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Nighttime Insomnia Symptoms and Perceived Health in the America Insomnia Survey (AIS)

James K. Walsh, PhD[1]; Catherine Coulouvrat, MD[2]; Goeran Hajak, MD[3]; Matthew D. Lakoma, MPH[4]; Maria Petukhova, PhD[4]; Thomas Roth, PhD[5]; Nancy A. Sampson, BA[4]; Victoria Shahly, PhD[4]; Alicia Shillington, PhD[6]; Judith J. Stephenson, SM[7]; Ronald C. Kessler, PhD[4]

[1]Sleep Medicine and Research Center, St. Luke's Hospital, St. Louis, MO; [2]Sanofi-Aventis; [3]Department of Psychiatry and Psychotherapy, University of Regensburg, Germany; [4]Department of Health Care Policy, Harvard Medical School, Boston, MA; [5]Sleep Disorders and Research Center, Henry Ford Health System, Detroit, MI; [6]Epi-Q, Inc., Oak Brook, IL; [7]HealthCore, Inc., Wilmington, DE

Study Objectives: To explore the distribution of the 4 cardinal nighttime symptoms of insomnia—difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), early morning awakening (EMA), and nonrestorative sleep (NRS)—in a national sample of health plan members and the associations of these nighttime symptoms with sociodemographics, comorbidity, and perceived health.

Design/Setting/Participants: Cross-sectional telephone survey of 6,791 adult respondents.

Intervention: None.

Measurements/Results: Current insomnia was assessed using the Brief Insomnia Questionnaire (BIQ)—a fully structured validated scale generating diagnoses of insomnia using DSM-IV-TR, ICD-10, and RDC/ICSD-2 inclusion criteria. DMS (61.0%) and EMA (52.2%) were more prevalent than DIS (37.7%) and NRS (25.2%) among respondents with insomnia. Sociodemographic correlates varied significantly across the 4 symptoms. All 4 nighttime symptoms were significantly related to a wide range of comorbid physical and mental conditions. All 4 also significantly predicted decrements in perceived health both in the total sample and among respondents with insomnia after adjusting for comorbid physical and mental conditions. Joint associations of the 4 symptoms predicting perceived health were additive and related to daytime distress/impairment. Individual-level associations were strongest for NRS. At the societal level, though, where both prevalence and strength of individual-level associations were taken into consideration, DMS had the strongest associations.

Conclusions: The extent to which nighttime insomnia symptoms are stable over time requires future long-term longitudinal study. Within the context of this limitation, the results suggest that core nighttime symptoms are associated with different patterns of risk and perceived health and that symptom-based subtyping might have value.

Keywords: Insomnia, subtypes, comorbidity, perceived health, prevalence, societal burden

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INTRODUCTION

Four cardinal nighttime symptoms anchor the diagnosis of insomnia in all standard sleep disorder nosologies,[1] including: the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR)[2]; the American Academy of Sleep Medicine's Research Diagnostic Criteria (RDC) and International Classification of Sleep Disorders-2 (ICSD-2);[3] and the World Health Organization's International Classification of Diseases-10 (ICD-10).[4] These four symptoms are difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), early morning awakening (EMA), and nonrestorative sleep (NRS).

Despite their central role in classification, it remains unclear whether these four nighttime symptoms identify stable or meaningful insomnia subtypes. There is at least some indication in the literature that nighttime symptoms are fairly stable over time in community samples[5,6] and have differential associations with daytime distress and impairment.[7] However, these results are based for the most part on small samples with limited generalizability[3,5,8,9] or on larger epidemiologic samples using inconsistent diagnostic criteria with limited comparability,[10-12] thus making it difficult to draw firm conclusions about the implications of these results for insomnia subtyping.

The current report presents new data relevant to this issue based on analysis of a recently completed national survey of health plan subscribers. We examine the prevalence, co-occurrence, and differential associations of the four cardinal nighttime symptoms of insomnia with other physical and mental conditions, and perceived health. We also examine the extent to which these associations are mediated by daytime distress and impairment. These data expand the range of outcomes considered in previous studies of the relative importance of the four nighttime symptoms of insomnia. In addition, the analysis is based on a much larger and more representative sample than previous studies of differential associations of these symptoms. A unique aspect of the study is the use of simulation to calculate the relative importance of each nighttime insomnia symptom to population-level decrements in perceived health, providing a novel perspective on the public health significance of the symptoms.

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Address correspondence to: Ronald C. Kessler, PhD, Department of Health Care Policy, Harvard Medical School, 180 Longwood Avenue, Boston, MA 02115; Tel: (617) 432-3587; Fax: (617) 432-3588; E-mail: nsc@hcp.med.harvard.edu

METHODS

Sample

The data reported here are from the America Insomnia Survey (AIS), a national survey 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.[13,14] The sample was not restricted to plan members with a diagnosis of insomnia, as important purposes of the survey were to estimate the total prevalence of insomnia and the proportion of people with insomnia who were diagnosed and treated. However, 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, although sample selection was made independent of number of healthcare visits. Sample eligibility was also limited to members who provided the plan with a telephone number, spoke English, and had no impairment that limited their ability to be interviewed by telephone. The sample was selected with stratification to match the US 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).

AIS respondent recruitment began with an advance letter that explained that the survey was designed "to better understand how health and health problems affect the daily lives of people," that respondents were randomly selected, that participation was voluntary and would not affect health care benefits, that responses were completely confidential, and that a $20 incentive was offered for participation. A toll-free number was included in the letter for respondents who wanted to ask questions or decline participation. Following contact, verbal informed consent was obtained before beginning interviews. The Human Subjects Committee of the New England Institutional Review Board approved these recruitment and consent 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 in the sample and the US Census population on the cross-classification of the sociodemographic and geographic selection criteria.

In addition to assessing insomnia, the AIS included a wide variety of questions about the correlates of insomnia. In order to reduce respondent burden, many of the questions about correlates were administered only to a probability subsample of the entire AIS sample. One set of these questions concerned physical and mental conditions found in previous research to be highly comorbid with insomnia. Self-report questions about these conditions were administered to all AIS respondents who reported sleeping problems (including those classified as having subthreshold or mild insomnia) plus a random 50% of other respondents. The respondents in this comorbidity subsample who did not report sleep problems were assigned a weight of 2.0 (multiplied by the weight described in the previous paragraph) to adjust for the fact that they represented only half of all those without sleeping problems. The 6,791 respondents in this comorbidity subsample are the focus of the current report.

Measures

Insomnia

Insomnia in the 30 days before interview was assessed with a self-report instrument developed specifically for the AIS, the Brief Insomnia Questionnaire (BIQ). As noted above, the BIQ was designed to operationalize inclusion criteria of DSM-IV-TR, ICD-10, the RDC, and ICSD-2 for a diagnosis of general insomnia (referred to hereafter as *broadly defined insomnia* or *insomnia*). (The full text of the BIQ and coding rules for diagnoses are available at www.hcp.med.harvard.edu/wmh/affiliated_studies.php. The instrument is in the public domain and can be used by other investigators without restriction.)

The cases considered here meet full inclusion criteria in at least one of these systems. Included here were DSM-IV-TR inclusion Criteria A (predominant complaint of difficulty initiating or maintaining sleep or nonrestorative sleep for ≥ 1 month) and B (the sleep disturbance or associated daytime fatigue causes clinically significant distress or impairment) for a diagnosis of Primary Insomnia, ICD-10 inclusion Criteria A (complaint of difficulty falling asleep or maintaining sleep or poor quality sleep), B (≥ 3 times per week for ≥ 1 month), C (preoccupation with sleeplessness and excessive concern over consequences), and D (marked distress or interference with activities of daily living) for a diagnosis of Non-organic Insomnia, and RDC/ICSD-2 inclusion Criteria A (difficulty initiating or maintaining sleep or waking up too early or chronically nonrestorative sleep), B (difficulty occurs despite adequate opportunity and circumstances for sleep), and C (daytime impairment related to the nighttime sleep difficulty) for a diagnosis of Insomnia Disorder. It should be recalled that RDC and ICSD-2 general criteria for insomnia were developed to be identical, excepting that the former are intended for research applications and the latter for clinical use,[15] which is why we refer to these as defining RDC/ICSD-2 insomnia.

The BIQ question series began by asking respondents how many nights out of 7 in a typical week they have problems falling asleep, how many nights they have problems staying asleep throughout the night, how many mornings out of 7 they typically wake up before they want to, and how many mornings they wake up still feeling tired or unrested. Positive responses were followed with questions about how long it usually takes to fall asleep on nights with a problem falling asleep, how much time they usually spend awake at night on nights they have trouble sleeping, how many times per night they usually wake up during those nights, how long it usually takes them to get back to sleep once they wake up at night, and how much earlier than they wished do they awaken in the morning when they awaken early. Respondents who reported nonrestorative sleep were asked to rate the severity of their problem waking up feeling tired or unrested using the response options mild, moderate, severe, and very severe.

Respondents with sleep problems were then asked how many weeks, months, or years these problems had been going on in order to operationalize the one-month duration requirement in DSM-IV-TR and ICD-10. They were also asked 2 questions about adequate opportunity to sleep prefaced with the preamble "(t)he next questions are about how much your sleep problems are caused by the place you sleep being too light, too noisy, too hot or cold, or uncomfortable." The first question was: "How much do you think your sleep problems are caused by problems with the place you sleep—would you say not at all, a little, some, a lot, or totally?" The second question was: "Some people have sleep problems because they either have to get up very

early, stay up late, or get up in the night because of their job or because of having a baby or a sick person who needs their help. How much do you think your sleep problems are caused by these kinds of demands on your time—would you say not at all, a little, some, a lot, or totally?"

Respondents with sleep problems were then asked 16 questions about daytime distress and impairment. The first 8 of these questions asked how much difficulty respondents had because of their sleep problems over the past 30 days in each of the following areas: reduced motivation; performance at work, school, or social activities; making errors or having accidents; irritability, nerves, or mood disturbance; daytime attention, concentration, or memory problems; daytime fatigue; daytime sleepiness; and tension headaches or digestive problems. The response options were none, mild, moderate, or severe difficulty. The next 4 distress-impairment questions were a modified version of the Sheehan Disability Scales (SDS)[16] that asked respondents to rate the extent to which their sleep problems interfered with their daily activities during the past 4 weeks using a 0-to-10 scale, where 0 means no interference and 10 means very severe interference. The 4 areas of role functioning were: "your home management, like cleaning, shopping, and taking care of your home; your ability to work; your social life; and your close personal relationships." Respondents were reminded of the anchors before answering each question and were also instructed that they could use any number between 0 and 10 to answer.

The next 2 distress-impairment questions asked about days out of role due to sleep problems: "About how many days out of 30 in the past month were you totally unable to work or carry out your other usual daily activities because of problems with your sleep? About how many days out of 365 in the past year were you totally unable to work or carry out your other usual daily activities because of problems with your sleep?" The final 2 distress-impairment questions asked respondents how much concern or worry they had about their sleep (response options: none, mild, moderate, and severe) and how worried or distressed they were about their sleep problems (response options: not at all, a little, some, much, and very much).

Factor analysis of responses to the distress/impairment questions revealed a strong unidimensional structure, with eigenvalues of 9.1 and 0.9 for the first 2 unrotated principal factors and factor loadings in the range 0.72-0.88. (Detailed results of the factor analysis are available on request.) Based on this result, a factor-based scale of daytime distress/impairment due to nighttime sleep problems was created and used as a mediator in analyses described below of the associations between nighttime insomnia symptoms and perceived health.

The coding scheme used to combine BIQ question responses to generate diagnoses defined DSM-IV-TR Criterion A, ICD-10 Criteria A and B, and RDC/ICSD-2 Criterion A as requiring ≥ 30 days of either problems initiating sleep ≥ 3 nights a week with an average of ≥ 30 min to fall asleep at night, problems staying asleep ≥ 3 nights a week with an average of 30 min of being awake, waking ≥ 3 times a night ≥ 3 nights a week, waking too early ≥ 3 nights a week with an average of ≥ 30 min too early, or nonrestorative sleep with at least moderate severity ≥ 3 nights a week. RDC/ICSD-2 Criterion B was defined as requiring the respondent to not report that their sleep problems were caused a lot or totally by problems with the place they sleep and that the problems were not caused a lot or totally by demands on their time that required them to sleep irregularly. DSM-IV-TR Criterion B, ICD-10 Criterion D, and RDC/ICSD-2 Criterion B were defined as requiring endorsement of ≥ 2 (one in the case of RDC/ICSD-2) of the distress-impairment questions with responses of at least moderate severity to the first 8 questions, 7-10 to the SDS items, and either at least moderate concern-worry about sleep or much or very much worry-distress about sleep. The latter 2 items were also used to define ICD-10 Criterion C. Psychometric analyses documented good short-term test-retest reliability and good individual-level concordance of these BIQ inclusion criteria diagnoses with diagnoses based on blinded clinical reappraisal interviews carried out by sleep medicine experts, with an area under the receiver operating characteristic curve (AUC, a measure of classification accuracy insensitive to disorder prevalence) of 0.86.[13]

Our decision not to operationalize diagnostic hierarchy or organic exclusion rules in the BIQ was consistent with a revision under consideration for DSM-5 to eliminate the current DSM-IV distinction between primary insomnia and sleep disorders due to another mental disorder or a general medical condition in favor of a unitary diagnosis of insomnia disorder with concurrent specification of clinically comorbid conditions.[17] However, as detailed below, we controlled for a wide variety of comorbid conditions to adjust for confounding between primary and comorbid insomnia. This approach is consistent with the recommendations of the 2005 NIH State of the Science position on the classification of insomnia disorders[18] and the 2006 Recommendations for Research Assessment of Insomnia.[19]

Other physical and mental conditions

Medical and pharmacy claims data and self-reports were used to assess the presence in the 12 months before interview of 21 conditions documented in the literature to be significantly associated with elevated rates of insomnia.[20] These 21 conditions include cardio-metabolic disorders (congestive heart failure, diabetes, heart disease, hypertension), musculoskeletal disorders (chronic back or neck pain, osteoarthritis, rheumatoid arthritis), respiratory disorders (asthma, chronic obstructive pulmonary disease, seasonal allergies), digestive disorders (gastroesophageal reflux disease, ulcer), other sleep disorders (sleep apnea, restless leg syndrome), neuropathic pain, 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 obtained from claims data were based on ICD-9 codes in medical claims and inferred from pharmacy claims. In light of the fact that that a number of conditions pertinent to insomnia are known to be undertreated (e.g., depression), the AIS interview also obtained self-report data about symptom-based conditions, irrespective of whether the conditions were treated. These self-reported diagnoses were obtained in 2 ways. First, respondents completed a chronic conditions checklist based on the list used in the US National Health Interview Survey[21,22] (http://www.hcp.med.harvard.edu/ncs/replication.php). Checklists of this sort have been widely used in prior population-based studies and have been shown to yield more complete and accurate reports than estimates derived from responses to open-ended questions.[23] Methodological studies in both the US and

UK have documented good concordance between such condition reports and medical records.[24-26] Second, symptom-based conditions were detected using a series of validated disorder-specific self-report scales (e.g., the Berlin Sleep Apnea scale, the Restless Leg Syndrome Questionnaire, the Quick Inventory of Depressive Symptoms, and the Generalized Anxiety Disorder 7-item scale[27-29]). Conditions were defined as present if they either appeared in claims data or were self-reported.

Perceived health

The short-form 12 (SF-12) was used to assess perceived health in the 4 weeks before interview. The SF-12 is a 12-item subset of questions abstracted from the longer and more widely-used SF-36[30] and selected to maximize associations with the 2 summary SF-36 scores of Physical Component Summary (PCS) and Mental Component Summary (MCS).[31] Like the longer SF-36 versions of these summary scales, the SF-12 PCS and MCS scales range from 0 (worst health) to 100 (best health). Cross-national psychometric analyses have documented very high correlations between SF-12 and SF-36 summary scores.[32] The AIS interview also included a preference-based health utility index developed from the SF-12 to summarize information about physical and mental health status. This summary measure, known as the SF-6D,[33] is typically scaled in the range 0.0-1.0 in health utility studies, but was re-scaled for the current analysis to match the 0 (worst perceived health) to 100 (perfect perceived health) ranges of the PCS and MCS scales.

Sociodemographics

The AIS assessed a number of sociodemographic variables that have been examined in previous studies of risk factors for insomnia.[34] These include respondent age, sex, race/ethnicity, education, marital status, employment status, and work schedule. However, as a previous report found that insomnia in the AIS is unrelated to race/ethnicity and marital status,[14] results are reported here only for the remaining 5 sociodemographics.

Analysis Methods

An individual respondent was counted as having ≥ 1 of the 4 nighttime insomnia symptoms only if he or she met the ≥ 3/nights a week and 30-min/night criteria mentioned above. The prevalence of DIS, DMS, EMA, and NRS as well as of the various combinations of these symptoms were examined with simple cross-tabulations in the total sample, in the subsample of respondents with any of the 4 symptoms reaching diagnostic thresholds, and in the even smaller subsample of respondents who met inclusion criteria for a diagnosis of broadly defined general insomnia. A series of multiple logistic regression equations was then estimated to examine whether the sociodemographic variables differed in their associations with each of the 4 nighttime insomnia symptoms. A separate series of multiple linear regression equations was then estimated with the nighttime symptoms among respondents, with insomnia used to predict the 3 summary SF-12 perceived health scores, controlling for sociodemographics and other potentially comorbid conditions. Comparisons across equations with Wald χ^2 tests were used to determine whether the joint associations of the 4 symptoms were additive or interactive (that is, whether there were interactions among the symptoms in predicting the outcomes).

Unstandardized regression coefficients in these regression analyses were compared in the best-fitting equations to examine differences across the symptoms at the individual level. (An *unstandardized* regression coefficient is one in which the variables are scored in their natural metrics; in this case, leading to the interpretation of a regression coefficient of X.Y as meaning that presence vs. absence of the dichotomous predictor symptom is associated with a difference of X.Y points on the 0-100 outcome scale score.) Standardized regression coefficients were compared to examine the relative importance of the symptoms at the aggregate level (i.e., taking into consideration prevalence as well as unstandardized regression coefficients). (A *standardized* regression coefficient is one in which the predictors are standardized to have a variance of 1.0, leading to the interpretation of a regression coefficient of 0.X as meaning that a one standard deviation difference in probability of having the predictor symptom is associated with an X% difference in the outcome score.) Daytime distress/impairment was then controlled using the summary scale constructed from the BIQ questions in an effort to determine the extent to which the associations of nighttime insomnia symptoms with perceived health were mediated by daytime distress/impairment. Statistical significance in all these equations was consistently evaluated using 0.05-level 2-sided tests. As the AIS data are weighted, the design-based Taylor series linearization method[35] implemented in the SAS 9.1 software system[36] was used to estimate standard errors of all regression coefficients and to calculate Wald χ^2 tests.

Finally, to provide a different perspective on the relative importance of the nighttime insomnia symptoms, the relative population attributable risk proportion (PARP) of each symptom was computed. Put simply, PARP can be thought of as the proportion of the observed decrement in perceived health that is *due to* one or more predictors, where the term *due to* is used in a statistical sense to refer to prediction rather than a causal sense. Using a more rigorous definition, PARP is the proportion of the overall population-level decrement in perceived health that would not have occurred under a given regression model in the absence of one or more predictors if the coefficients associated with the predictors in that model were due to causal effects of the predictors.[37] PARP was calculated using simulation methods to generate individual-level predicted values of the SF-12 scores from the coefficients in the best-fitting linear regression models. Six sets of predicted values were computed. In the first set, the estimates were made using all the coefficients in the linear regression equation. In the next four sets, we assumed that the coefficient associated with one and only one of the 4 nighttime insomnia symptoms was zero (i.e., that this particular symptom was eradicated). In the last set, we assumed that the coefficients associated with all 4 nighttime insomnia symptoms were zero. The mean individual-level difference in predicted scores on the outcome between the first and last of these 6 sets of calculations was defined as the total predicted effect of insomnia (i.e., the extent to which outcome scores would change in the absence of insomnia). The ratios of the mean individual-level differences in predicted scores between the first and each of the second through fifth sets were then compared to the difference between the first and sixth in the total sample to define PARP. As the symptoms are all positively interrelated, the sum of these proportions is less than 100% for each outcome.

Table 1—Prevalence of insomnia symptoms and multivariate symptom profiles

	Conditional prevalence of the symptom profile among…								
	All respondents		Respondents with any symptom		Respondents with insomnia		Conditional prevalence of insomnia given the symptom profile		
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	(n)
I. Overall									
DIS[1]	12.5	(0.4)	29.4	(0.8)	37.7	(1.1)	71.5	(1.6)	(1026)
DMS[1]	23.5	(0.5)	55.2	(0.9)	61.0	(1.2)	61.6	(1.2)	(1869)
EMA[1]	23.7	(0.5)	55.7	(0.9)	52.2	(1.2)	52.3	(1.3)	(1754)
NRS[1]	6.6	(0.2)	15.6	(0.6)	25.2	(0.9)	90.1	(1.1)	(667)
Any symptoms	42.6	(0.6)	100.0	–	100.0	–	55.8	(0.9)	(3250)
II. Number of Symptoms									
Exactly one	25.4	(0.6)	59.6	(0.9)	47.4	(1.2)	44.4	(1.2)	(1802)
Exactly two	11.6	(0.4)	27.4	(0.8)	33.2	(1.1)	67.8	(1.7)	(938)
Exactly three	4.5	(0.2)	10.5	(0.5)	15.1	(0.8)	80.1	(2.4)	(402)
All four	1.1	(0.1)	2.5	(0.2)	4.2	(0.4)	93.3	(2.4)	(108)
III. One Symptom									
DIS-only	2.9	(0.2)	6.8	(0.5)	6.8	(0.6)	56.3	(3.7)	(206)
DMS-only	8.9	(0.4)	20.9	(0.8)	17.1	(0.9)	45.6	(2.1)	(649)
EMA-only	11.9	(0.4)	28.0	(0.9)	17.7	(1.0)	35.2	(1.8)	(782)
NRS-only	1.7	(0.1)	3.9	(0.3)	5.9	(0.5)	83.9	(2.8)	(165)
IV. Two Symptoms									
DIS-DMS	2.9	(0.2)	6.8	(0.5)	8.1	(0.6)	67.3	(3.5)	(221)
DIS-EMA	1.2	(0.1)	2.8	(0.3)	3.0	(0.4)	61.6	(5.7)	(87)
DIS-NRS	0.8	(0.1)	1.8	(0.2)	3.0	(0.4)	96.2	(2.2)	(74)
DMS-EMA	5.5	(0.3)	12.9	(0.6)	14.0	(0.8)	60.5	(2.6)	(421)
DMS-NRS	0.8	(0.1)	2.0	(0.2)	3.1	(0.4)	87.6	(3.5)	(86)
EMA-NRS	0.5	(0.1)	1.2	(0.2)	1.9	(0.3)	90.1	(4.2)	(49)
V. Three Symptoms									
DIS-DMS-EMA	2.7	(0.2)	6.2	(0.4)	8.0	(0.6)	71.6	(3.5)	(217)
DIS-DMS-NRS	0.9	(0.1)	2.2	(0.2)	3.7	(0.4)	94.0	(2.4)	(95)
DIS-EMA-NRS	0.2	(0.0)	0.4	(0.1)	0.7	(0.2)	94.6	(5.3)	(18)
DMS-EMA- NRS	0.7	(0.1)	1.6	(0.2)	2.6	(0.3)	90.6	(3.4)	(72)
VI. Four Symptoms									
DIS-DMS-EMAS-NRS	1.1	(0.1)	2.5	(0.2)	4.2	(0.4)	93.3	(2.4)	(108)
(n)	(6,791)		(3,250)		(2,030)				

[1]DIS, difficulty initiating sleep 3+ nights per week with 30+ minutes needed to fall asleep for 30+days; DMS, difficulty maintaining sleep 3+ nights per week (either 3+ awakenings per night or 30+ minutes awake) for 30+ days; EMA, early morning awakening 3+ nights per week with awakening 30+ minutes earlier than desired for 30+ days; NRS, nonrestorative Sleep 3+ mornings per week for 30+ days.

RESULTS

Prevalence of Nighttime Insomnia Symptoms and Symptom Profiles

The most common nighttime insomnia symptoms in the total sample (i.e., whether or not the respondent met criteria for a diagnosis of general insomnia) were EMA (23.7%) and DMS (23.5%), with DIS considerably less common (12.5%), and NRS least common (6.6%) (Table 1). At least one of these symptoms was reported by 42.6% of respondents, with 59.6% of those having symptoms reporting exactly one, 27.4% two, 10.5% three, and 2.5% all four. Over 60% of all people with any of these 4 symptoms had 1 of 3 symptom profiles: EMA-only (28.0%), DMS-only (20.9%), and DMS-EMA (12.9%). No other symptom profile included as many as 10% of all people with symptoms. Tetrachoric correlations between pairs of symptoms were all statistically significant and positive, with a range between 0.20 (EMA-NRS) and 0.58 (DIS-DMS).

We previously reported that the estimated prevalence (standard error) of insomnia in the AIS in the 30 days before interview was 23.6% (0.4), bearing in mind that we included in this definition diagnoses based on either DSM-IV (22.1%), ICD-10 (3.9%), or RDC/ICSD-2 (14.7%) inclusion criteria.[14] Prevalence of the nighttime symptoms were, of course, higher among respondents who meet criteria for a diagnosis of insomnia than in the total sample, with DMS being most common

Table 2—Associations of overlapping insomnia subsamples defined by nighttime symptoms[1] with other physical and mental conditions (n = 6,791)

	Insomnia with DIS[2]				Insomnia with DMS[2]				Insomnia with EMA[2]			
	%[3]	%[4]	OR	(95% CI)	%[3]	%[4]	OR	(95% CI)	%[3]	%[4]	OR	(95% CI)
I. Cardio-metabolic												
Congestive heart failure	1.9	1.0	1.9*	(1.0–3.4)	1.4	1.0	1.3	(0.8–2.2)	1.5	1.0	1.5	(0.8–2.6)
Diabetes	13.1	10.2	1.3*	(1.1–1.7)	13.2	10.0	1.4*	(1.1–1.7)	11.4	10.3	1.1	(0.9–1.4)
High blood pressure	32.3	29.5	1.1	(1.0–1.3)	36.4	28.6	1.4*	(1.3–1.6)	33.1	29.2	1.2	(1.0–1.4)
II. Musculoskeletal												
Frequent back or neck pains	57.3	34.6	2.5*	(2.2–3.0)	55.9	33.4	2.5*	(2.2–2.9)	54.0	34.2	2.3*	(2.0–2.6)
Arthritis (rheumatoid or osteoarthritis)	31.7	23.7	1.5*	(1.3–1.8)	35.6	22.5	1.9*	(1.7–2.2)	32.9	23.2	1.6*	(1.4–1.9)
III. Respiratory												
Chronic bronchitis or emphysema	14.9	7.0	2.3*	(1.9–2.9)	11.5	7.0	1.7*	(1.4–2.1)	11.1	7.2	1.6*	(1.3–2.0)
COPD[5]	5.0	3.3	1.6*	(1.1–2.2)	5.4	3.1	1.8*	(1.3–2.4)	5.3	3.2	1.7*	(1.2–2.3)
Seasonal allergies	47.3	38.1	1.5*	(1.2–1.7)	44.6	38.0	1.3*	(1.2–1.5)	43.9	38.3	1.3*	(1.1–1.5)
IV. Digestive												
Chronic heartburn or GERD[6]	30.9	15.3	2.5*	(2.1–2.9)	29.9	14.4	2.5*	(2.2–2.9)	26.8	15.2	2.0*	(1.7–2.4)
Frequent diarrhea, constipation, or gas	33.6	14.3	3.0*	(2.5–3.6)	29.7	13.8	2.7*	(2.3–3.1)	26.9	14.5	2.2*	(1.8–2.5)
V. Sleep												
Sleep apnea	15.8	8.4	2.0*	(1.6–2.5)	16.9	7.8	2.4*	(2.0–2.9)	16.6	8.0	2.3*	(1.9–2.8)
Restless leg syndrome	11.8	3.3	3.9*	(3.0–5.0)	10.1	3.1	3.5*	(2.8–4.5)	8.2	3.5	2.4*	(1.9–3.2)
VI. Emotional												
Depression	25.4	5.9	5.4*	(4.5–6.6)	20.4	5.5	4.4*	(3.7–5.3)	17.7	6.2	3.2*	(2.7–3.9)
Generalized anxiety disorder	22.3	4.0	6.8*	(5.5–8.3)	17.5	3.7	5.6*	(4.6–6.8)	15.1	4.4	3.9*	(3.2–4.8)
Any other emotional disorder	9.9	3.4	3.1*	(2.4–4.0)	7.4	3.4	2.3*	(1.8–2.9)	7.5	3.5	2.2*	(1.7–2.9)
VII. Other												
Migraine headaches	35.4	15.3	3.0*	(2.6–3.6)	27.4	15.3	2.1*	(1.8–2.4)	29.5	15.3	2.3*	(2.0–2.7)
Other frequent or severe headaches	37.0	14.3	3.5*	(3.0–4.2)	30.9	13.9	2.8*	(2.4–3.2)	30.9	14.3	2.7*	(2.3–3.1)
Urinary or bladder problems	16.9	9.1	2.0*	(1.7–2.5)	17.1	8.5	2.2*	(1.9–2.6)	15.0	9.0	1.8*	(1.5–2.2)
Other chronic pain[7]	52.6	32.1	2.3*	(2.0–2.7)	52.8	30.8	2.5*	(2.2–2.9)	49.1	31.8	2.1*	(1.8–2.4)
Obesity	27.6	22.8	1.3*	(1.1–1.5)	27.3	22.5	1.3*	(1.1–1.5)	24.6	23.0	1.1	(0.9–1.3)
Climacteric symptoms	1.7	1.8	1.0	(0.6–1.7)	2.3	1.7	1.4	(0.9–2.1)	2.0	1.7	1.2	(0.8–1.9)

*Significant comorbidity between insomnia and the other condition at the 0.05 level, 2-sided test. [1]The overlapping subsamples represent respondents with insomnia who have the symptom in the column regardless of whether they also have any of the other 3 symptoms. [2]See fn 1 in Table 1 for definitions. [3]Prevalence estimates of the other conditions among respondents with the type of insomnia indicated in the column heading. [4]Prevalence estimates of the other conditions among all other respondents (including not only those who do not have insomnia but also those with types of insomnia other than the type represented in the column). [5]Chronic obstructive pulmonary disease. [6]Gastroesophageal reflux disease. [7]Pain of any sort not included in the above disorders, such as muscle or joint pain.

Table 2 continues on the following page

(present in 61.0% of all respondents with insomnia), followed by EMA (52.2%), DIS (37.7%), and NRS (25.2%). Nearly half of all respondents with insomnia (47.4%) had only one nighttime symptom, 33.2% two, 15.1% three, and 4.2% all four. As in the total sample, the most common symptom profiles among respondents with insomnia were EMA-only (17.7%), DMS-only (17.1%), and DMS-EMA (14.0%). No other profile included as many as 10% of all cases. Probability of meeting diagnostic criteria for insomnia among respondents with one or more symptoms was highest for respondents with NRS (90.1%), lowest for those with EMA (52.3%), and intermediate for DMS (61.6%) and DIS (71.5%). Not surprisingly, the more nighttime symptoms a person reported, the higher their probability of meeting diagnostic inclusion criteria: 44.4% for people with exactly one symptom, 67.8% for two, 80.1% for three, and 93.3% for all four.

Comorbidities of Insomnia with Other Physical and Mental Conditions

We divided respondents with insomnia into overlapping subsamples that had each of the 4 nighttime symptoms, regardless of other reported symptoms (e.g., one subsample for insomnia with DIS whether or not respondents also had any of the other 3 nighttime symptoms). We then examined prevalence of each other condition with and without insomnia in each of these 4 overlapping subsamples. The most highly prevalent of the 21 conditions among respondents with insomnia were consistent across subsamples: chronic back/neck pain (52.8% to 60.1%), other chronic pain (48.7% to 56.4%), and seasonal allergies (43.9% to 49.6%) (Table 2). The least common were also consistent across subsamples: congestive heart failure (1.4% to 2.1%), climacteric symptoms (1.7% to 2.3%), and chronic obstructive pulmonary disease (4.4% to 5.4%).

Table 2 *(continued)*—Associations of overlapping insomnia subsamples defined by nighttime symptoms[1] with other physical and mental conditions (n = 6,791)

	Insomnia with NRS[2]				Any insomnia			
	%[3]	%[4]	OR	(95% CI)	%[3]	%[4]	OR	(95% CI)
I. Cardio-metabolic								
Congestive heart failure	2.1	1.0	2.0*	(1.1–3.6)	1.4	1.0	1.4	(0.9–2.2)
Diabetes	10.0	10.5	1.0	(0.7–1.3)	11.5	10.1	1.2	(1.0–1.4)
High blood pressure	31.2	29.6	1.1	(0.9–1.3)	32.6	28.8	1.2*	(1.1–1.3)
II. Musculoskeletal								
Frequent back or neck pains	60.1	35.1	2.8*	(2.3–3.3)	52.8	31.6	2.4*	(2.2–2.7)
Arthritis (rheumatoid or osteoarthritis)	33.4	23.8	1.6*	(1.3–1.9)	31.4	22.2	1.6*	(1.4–1.8)
III. Respiratory								
Chronic bronchitis or emphysema	15.7	7.2	2.4*	(1.9–3.1)	11.8	6.4	2.0*	(1.6–2.4)
COPD[5]	4.8	3.3	1.5	(1.0–2.2)	4.4	3.1	1.4*	(1.1–1.9)
Seasonal allergies	49.6	38.3	1.6*	(1.3–1.9)	44.7	37.2	1.4*	(1.2–1.5)
IV. Digestive								
Chronic heartburn or GERD[6]	29.8	15.8	2.3*	(1.9–2.7)	27.5	13.3	2.5*	(2.2–2.8)
Frequent diarrhea, constipation, or gas	33.4	15.0	2.9*	(2.4–3.4)	28.5	12.2	2.9*	(2.5–3.3)
V. Sleep								
Sleep apnea	19.8	8.4	2.7*	(2.2–3.3)	15.6	7.0	2.4*	(2.1–2.9)
Restless leg syndrome	11.6	3.6	3.5*	(2.7–4.7)	8.7	2.6	3.5*	(2.8–4.5)
VI. Emotional								
Depression	26.9	6.4	5.3*	(4.3–6.6)	18.0	4.5	4.7*	(3.9–5.6)
Generalized anxiety disorder	21.0	4.7	5.4*	(4.3–6.8)	15.7	2.6	7.1*	(5.7–8.7)
Any other emotional disorder	12.2	3.5	3.8*	(2.9–5.1)	7.5	2.9	2.7*	(2.1–3.4)
VII. Other								
Migraine headaches	31.9	16.1	2.4*	(2.0–2.9)	27.8	13.8	2.4*	(2.1–2.8)
Other frequent or severe headaches	35.4	15.2	3.1*	(2.6–3.7)	30.2	12.0	3.2*	(2.8–3.6)
Urinary or bladder problems	18.6	9.2	2.3*	(1.8–2.8)	15.2	8.1	2.0*	(1.7–2.4)
Other chronic pain[7]	56.4	32.5	2.7*	(2.3–3.2)	48.7	29.4	2.3*	(2.0–2.6)
Obesity	25.4	23.1	1.1	(0.9–1.4)	25.4	22.5	1.2	(1.0–1.3)
Climacteric symptoms	2.2	1.7	1.3	(0.7–2.3)	2.0	1.7	1.2	(0.8–1.8)

*Significant comorbidity between insomnia and the other condition at the 0.05 level, 2-sided test. [1]The overlapping subsamples represent respondents with insomnia who have the symptom in the column regardless of whether they also have any of the other 3 symptoms. [2]See fn 1 in Table 1 for definitions. [3]Prevalence estimates of the other conditions among respondents with the type of insomnia indicated in the column heading. [4]Prevalence estimates of the other conditions among all other respondents (including not only those who do not have insomnia but also those with types of insomnia other than the type represented in the column). [5]Chronic obstructive pulmonary disease. [6]Gastroesophageal reflux disease. [7]Pain of any sort not included in the above disorders, such as muscle or joint pain.

Inspection of bivariate associations of insomnia with the 21 conditions shows that virtually all (95% to 100%) odds ratios (ORs) were positive and that the vast majority (85% to 90%) of ORs were statistically significant at the 0.05 level. Median values of the ORs are in the range 2.1-2.4 and interquartile ranges ([IQR]; 25th-75th percentiles) of ORs were in the range 1.3-3.0. ORs were fairly comparable in magnitude across the 4 nighttime insomnia symptoms, with median (IQR) values of 2.3 (1.5-3.0) for insomnia with DIS, 2.2 (1.4-2.5) for insomnia with DMS, 2.1 (1.6-2.9) for insomnia with EMA, and 2.4 (1.6-2.9) for insomnia with NRS. Four conditions have consistently high ORs (2.4-6.8) across subsamples (chronic headaches, restless leg syndrome, generalized anxiety disorder, depression), and 4 have consistently weak ORs (1.0-1.4) across subsamples (diabetes, hypertension, obesity, and climacteric symptoms).

Bivariate Associations of Insomnia with Perceived Health

SF-12 summary scale scores of perceived health had means of 53.2 (MCS), 51.7 PCS, and 83.7 (total) in the total sample (Table 3). These scores were all significantly lower among respondents with than without insomnia: 48.9 vs. 54.5 (χ^2_1 = 555.2, P < 0.001) for MCS, 48.9 vs. 52.6 (χ^2_1 = 224.8, P < 0.001) for PCS, and 76.5 vs. 86.0 (χ^2_1 = 807.1, P < 0.001) for SF-6D. Furthermore, scores on all 3 SF-12 scales were consistently lower among respondents in each of the 15 subgroups of insomnia defined by the cross-classification of the 4 nighttime symptoms than among respondents without insomnia. Among respondents with insomnia, scores on all 3 scales varied significantly across the 15 symptom profiles (χ^2_{14} = 95.5-214.6, P < 0.001). This variation was due largely to significant decreases in scale scores with increasing number of nighttime symptoms (χ^2_3 = 51.0-152.9, P < 0.001 not

Table 3—Mean and interquartile range (IQR) SF-12 summary perceived health scores among respondents with and without insomnia as a function of nighttime symptom profile (n = 6,791)

	MCS[1]		PCS[1]		SF-6D[1]	
	Mean	(IQR)	Mean	(IQR)	Mean	(IQR)
I. Total sample and overall subsamples with and without insomnia						
Total sample	53.2	(49.8-57.7)	51.7	(48.9-57.3)	83.7	(78.1-92.2)
No insomnia	54.5	(51.7-58.2)	52.6	(50.0-57.5)	86.0	(81.5-92.2)
Any insomnia	48.9*	(43.4-55.7)	48.9*	(43.5-56.9)	76.5*	(65.9-86.2)
χ^2_1	555.2**		224.8**		807.1**	
II. Insomnia with particular nighttime symptoms[2]						
DIS[3]	47.0*	(39.9-54.4)	47.8*	(41.9-56.5)	73.6*	(64.2-85.9)
DMS[3]	48.7*	(42.8-55.8)	47.7*	(41.2-56.3)	75.1*	(65.6-86.1)
EMA[3]	49.4*	(44.0-55.9)	48.6*	(43.0-56.8)	76.7*	(65.9-86.2)
NRS[3]	46.2*	(39.4-53.6)	46.2*	(39.2-56.1)	71.4*	(61.8-82.3)
III. Number of nighttime symptoms among respondents with Insomnia						
Exactly 1	50.2*	(45.7-56.3)	50.7*	(46.4-57.2)	79.4*	(72.0-89.8)
Exactly 2	48.4*	(42.8-55.5)	49.18	(43.6-56.9)	76.0*	(65.8-86.1)
Exactly 3	46.8*	(39.3-54.0)	45.1*	(38.1-54.5)	70.9*	(61.5-81.2)
All 4	45.4*	(37.4-53.3)	41.6*	(28.8-54.5)	67.0*	(57.4-78.4)
χ^2_3	51.0**		89.1**		152.9**	
IV. Insomnia multivariate nighttime symptom profiles[4]						
DIS-only	48.2*	(40.9-55.0)	51.3*	(48.9-57.2	78.3*	71.2-88.1
DMS-only	50.6*	(45.4-57.0)	49.8*	(44.4-56.9)	78.6*	(69.7-86.3)
EMA-only	51.4*	(48.1-56.9)	51.8	(48.3-57.2)	81.8*	(73.8-90.4)
NRS-only	47.7*	(42.2-54.1)	49.4*	(44.8-57.1)	75.6*	(65.8-86.0)
χ^2_3	18.2**		14.8**		29.5**	
DIS-DMS	48.1*	(42.1-55.4)	49.7*	(46.0-57.2)	76.6*	(65.6-86.3)
DIS-EMA	48.3*	(41.8-55.1)	52.2	(49.9-57.4)	77.7*	(65.9-87.5)
DIS-NRS	44.2*	(36.2-52.5)	48.6*	(43.7-56.2)	71.7*	(60.8-84.2)
DMS-EMA	50.1*	(45.7-57.0)	48.5*	(42.7-57.2)	77.2*	(67.3-86.1)
DMS-NRS	47.2*	(41.4-53.6)	46.7*	(39.3-54.3)	72.0*	(61.8-79.9)
EMA-NRS	46.5*	(39.6-55.5)	49.7	(42.7-58.3)	74.6*	(64.7-86.2)
χ^2_5	16.3**		10.3		22.8**	
DIS-DMS-EMA	47.5*	(40.1-54.5)	46.0*	(38.2-55.1)	72.3*	(61.7-82.0)
DIS-DMS-NRS	44.3*	(36.5-51.8)	44.3*	(35.4-53.8)	68.1*	(58.1-75.7)
DIS-EMA-NRS	46.0*	(39.6-49.5)	44.7*	(35.7-50.5)	69.1*	(60.5-77.4)
DMS-EMA-NRS	48.3*	(40.5-54.3)	43.7*	(32.7-54.3)	71.2*	(62.4-81.0)
χ^2_3	6.0		3.8		8.9**	
DIS-DMS-EMA-NRS	45.4*	(37.4-53.3)	41.6*	(28.8-54.5)	67.0*	(57.4-78.4)

*Significant difference in the mean outcome score compared to respondents without insomnia. **Significant variation in the mean outcome scores among subgroups in the same part of the table. The tests in Part I evaluate the significance of differences between all respondents with insomnia versus all those without insomnia. The tests in Part III evaluate the significance of differences among respondents with insomnia depending on number of nighttime symptoms. The tests in subsets of Part IV, finally, evaluate the significance of differences among insomniacs with the same number of symptoms as a function of symptom profiles. [1]MCS, Mental Component Summary; PCS, Physical Component Summary; SF-6D, a preference-based health utility index that combines information from the MCS and PCS. [2]The results reported in these four rows are for overlapping subsamples of respondents with insomnia who have the symptom in the row regardless of whether they also have any of the other three symptoms. [3]See fn 1 in Table 1 for definitions. [4]Means on all three scales different significantly across the 15 insomnia symptom profiles: χ^2_{14} = 95.5, P < 0.001 for MCS; 124.3, P < 0.001 for PCS; 214.6, P < 0.001 for SF-6D.

shown), although less substantial differences could also be seen among multivariate profiles with a given number of symptoms (χ^2_3 = 14.8-29.5, P < 0.001-0.002 among cases with exactly one symptom; χ^2_5 = 10.3-22.8, P = 0.006-0.066 among those with 2; χ^2_3 = 3.8-8.9, P = 0.03-0.29 among those with 3).

Associations of Insomnia with Sociodemographic Variables

Some of the sociodemographic correlates of insomnia varied significantly by nighttime insomnia symptoms (Table 4). Age was a consistently significant correlate of insomnia with each of the 4 nighttime symptoms (χ^2_3 = 22.3-52.1, P < 0.001), but the shape of this association varied significantly (χ^2_9 = 100.6,

Table 4—Sociodemographic correlates of insomnia in overlapping subsamples defined by presence of nighttime symptoms[1] (n = 6,791)

	DIS[2]		DMS[2]		EMA[2]		NRS[2]		
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	χ^2
Age									
18–29	2.9*	(2.2–3.9)	1.0	(0.8–1.3)	1.3	(1.0–1.6)	2.4*	(1.6–3.4)	
30–44	2.2*	(1.6–2.9)	1.5*	(1.2–1.9)	1.6*	(1.3–2.1)	2.2*	(1.5–3.2)	
45–64	1.8*	(1.4–2.3)	1.6*	(1.3–2.0)	1.7*	(1.4–2.1)	1.8*	(1.3–2.5)	
65+	1.0	–	1.0	–	1.0	–	1.0	–	
χ^2_3	52.1*		43.7*		30.7*		22.3*		100.6**
Sex									
Female	1.6*	(1.4–1.9)	1.6*	(1.4–1.8)	1.3*	(1.2–1.5)	1.7*	(1.4–2.0)	
Male	1.0	–	1.0	–	1.0	–	1.0	–	
χ^2_1	42.8*		61.4*		17.7*		34.3*		12.0**
Education									
Less than high school	1.6	(1.0–2.7)	1.3	(0.9–2.0)	1.2	(0.8–1.9)	0.8	(0.4–1.8)	
High school graduate	1.5*	(1.3–1.8)	1.2*	(1.0–1.3)	1.3*	(1.2–1.5)	1.2*	(1.0–1.5)	
Some post–HS	1.5*	(1.2–1.8)	1.2	(1.0–1.4)	1.3*	(1.0–1.5)	1.5*	(1.2–1.9)	
College graduate	1.0	–	1.0	–	1.0	–	1.0	–	
χ^2_3	30.3*		8.5*		19.2*		13.7*		18.4**
Employment status									
Student	1.0	(0.7–1.4)	0.8	(0.6–1.2)	0.8	(0.6–1.2)	0.8	(0.5–1.2)	
Homemaker	0.9	(0.7–1.3)	0.9	(0.7–1.2)	1.1	(0.8–1.4)	0.9	(0.6–1.3)	
Retired	1.6*	(1.2–2.2)	1.4*	(1.1–1.7)	1.2	(1.0–1.5)	1.3	(0.9–1.8)	
Disabled	5.3*	(3.4–8.2)	4.1*	(2.8–6.2)	3.6*	(2.4–5.5)	5.5*	(3.4–8.9)	
Employed	1.0	–	1.0	–	1.0	–	1.0	–	
Other	2.0*	(1.5–2.6)	1.2	(1.0–1.6)	1.2	(0.9–1.6)	1.6*	(1.2–2.3)	
χ^2_5	74.1*		56.2*		39.1*		58.3*		21.0
Work schedule									
Evenings	1.9*	(1.2–2.9)	1.4	(0.9–2.0)	1.6*	(1.1–2.4)	1.0	(0.5–1.8)	
Nights	2.4*	(1.6–3.6)	1.0	(0.7–1.6)	1.3	(0.8–2.0)	1.6	(0.9–2.7)	
Split Shifts	1.3	(0.7–2.4)	1.2	(0.7–2.1)	1.3	(0.8–2.2)	1.6	(0.8–3.1)	
Rotating Shifts	1.2	(0.8–2.1)	1.2	(0.8–1.8)	1.0	(0.6–1.6)	0.8	(0.4–1.6)	
Other	1.5*	(1.1–2.0)	1.2	(1.0–1.5)	1.0	(0.8–1.3)	1.1	(0.8–1.6)	
Days	1.0	–	1.0	–	1.0	–	1.0	–	
χ^2_5	31.5*		5.4		7.2		5.6		24.6**
χ^2_{17}	219.7*		172.8*		115.1*		128.7*		

*Significant association with the insomnia symptom at the 0.05 level, 2–sided test. **Significant difference in the set of coefficients associated with the sociodemographic variable across the four equations at the 0.05 level, 2–sided test. The number of degrees of freedom associated with the χ^2 tests are 9 for age, 3 for sex, 9 for education, 15 for employment status, and 15 for work schedule. [1]The overlapping subsamples represent respondents with insomnia who have the symptom in the column regardless of whether they also have any of the other 3 symptoms. [2]See fn 1 in Table 1 for a description of the AIS comorbidity subsample.

$P < 0.0001$) due to inverse relationships of age with both DIS and NRS compared to positive relationships of age with DMS and EMA. Sex was also a consistently significant correlate of insomnia with all 4 symptoms ($\chi^2_1 = 17.7\text{-}61.4$, $P < 0.001$), as women consistently had significantly higher odds than men. This association varied significantly across the outcomes ($\chi^2_3 = 12.0$, $P = 0.010$), though, due to a weaker sex difference for EMA than other symptoms. Education also correlated consistently with all 4 insomnia symptoms ($\chi^2_3 = 8.5\text{-}30.3$, $P = 0.04 - < 0.001$), but with ORs varying significantly ($\chi^2_9 = 18.4$, $P = 0.030$) due to respondents with less than a college education having the highest odds of DIS, DMS, and EMA, but those with some college education having the highest odds of NRS.

Employment status, in comparison, was a consistently significant correlate ($\chi^2_5 = 39.1\text{-}74.1$, $P < 0.001$) of insomnia with each of the 4 symptoms with ORs that did not vary across symptoms ($\chi^2_{15} = 21.0$, $P = 0.14$). The pattern observed was for students, homemakers, and the employed to have the lowest odds of insomnia, the disabled to have the highest odds, and the retired and those in *other* employment statuses (mostly unemployed and looking for a job) to have intermediate odds. The final significant sociodemographic variable, work schedule among the employed, was significantly related to insomnia with DIS ($\chi^2_5 = 31.5$, $P < 0.001$), but not to insomnia with any other symptoms ($\chi^2_5 = 5.4\text{-}7.2$, $P = 0.20\text{-}0.38$). The association with DIS was due to significantly elevated odds among workers on

Table 5—Regression coefficients of associations between insomnia nighttime symptoms[1] and SF-12 summary perceived health scales (n = 6,791)

	MCS[2]			PCS[2]			SF-6D[2]		
	b[3]	(SE)	β[3]	b[3]	(SE)	β[3]	b[3]	(SE)	β[2]
I. Without controls for daytime impairment									
DIS[4]	-2.9*	0.5	-0.3	-0.4	0.4	0.0	-1.5*	0.5	-0.2
DMS[4]	-2.6*	0.4	-0.5	-1.2*	0.3	-0.2	-2.8*	0.4	-0.5
EMA[4]	-2.1*	0.3	-0.3	-0.3	0.3	-0.1	-1.4*	0.4	-0.2
NRS[4]	-4.0*	0.5	-0.4	-2.5*	0.4	-0.2	-4.5*	0.5	-0.4
Number of subtypes – 1	2.6*	0.4	0.6						
χ^2_4	128.1*			76.6*			273.7*		
χ^2_3	98.1*			23.5*			120.0*		
II. With controls for daytime impairment									
DIS[4]	-1.6*	0.5	-0.2	0.0	0.4	0.0	-0.1	0.5	0.0
DMS[4]	-1.2*	0.4	-0.2	-0.8*	0.3	-0.1	-1.2*	0.4	-0.2
EMA[4]	-1.3*	0.3	-0.2	-0.2	0.3	0.0	-0.6	0.4	-0.1
NRS[4]	-1.5*	0.5	-0.1	-1.7*	0.4	-0.2	-1.3*	0.5	-0.1
Number of subtypes – 1	2.0*	0.4	0.5						
χ^2_4	28.4*			24.6*			23.7*		
χ^2_3	27.2*			6.7			14.9*		

*Significant at the 0.05-level, 2-sided test. [1]The symptoms are defined in overlapping subsamples representing respondents with insomnia who have the symptom in the row regardless of whether they also have any of the other 3 symptoms. [2]MCS, Mental Component Summary; PCS, Physical Component Summary; SF-6D, a preference-based health utility index that combines information from the MCS and PCS. [3]b is the unstandardized regression coefficient; β is the standardized regression coefficient. See the text for a discussion of the difference between these 2 kinds of coefficients. [4]See fn 1 in Table 1 for definitions.

evening and night shifts, more modestly elevated odds among workers on other shifts than a day shift, and lowest odds among workers on a day shift.

Multiple Regressions of Insomnia with Perceived Health

Linear regression equations were estimated in which dichotomous measures of insomnia with each of the 4 nighttime symptoms were used to predict each of the 3 summary perceived health scores using a number of different model assumptions. Sociodemographics and other physical and mental disorders were controlled in all models. Six models were estimated for each outcome. The first (M1) included a separate dummy variable for insomnia with each of the 4 nighttime symptoms. The other 5 models added interactions to M1 involving various combinations of the 4 nighttime symptoms. Comparisons of model fit (detailed results available on request) show that insomnia is significantly associated with all 3 outcomes in M1 (χ^2_4 = 82.4-228.2, P < 0.001), that none of the more complex models improves on the fit of M1 in the PCS or SF-6D equations, and that a somewhat more complex model is optimal in the MCS equation. The latter model includes a variable for number of nighttime symptoms.

Inspection of unstandardized regression coefficients in the best-fitting models show that each of the 4 insomnia symptoms is independently related to MCS and SF-6D, while only insomnia with DMS and NRS are associated with PCS (Table 5, Part I). All coefficients are negative, meaning that insomnia is consistently associated with worse perceived health. Global tests show that we can reject the hypothesis that the slopes associated with the 4 insomnia symptoms are of the same magnitude (χ^2_3 = 23.5-120.0, P < 0.001). Insomnia with NRS has the largest unstandardized regression coefficient in all 3 equations. The ratio of the NRS coefficient to the next largest coefficient is significantly greater than 1.0 for PCS (χ^2_1 = 6.6, P = 0.010) and SF-6D (χ^2_1 = 6.4, P = 0.011), but not MCS (1.4, χ^2_1 = 0.5, P = 0.47). Insomnia with EMA has the smallest regression coefficient in all 3 equations, but is significant for MCS and SF-6D although not for PCS. The significant interaction associated with number of insomnia symptoms in the MCS model, finally, has a sign opposite that of the other coefficients, indicating that the joint effects of the 4 insomnia symptoms are *subadditive*, that is, the coefficient between any given multi-symptom insomnia symptom profile is significantly less than the sum of the coefficients based on the marginal coefficients in that profile.

As noted above, the standardized regression coefficients in these equations adjust for the substantial variation in prevalence of insomnia symptoms by assessing the associations of a standard deviation in symptoms with a standard deviation in perceived health. This is a useful transformation because NRS, although having a higher unstandardized regression coefficient than other insomnia symptoms, is by far the least prevalent symptom (6.6% vs. 12.5-23.7%). This means that the much stronger individual-level associations of NRS with perceived health (unstandardized coefficients) are dampened at the societal level (standardized coefficients). Because of this dampening, the standardized NRS coefficients are comparable to the DMS coefficients, although larger than the DIS and EMA coefficients, in all models.

One plausible interpretation of the finding that NRS has the strongest individual-level association with perceived health is

that NRS is most strongly related to daytime distress/impairment and that daytime distress/impairment mediates the associations of insomnia with perceived health. In order to evaluate this possibility, the summary scale of daytime distress/impairment was used in two ways.

First, we used the daytime distress/impairment score as an outcome variable in the same kind of linear multiple regression analysis used to study the associations of nighttime insomnia symptoms predicting perceived health. As one might expect, all 4 insomnia symptoms were found to be significantly associated with this summary daytime distress/impairment scale, but the less obvious finding is that NRS had the highest regression coefficient (standard error in parentheses) in predicting normalized (to have a theoretical range between 0 and 100, with high scores representing more distress/impairment) scores on the summary daytime distress/impairment scale (5.4 [0.3]), and EMA the lowest (2.3 [0.2]), with intermediate values for DMS (3.5 [0.2]) and DIS (2.7 [0.3]).

Second, we included the summary daytime distress/impairment scale as a control in the regression equations for insomnia predicting perceived health (Table 5, Part II). We found that daytime distress/impairment is a powerful mediator. All 12 of the regression coefficients in the three equations become smaller in magnitude after controlling daytime distress/impairment, with a median (IQR) reduction in coefficient size of 56% (38% to 62%). Two of the 10 significant insomnia symptom coefficients in the models without daytime distress/impairment become insignificant in the models with daytime distress/impairment (DIS and EMA in the equation for SF-6D).

Another possibility is that NRS is the nighttime insomnia symptom most strongly comorbid with the other sleep disorders considered in the AIS, sleep apnea and restless legs syndrome (RLS), and that the latter disorders are the ones responsible for the associations with perceived health. We controlled in the multiple regression equations for these disorders as well as for all the other physical and mental conditions that were found to be comorbid with insomnia in order to control for any such confounding, but those equations assumed that there were no interactions between insomnia and these other conditions. To evaluate whether this assumption is correct, we added interaction terms between each insomnia symptom and comorbid sleep apnea or RLS to each prediction equation. These interactions were insignificant in all 3 equations both in the absence (χ^2_4 = 2.9-6.1, P = 0.19-0.58) and presence (χ^2_4 = 2.6-4.8, P = 0.31-0.63) of controls for daytime distress/impairment. This means that the associations of nighttime insomnia symptoms with perceived health are independent of comorbid sleep disorders in the additive multivariate models. (Detailed results are available on request.)

Relative Population Attributable Risk Proportions (PARP)

A somewhat different perspective on the relative importance of the different nighttime insomnia symptoms is obtained by simulating the expected relative effects of sequentially eradicating these symptoms under the simplifying assumption that the regression coefficients in the equations represent causal effects of insomnia on perceived health (Table 6). These calculations suggest that the largest proportional societal-level improvement in MCS would result from eradicating DIS (25.2%), whereas the largest comparable improvement in PCS and SF-6D would result from eradicating DMS (40.7% and 38.0%, respectively). Insomnia associated with NRS, while always having a relative PARP approximate the largest, is never itself the largest due to its comparatively low prevalence. The relative PARP associated with eradicating insomnia associated with EMA is consistently lower (7.0% to 13.4%) than that of insomnia associated with the other symptoms (19.6% to 40.7%).

Table 6—Relative population attributable risk proportions (PARPs)[1] of SF-12 perceived health scales due to the 4 nighttime symptoms[2] (n = 6,791)

	MCS[3]	PCS[3]	SF-6D[3]
DIS	25.2	7.6	19.6
DMS	23.2	40.7	38.0
EMA	7.0	13.4	12.7
NRS	21.7	37.3	27.9

[1]See the text for a description of PARP. [2]The symptoms are defined in overlapping subsamples representing respondents with insomnia who have the symptom in the row regardless of whether they also have any of the other 3 symptoms. [3]MCS, Mental Component Summary; PCS, Physical Component Summary; SF-6D, a preference-based health utility index that combines information from the MCS and PCS.

DISCUSSION

The data reported here estimated the comparative prevalence of core nighttime insomnia symptoms in a representative sample of US health plan subscribers and the associations of these symptoms with sociodemographic variables, other physical and mental disorders known to be comorbid with insomnia, and perceived health. The analyses explored whether nighttime insomnia symptoms identify sufficiently different patterns of risk, comorbidity, and burden that they may justify further investigation of the implications of these distinctions in clinical samples and in community samples evaluated using clinical diagnoses and sleep studies.

Regarding symptom prevalence, we found that DMS and EMA are the most common nighttime insomnia symptoms, followed by DIS and NRS. This is true both in the entire sample and among respondents with broadly defined insomnia. In the total sample, DMS and EMA were each reported by about one-quarter of respondents. Slightly more insomnia cases reported DMS (61%) than EMA (52.2%). Most recent population-based studies of adults using an unrestricted age range[11,38-40] have also found DMS to be the most prevalent nighttime insomnia symptom. When different profiles emerged, samples were generally selected to overrepresent either youth,[6,41] or the elderly.[5]

Previous results regarding the second-ranked nighttime insomnia symptom have been less consistent. Lichstein and colleagues[42] summarized the insomnia symptom prevalence literature prior to 2003 and calculated a median symptom prevalence for 46 random-sample studies. Estimates were usually lower in these studies than in the AIS, with medians of 15.5% for DMS compared to 23.5% in the AIS, 12.7% for EMA compared to 23.7% in the AIS, and 13.4% for DIS compared to 12.5% in the AIS. These averages must be interpreted with caution, though, as they have very wide ranges (4.6% to 67.5%

for DIS and 5.6% to 74.0% for DMS, with the range for EMA not reported) that reflect methodological differences across the studies both in symptom definition and sample characteristics. Several studies reviewed were conducted outside the US, and it is noteworthy that a wide cross-national range was found in symptom reports even when measures and samples were standardized across sites.[43] Approximately half (47.4%) of AIS respondents with insomnia reported only a single nighttime symptom, 33.2% two, 15.1% three, and 4.2% all four. Few previous studies have reported distributional findings that can be compared with this one. The AIS distribution is very similar to that reported in a large community sample in Quebec, where 52.3% reported a single symptom, 30.7% two, and 12.2% three, with NRS not being assessed.[44] We are unaware of other comparable data for general adult populations and using prevailing diagnostic criteria.

The most common nighttime symptom profiles among AIS cases were EMA-only, DMS-only, and EMA-DMS. It would be interesting to determine whether the EMA-only and DIS-only profiles are respectively characterized by a phase advance and a phase delay in circadian timing and if the EMA-DMS profile fits a phenotype characterized by 24-hour hyperarousal.[45] However, these possibilities assume that symptom profiles are fairly stable over time. Data that examine this issue of the temporal stability of subtypes are sparse and inconsistent. While a follow-up study of general practice outpatients revealed low stability of DIS, DMS, and EMA over a period of four months,[9] nonclinical samples have demonstrated stability of DMS and EMA in young adults followed for two and seven years,[6] and of DIS and DMS in older adults followed for two years.[5] This inconsistency of results across studies regarding temporal stability of symptoms perhaps reflects the greater symptomatic variability in selected patient populations relative to the general population. Large-scale longitudinal general population data are needed to resolve this uncertainty.

A word is also in order about the high insomnia prevalence estimate in the AIS (23.6%) compared to the 6%-10% estimate in many previous epidemiological studies.[46] The high AIS prevalence is driven largely by the DSM-IV estimate (22.1%), which is much higher than the ICD (3.9%) or RDC/ICSD-2 (14.7%) estimate.[14] Only seven of the more than 50 previously published epidemiological studies of insomnia cited in published reviews were based on full DSM-IV criteria, and all of these studies used the Sleep-EVAL to make diagnoses.[46] As noted above, the Sleep-EVAL includes a number of idiosyncratic requirements that go well beyond DSM, ICD, or RDC/ICSD criteria, presumably leading to underestimation of prevalence. We are aware of only one other large (n = 12,778) general population epidemiological survey that assessed adult insomnia prevalence with a fully structured diagnostic instrument using DSM-IV criteria.[47] The insomnia prevalence estimate in that study (19.0%) was quite similar to the AIS estimate (22.1%). In addition, consistent with the assertion that the AIS prevalence estimate is not upwardly biased, a clinical reappraisal study found no bias in the estimated prevalence of insomnia in the AIS compared to diagnoses based on blinded clinical interviews by sleep medicine experts.[13]

The AIS finding of significant comorbidity between insomnia and a wide range of other physical and mental conditions is broadly consistent with previous studies,[48,49] although the magnitude of associations has generally been weaker, especially with physical (as opposed to mental) disorders, when insomnia was defined loosely[11,12,38,50] rather than rigorously.[20,51,52] In comparison, the AIS finding that strength of comorbidity does not vary greatly depending on the presence or absence of particular nighttime insomnia symptoms has been found consistently in previous studies, regardless of how rigorously insomnia was defined.[52,53]

More evidence of variation in associations across the four nighttime insomnia symptoms was found in the AIS for sociodemographics. This applied to age (positively related to DMS and EMA but inversely to DIS and NRS), sex (higher prevalence of all symptoms among women than men, but less so for EMA than the other symptoms), education (inversely related to DIS, DSM, and EMA, but not NRS), and work schedule (related to DIS but not the other symptoms). Previous evidence involving similar analyses of age[42,54,55] and sex[42] have shown patterns generally consistent with those in the AIS.

A number of epidemiological studies examined associations between insomnia and perceived health as indexed by the SF-36 or SF-12.[39,50,56-60] With the exception of one study that had a very low response rate,[56] marked reductions in perceived health were found among respondents with insomnia. These reductions persisted after controlling for covariates known to influence quality of life, including comorbid physical[39,50,57] and mental[57,58,60] disorders.

We are unaware, though, of previous population-based studies of adults using prevailing diagnostic criteria that reported separate associations of the four nighttime insomnia symptoms with perceived health. It is consequently not possible to evaluate the generalizability of either our findings that these four symptoms are significantly related to poor perceived health after controlling for comorbidity or that these associations are substantially reduced when a control is introduced into the regression equation for daytime distress/impairment. One previous study reported (consistent with the AIS) that DIS and DMS both had independent associations with low perceived health after controlling for comorbid conditions,[57] but neither EMA nor NRS were assessed. One other previous epidemiological study found that NRS was more strongly associated than either DIS or DMS with daytime impairment and distress.[59] This is consistent with our finding that NRS has the strongest of these individual-level associations.

These results suggest that from the perspective of an individual patient, treatments targeted at NRS would be expected to have the greatest potential effects on overall perceived health, while treatments targeted at EMA would be expected to have the weakest effects. In comparison, the AIS analysis of PARP portrays quite a different situation from a societal perspective; the higher PARPs for DMS relative to other nighttime insomnia symptoms suggest that successful treatments targeted at DMS would confer the greatest effect in improving population-level perceived health. This is due to the fact that DMS is more common than NRS and has stronger individual-level associations with perceived health than either DIS or EMA.

Our finding that the associations of nighttime insomnia symptoms with perceived health are substantially reduced when controls are introduced for daytime distress/impairment addresses a long-standing question regarding whether a persistent report of

difficulty with sleep onset or maintenance at night, without a daytime complaint, be considered an insomnia disorder. Our finding of the importance of daytime symptoms is broadly consistent with the results of the small number of studies that have focused on the subjective meaning of insomnia and found that daytime symptoms loom large in the thinking of insomniacs about their sleep problems.[61,62] However, we also found that nighttime insomnia symptoms continue to be significantly associated with perceived health, albeit in attenuated form, even when daytime distress/impairment is controlled. This finding is consistent with a number of studies that have documented significant associations of nighttime insomnia symptoms even in the absence of daytime symptoms with significant adverse health outcomes.[63-65] Clearly, determining the relative importance of daytime and nighttime features of insomnia, and which metrics should be used to quantify those features, will require further research.

Several important limitations of the current report must be noted. Two of these involve the sample. First, the AIS cooperation rate (65.0%) was relatively low, which might have distorted estimates of prevalence and correlates. Second, respondents were all members of a large national commercial health plan, which might mean that the results do not apply 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. Another design limitation is that the AIS has a cross-sectional naturalistic study design, which is ill-suited to making temporal, much less causal, inferences about the associations documented here. It is consequently possible that some part of the associations documented here between insomnia symptoms and perceived health is actually due to perceived health or its causes leading to insomnia. We have no way to evaluate this possibility with the cross-sectional AIS data. A related issue is that the net associations of insomnia symptoms with perceived health will be underestimated to the extent that comorbid conditions are consequences of insomnia, another possibility that we cannot evaluate because of the cross-sectional AIS design.

There are also limitations associated with the diagnosis of insomnia. These diagnoses were based on the fully structured BIQ rather than on clinical interviews. Although this limitation is partially addressed by the good concordance between BIQ diagnoses and independent clinical diagnoses made by experienced sleep medicine experts, there will inevitably be less subtlety in diagnoses based on a screening scale. In addition, diagnostic hierarchy rules and organic exclusion rules were not used in making diagnoses, although controls were included in the regression equations to adjust for comorbid physical and mental disorders. With regard to this limitation, though, it should be noted that our decision to diagnose insomnia without hierarchy and organic exclusions is consistent with the most recent recommendations of the task force revising the DSM criteria,[17] while our approach of using controls to adjust for the effects of comorbid conditions is consistent with the recommendations of both the 2005 NIH State-of-the-Science Conference[18] and the 2006 Recommendations for Research Assessment of Insomnia.[19] In the special case of other sleep disorders (sleep apnea and restless leg syndrome), which might be considered of special importance as sources of comorbidity, we carried out a sensitivity analysis and found that the net associations of insomnia symptoms with perceived health do not vary significantly depending on the presence vs. absence of these conditions.

Within the context of these limitations, we found that nighttime insomnia symptoms are highly prevalent in the population, with DMS and EMA by far the most common and NRS the least common. We found that three symptom profiles—DMS-only, EMA-only, and DMS-EMA—account for over 60% of people with nighttime symptoms and nearly 50% of those with insomnia. We also found that all four nighttime symptoms are significant predictors of perceived health, that their joint effects are largely additive, and that these associations are largely mediated by daytime distress-impairment. The strongest predictor at the individual level is NRS and the weakest is EMA. At the societal level, though, where both prevalence and strength of individual-level association are considered, the strongest predictor of perceived health is DMS. Nevertheless, the extent to which these symptom profiles are stable over time remains uncertain. Future long-term longitudinal study in general population adult samples is needed to resolve discrepancies in currently available evidence regarding symptom stability. Moreover, although the AIS results provide a preliminary indication that symptom-based subtyping might turn be of clinical value, they need to be evaluated much more thoroughly in studies using expert clinical interview and polysomnographic identification of comorbid sleep disorders to confirm the existence of subtypes and to determine the possibility of differential responses of subtypes to treatment in intervention trials.

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