asked whether the participant had ever been told by a doctor the he/she had sleep apnea.

An Epworth Score was calculated for each participant (N=6203) who had answered all eight questions that comprise this measure of daytime sleepiness.[16]

Other Measurements

Age at the time of sleep study was defined in years. BMI was calculated as weight (kg) / height (m^2). Height was obtained from parent studies. Weight was measured using a portable scale on the night of the polysomnogram with the participant wearing light clothes. If weight from the night of the polysomnogram was unavailable, weight was obtained from parent studies.

Chronic Disease Score

The CDS was originally developed at Group Health Cooperative (Seattle WA), a staff-model HMO, as a measure of chronic disease status that used one year of pharmacy data.[17] It was found to be correlated with physician rating of disease sever-

Table 1—Description of study subjects including prevalence of chronic illnesses and insomnia complaints (n=6440)

Variable	n	Mean or Valid %	Percentiles (25th/50th/ 75th)	Standard Deviation
Age	6439	62.9	55 / 62 / 71	11.0
Male	6440	47.2%		
BMI	6332	28.5	24.9/ 27.8 / 31.2	5.4
AHI	6438	8.8	1.3 / 4.4 / 11.1	12.5
CT90	6438	3.6	0.00 / 0.22 / 2.04	10.5
Arousal Index*	4756	18.7	11.9 / 16.5 / 23.1	10.0
Epworth	6203	7.7	4 / 7 / 11	4.4
Chronic Disease Score	6424	2866	1221 / 2264 / 3733	2100
Sleep apnea**	6353	4.0%		
Insomnia***	6334	30.7%		
Angina	6260	7.9%		
Asthma	6334	8.7%		
COPD	6324	1.2%		
Chronic bronchitis	6308	5.8%		
Heart failure	6148	2.0%		
MI	6255	7.2%		
Stroke	6288	3.7%		
Diabetes	6139	10.8%		
Hypertension	6175	38.3%		
Often wake up early	6350	18.0%		
Often trouble falling asleep	6348	15.4%		
Often wake up during night	6352	20.6%		
Often not sleep enough	6330	18.2%		
Often sleepy	6355	13.2%		
Often unrested	6356	18.0%		

* Only studies in which arousals were scored reliably used; **AHI>11.0 and self-report of being often sleepy; ***self report of often have trouble falling asleep, waking during night or waking up early.

ity and predict hospitalizations and mortality in the following year. Subsequently, a revised CDS that used six months of pharmacy data was subsequently developed and validated in the same setting.[11] Each class of medication used to treat chronic illness was assigned an empirically derived weight using regression models that include age and gender categories to predict actual total healthcare costs over the next six-month period. The revised CDS provides a measure of chronic disease status that is correlated with physician ratings of disease severity as well as ambulatory visits, hospitalization, and mortality.[11] It represents the expected total healthcare costs in dollars over the next six-months for an individual. The CDS has been replicated and validated in a variety of settings including another HMO, a Veteran Affairs Medical Center and a European health insurance plan.[18,19,20] One study indicated that the CDS was robust in its ability to predict healthcare costs using a variety of pharmacy criteria to indicate the presence of a chronic illness.[20]

For the purposes of this study, a modified CDS, that used the medication data recorded during the home visit rather than six-months of pharmacy data, was calculated in a manner similar to the revised CDS. Since only a record of medications used within two weeks of the home visit was used, the modified CDS may underestimate healthcare costs and not accurately predict actual healthcare costs over the next six months. Nevertheless, it would be expected to correlate with healthcare costs and utilization, since it is derived in a similar manner to the original CDS.

Statistical Analysis

Analyses were performed using SPSS.[21] CDS was log-transformed prior linear regressions due to its non-normal distribution. Linear regressions were performed to examine the relationship between CDS and each of the following variables: AHI, CT90, Arousal Index, and Epworth score (Tables 2a and 2b). CDS was the dependent variable in linear regressions. In the unadjusted regression model, three indicator variables to represent the three highest quartiles of the variable of interest were included as independent variables to compare differences in CDS between the lowest and higher quartiles. In the adjusted regression model, age, gender, BMI, and nine indicator variables representing the 10 geographically distinct study sites where participant data was collected; were also included as independent variables. The anti-log of the numeric result derived from adjusted or unadjusted regression model was taken to obtain the geometric mean of the CDS for a particular quartile.

Regression analyses were performed to examine whether very high levels of AHI, CT90, and Epworth score were associated with large increases in CDS, regression analyses. These analyses examined the magnitude of difference in CDS between the sub-quartiles for the highest quartile for AHI, CT90 and Epworth score. They used CDS as the dependent variable and six indicator variables representing the second and third highest quartiles and the sub-quartiles of the highest quartile plus the covariates listed above.

Regression analysis was performed to determine whether the relationships between individual variables and CDS were independent. CDS was the dependent variable and continuous variables to represent AHI, CT90, arousal index, and Epworth score were entered simultaneously with covariates.

Table 2a—Mean CDS by sleep-disordered breathing and sleepiness quartiles

Parameter	n	Mean CDS			
		Top quartile	2nd quartile	3rd quartile	Lowest quartile
AHI	6422	2700***	2435***	2133***	1831
CT90	6422	2737***	2390***	2124***	1854
Arousal Index	4745	2568***	2177***	2036*	1912
Epworth	6187	2381**	2273	22156	2216

Table 2b—Mean CDS adjusted for age, gender, BMI and study site by sleep-disordered breathing and sleepiness quartiles

Parameter	n	Mean CDS			
		Top quartile	2nd quartile	3rd quartile	Lowest quartile
AHI	6317	2428**	2307	2271	2294
CT90	6317	2405**	2324	2308	2264
Arousal Index	4660	2278	2218	2210	2246
Epworth	6091	2474***	2343**	2271	2238

Linear regression performed with ln (CDS) as the dependent variable.
p-values compare quartile of interest to lowest quartile: *p<0.05; **p<0.01; ***p<0.001

CDS in subjects with specific chronic illnesses were compared to CDS in those without these illnesses ("no" response on interview or didn't fit sleep apnea or insomnia profile). Age, gender, BMI, and study site were included as covariates in adjusted models. The anti-log of the numeric results obtained from the regression equations for each specific chronic illness was taken to obtain adjusted and unadjusted mean CDS values (Table 3).

Among subjects without self-reported non-sleep chronic illness (n=2605), CDS was compared between those who did and did not have a sleep disorder using regression analyses in a similar manner to what was used for Table 3. This was done to determine whether CDS would be higher in the presence for specific sleep disorders when none of the self-reported cardiovascular or pulmonary diseases were present.

Among subjects without SDB (AHI<5, n=3459) those with frequent specific sleep-related complaints (occurring at least often) were compared to those without the complaint using regression analyses in a similar manner to what was used for Table 3. This was done to determine whether specific sleep-related complaints in the absence of SDB are associated with increased CDS.

RESULTS

Descriptive data on the cohort are shown in Table 1. The cohort had mean age 63.6 and there was an approximately equal gender distribution. The prevalence of self-reported chronic illness ranged from 1.2% (COPD) to 38.3% (hypertension). Although the majority of participants had polysomnography results, and Epworth scores that were not outside the normal range, values in the top quartiles for each of these variables were elevated. 13.2% and 18.0% reported often or more feeling sleepy or unrested, respectively. Sleep apnea, defined by an AHI>11 and at least often sleepy, was found in 4% of subjects. Insomnia of any pattern was present in 30.7% of subjects. The prevalence of complaints of specific patterns of insomnia ranged 15.4% to 20.6%. "Not getting enough sleep" was reported to occur often or more by 18.2% of subjects. The median CDS was 2,264. The lowest quartile had CDS values at least 46% lower and the highest quartile had CDS values at least 65% higher than the median indicating a wide distribution of predicted six-month healthcare costs.

Table 2a provides the results of unadjusted linear regression comparing quartiles of sleep study parameters or Epworth Sleepiness Scale with CDS. For AHI, CT90, and arousal index, the geometric mean CDS for subjects increased at each successively higher quartile and was significantly different than the mean CDS for subjects in the lowest quartile. The mean CDS of the subjects in the highest quartiles for AHI and CT90 was approximately 50% greater than for subjects in the lowest quartiles. For the arousal index, the mean CDS of subjects in the highest quartile for arousal index was approximately 34% greater than that for subjects in the lowest quartile. Only subjects in the highest quartile for Epworth score had significantly higher mean CDS than those in the lowest quartile and the difference was of small magnitude (7%).

Table 2b provides the results of linear regression models of CDS for which age, gender, BMI, and study site have been adjusted. After adjusting for these variables, for both AHI and CT90, only subjects in the highest quartiles had significantly higher mean CDS than those in the lowest quartile, and the magnitude of the difference was small (6%). Arousal index was not statistically significant after adjustment for covariables. Subjects in the highest quartile of Epworth score continued to have significantly higher mean CDS than those in the lowest quartile and the magnitude of the difference remained similar (11%).

To examine patterns at very high levels of SDB or sleepiness, the adjusted mean CDS for sub-quartiles within the highest quartile of AHI, CT90 or Epworth score were calculated. The mean CDS for the highest sub-quartile of AHI (>29.9), CT90 (>15.8%), and Epworth score (≥16) were 2,516, 2,610, and 2,551. These values were 3.6%, 8.5% and 3.1% greater than the adjusted mean CDS for the highest quartiles of these variables and 9.7%, 15.3%, and 14% greater than the adjusted mean CDS for the lowest quartiles of these variables.

A linear regression analysis with log-transformed CDS as the dependent variable and continuous variables for AHI, CT90, arousal index and Epworth score as independent variables (along

Table 3—CDS for subjects who have a specific chronic condition compared to subjects who do not (n=6440)

Chronic Illness (n=number with illness)	Unadjusted Mean CDS		Adjusted Mean CDS[§]	
	Chronic illness present	Chronic illness absent	Chronic illness present	Chronic illness absent
Heart Failure (124)	5277***	2240	3725***	2329
Diabetes (665)	4254***	2128	3783***	2122
Stroke (233)	4163***	2206	3071***	2300
MI (453)	4111***	2150	3194***	2250
Angina (497)	3956***	2149	3194***	2255
Emphysema (146)	3458***	2226	2696**	2313
COPD (76)	3394***	2234	2918***	2312
Hypertension (2363)	3123***	1864	2769***	2067
Sleep apnea[α] (256)	2830***	2228	2699***	2310
Chronic bronchitis (369)	2797***	2218	2650***	2299
Sleep apnea[β] (99)	2606*	2246	2639*	2325
Asthma (553)	2468**	2230	2715***	2291
Insomnia[γ](1944)	2438***	2169	2502***	2254
Any of the above illnesses (4292)	2675***	1612	2579***	1872

[α]AHI>11.0 and self-report of being often sleepy;
[β] Self-report of MD diagnosis
[γ]Self report of often having trouble falling asleep, waking up during the night or waking up early
[§]Adjusted for age, gender, BMI and study site
p-values compare subjects with specific chronic illness to rest of subjects; * p≤0.05; ** p≤0.01; *** p≤0.001

with age, gender, BMI and study site) showed that only CT90, and Epworth score remained statistically predictive of CDS when included in the same model. There was a strong positive correlation between AHI and CT90 (Spearman's correlation coefficient=0.74). After excluding CT90 from the model, AHI became highly significant, suggesting that CT90 may be a stronger predictor for CDS than AHI.

Table 3 shows unadjusted and adjusted mean CDS for individuals with and without specific chronic illnesses. Subjects with any of the chronic conditions examined had significantly higher CDS than subjects without the chronic condition. The magnitude of adjusted mean CDS was highest for diabetes and lowest for insomnia. The adjusted mean CDS for sleep apnea was similar to that for hypertension, chronic bronchitis, and asthma.

Table 4 shows a comparison of unadjusted and adjusted mean CDS based on sleep condition for individuals who had none of the chronic cardiovascular or pulmonary conditions listed in Table 3. CDS was greater for those with sleep apnea or insomnia. This difference was statistically significant in adjusted and unadjusted models for insomnia, the most prevalent of the conditions. These analyses indicate that CDS was capable of finding differences among subjects without self-reported cardiovascular or pulmonary conditions. This would be expected since CDS was computed using a much wider range of medication classes than just those used to treat these disorders. These analyses also suggest that some of the increase in CDS seen in subjects with sleep disorders was attributable to medical conditions other than listed in Table 3.

Table 5 shows unadjusted and adjusted mean CDS among subjects with and without frequent specific sleep-related complaints that did not have SDB. Subjects with complaints related to insomnia, sleepiness, fatigue, or not getting enough sleep had significantly higher adjusted mean CDS than those who did not have these complaints. Among the patterns of insomnia, trouble falling asleep had somewhat higher mean CDS than waking up during the night or early morning awakening. Sleepiness and fatigue had the highest mean CDS of the complaints examined.

DISCUSSION

This is the first study to show an association between subjective complaints of daytime sleepiness or inadequate sleep time and healthcare utilization (indirectly measured by the modified CDS). The Epworth score, a commonly used measure of subjective sleepiness, was associated with higher healthcare utilization after adjustment for potential confounders. The subjects in the highest quartile of the Epworth score (≥11, which corresponds to a range of Epworth score values that is considered consistent with increased daytime sleepiness) had modestly increased (11%) healthcare utilization when compared to subjects in the lowest quartile. Among subjects without significant SDB, feelings of sleepiness and fatigue were associated with 18%-20% higher healthcare utilization, indicating that the association could not be attributed to the presence of SDB. Self-report of insufficient sleep, a common cause of sleepiness was associated with a 9% higher healthcare utilization.

This is also the first study to demonstrate a relationship between objective measures of severity of SDB and healthcare utilization in a community-based population. We showed that AHI and CT90 are both associated with higher healthcare utilization after adjustment for potential confounders. For individuals with severe SDB (AHI>29.9) there was a modest (10%-15%) increase in healthcare utilization compared to subjects in the lowest quartile. Hypoxemic burden (CT90) appeared to be a stronger predictor of healthcare utilization than frequency of SDB (AHI).

There was no relationship between arousal index and CDS. It might be expected that sleep disruption measured by the arousal

Table 4—A comparison of CDS among subjects who have none of the cardiovascular or pulmonary illnesses listed in Table 3 (n=2605)

	Unadjusted Mean CDS		Adjusted Mean CDS§	
Sleep Condition (n=number with condition)	**Condition present**	**Condition absent**	**Condition present**	**Condition absent**
Sleep apneaα (67)	1988*	1647	1953	1828
Sleep apneaβ (24)	2026	1657	2444***	1821
Insomniaγ (712)	1747**	1616	1921***	1799

αAHI>11.0 and self-report of being often sleepy;
β Self-report of MD diagnosis
γSelf report of often having trouble falling asleep, waking up during the night or waking up early
§Adjusted for age, gender, BMI and study site
p-values compare subjects with specific chronic illness to rest of subjects; * p≤0.05; ** p≤0.01; *** p≤0.001

Table 5—CDS by frequency of sleep-related complaints for subjects without SDB (AHI<5, n=3459)

Sleep Complaint	**Unadjusted Mean CDS**		**Adjusted Mean CDS§**	
(n=number with complaint)	**Occurring ≥often**	**Occurring <often**	**Occurring ≥often**	**Occurring <often**
Trouble falling asleep (526)	2305***	1945	2363***	2057
Wake up during the night (711)	2192***	1949	2231***	2064
Unrested (583)	2121*	1973	2455***	2038
Sleepy (393)	2179**	1975	2441***	2060
Wake up early (616)	2247***	1944	2273***	2059
Not get enough sleep (606)	1992	1998	2256***	2064

§Adjusted for age, gender, BMI and study site
p-values compare subjects with frequent complaint to rest of subjects; *p<0.05; ** p<0.01; ***p<0.001

index would not be related to increased healthcare utilization since this measure has not been associated with adverse outcomes such as cardiovascular disease and hypertension in studies where measures of SDB have been shown to be significantly associated with these outcomes.[22,23]

This report also confirms findings from previous studies that complaints of insomnia are associated with increased healthcare utilization.[5] Individuals with complaints of often having trouble falling asleep, staying asleep or early morning awakening had 8%-15% higher CDS than those without frequent complaints of insomnia.

Though the percent increase in healthcare utilization observed with SDB, sleepiness, insomnia, and insufficient sleep were modest, because prevalence of these factors in the general population is high, they could be associated with a large total cost burden to the healthcare system. Importantly, sleep apnea and insomnia are not only common, but also under-recognized by healthcare providers and often go untreated.[24,25] Sleep deprivation and sleepiness are also common but not widely recognized as personal or public health concerns.[1,2,3,4]

If chronic sleep disruption, deprivation, and sleepiness cause increased healthcare utilization, recognizing and remedying these conditions may result in a reduction in healthcare costs. Alternatively, these associations may be a result of chronic illnesses that cause sleep disruption and sleepiness. The latter scenario suggests that sleep complaints may contribute to the morbidity resulting from chronic illness. If this is the case, increased attention to and care of sleep issues may improve quality of life in patients with chronic illness.

Unfortunately, given the cross-sectional design of this study, we were unable to distinguish whether a causal relationship is responsible for the associations between SDB, insomnia, sleepiness, insufficient sleep and chronic disease burden. Further, there may be additional confounders that we did not adjust for which explain these associations and diminish the role of sleep complaints.

Those individuals who met our criteria for the sleep apnea syndrome (AHI>11 plus frequent sleepiness) had mean CDS (2699), which was 17% higher than that for the remaining group (2310). This is substantially less than the 2.6-fold difference in median costs noted between OSA patients and age- gender-matched controls in clinical populations.[7] This suggests that in undiagnosed individuals with sleep apnea, medical costs may not be as high as in recognized sleep apneic individuals. It is likely that people with other chronic diseases were in increased contact with a healthcare system and were thus more likely to be referred to a sleep lab—inflating the association due to selection bias.

Our study provided a rough comparison of the healthcare costs between sleep apnea, insomnia, and other common chronic illnesses. Sleep apnea was associated with a CDS that is comparable to that for subjects with hypertension or asthma but lower than other cardiovascular diseases or diabetes. In contrast, insomnia was associated with a lower CDS. Implications for the impact of sleep apnea on healthcare costs relative to the impact of other chronic illnesses are unclear since our cross-sectional study design could not address whether a causal relationship was present.

Our cohort consisted of subjects with a wide range of BMI and sleep-related indices. The prevalence of sleep apnea was somewhat higher than that found in other community-dwelling popu-

lations, though the prevalence of insomnia was similar to what has been found previously.[2,6] The prevalence of specific chronic illnesses were higher than would be expected in the general population. Therefore our population was not entirely representative of the general population as it was enriched with individuals with SDB and chronic illness. Nevertheless, this cohort had a reasonable distribution of the above characteristics that allowed a valid examination of our hypotheses.

Since our cohort consisted of participants involved in epidemiological research, they would be expected to have had increased health provider contact relative to non-participants. This would have biased our cohort to have more medications prescribed and to have a higher CDS. This bias would not compromise the validity of our findings within our sample but might affect the ability to generalize the magnitude of our findings to the general population.

Another limitation of our study is that we did not directly measure healthcare costs; instead we used a modified CDS as a surrogate. The CDS was developed and validated in an HMO setting to predict total health care cost over six months using pharmacy data from the previous six months.[11] The CDS has not been validated in specific populations included in our study or in specific healthcare systems that our participants use. Our un-validated, modified CDS was created using a list of medications taken by the participant in the previous two weeks that was recorded and verified by an interviewer rather than from six months of longitudinal pharmacy data. Although this change appears reasonable based on a previous study, it may be that the modified CDS is not as good a predictor of total healthcare cost as the CDS.[20] In this scenario, this study might underestimate the magnitude of relationships to total healthcare costs.

This study of a community-based population demonstrated an association between measures of SDB and an indirect measure of healthcare utilization, the CDS. Sleep apnea syndrome was also associated with higher CDS and presumably healthcare utilization, though not of the magnitude reported in clinical populations. Similarly, associations between insomnia, sleepiness, fatigue, and inadequate sleep duration and CDS were observed. Sleep-related issues could cause substantial costs to the healthcare system as well as contributing to morbidity in chronic illnesses. A prospective examination of the relationship between sleep disorders and healthcare utilization is necessary to demonstrate whether a causal relationship exists between these factors.

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