

Ten-Year Stability of an Insomnia Sleeper Phenotype and Its Association With Chronic Conditions

Soomi Lee, PhD, Claire E. Smith, PhD, Meredith L. Wallace, PhD, Orfeu M. Buxton, PhD, David M. Almeida, PhD, Sanjay R. Patel, MD, MS, and Ross Andel, PhD

Objective: To identify distinct sleep health phenotypes in adults, examine transitions in sleep health phenotypes over time, and subsequently relate these to the risk of chronic conditions.

Methods: A national sample of adults from the Midlife in the United States study ($N = 3683$) provided longitudinal data with two time points (T1: 2004–2006, T2: 2013–2017). Participants self-reported on sleep health (regularity, satisfaction, alertness, efficiency, duration) and the number and type of chronic conditions. Covariates included age, sex, race, education, education, partnered status, number of children, work status, smoking, alcohol, and physical activity.

Results: Latent transition analysis identified four sleep health phenotypes across both time points: good sleepers, insomnia sleepers, weekend catch-up sleepers, and nappers. Between T1 and T2, the majority (77%) maintained their phenotype, with the nappers and insomnia sleepers being the most stable. In fully adjusted models with good sleepers at both time points as the reference, being an insomnia sleeper at either time point was related to having an increased number of total chronic conditions by 28%–81% at T2, adjusting for T1 conditions. Insomnia sleepers at both time points were at 72%–188% higher risk for cardiovascular disease, diabetes, depression, and frailty. Being a napper at any time point related to increased risks for diabetes, cancer, and frailty. Being a weekend catch-up sleeper was not associated with chronic conditions. Those with lower education and unemployed were more likely to be insomnia sleepers; older adults and retirees were more likely to be nappers.

Conclusion: Findings indicate a heightened risk of chronic conditions involved in suboptimal sleep health phenotypes, mainly insomnia sleepers.

Key words: sleep health, insomnia, nap, chronic conditions, morbidity, aging

Abbreviations: LTA = latent transition analysis, MIDUS = Midlife in the United States, SAQ = self-administered questionnaire

(*Psychosom Med* 2024;86:289–297)

From the Department of Human Development and Family Studies (Lee, Almeida), Pennsylvania State University, State College, Pennsylvania; Department of Psychology (Smith), University of South Florida, Tampa, Florida; Department of Psychiatry (Wallace), University of Pittsburgh, Pittsburgh; Department of Biobehavioral Health (Buxton), The Pennsylvania State University, State College, Pennsylvania; Department of Medicine (Patel), University of Pittsburgh, Pittsburgh, Pennsylvania; Edson College of Nursing and Health Innovation (Andel), Arizona State University, Phoenix, Arizona; and Department of Neurology, Second Faculty of Medicine (Andel), Charles University and Motol University Hospital, Prague, Czech Republic.

Address correspondence to Soomi Lee, PhD, Department of Human Development and Family Studies, The Pennsylvania State University, 219 HHD Building, University Park, PA 16802. E-mail: soomilee@usf.edu

Article Editor: Wendy M. Troxel

Received for publication September 21, 2023; revision received December 30, 2023.

Supplemental digital content is available for this article.

Copyright © 2024 by the American Psychosomatic Society

ISSN: 0033-3174

DOI: 10.1097/PSY.0000000000001288

INTRODUCTION

Aging involves neural, physiological, and functional changes that can lead to the development of chronic disease. One of the significant age-related changes is a decline in quantity of deep sleep and overall sleep quality (1,2), which poses a risk for chronic disease (3). Theoretically, sleep disturbances represent an initial reaction that, over time, can lead to disease (4,5). Although studies show that poor sleep is a risk for chronic conditions (6–8), there are notable gaps in the literature. First, most prior studies used a single sleep dimension, precluding the ability to measure multiple, co-occurring dimensions, and their links to chronic conditions (9,10). Second, existing evidence is primarily based on cross-sectional data that cannot assess whether changes in sleep health lead to increased or decreased risk of chronic conditions. A few studies in the cancer literature show increases in sleep problems in those with cancer (11) and a possibility of improving sleep in cancer survivors (12). Yet, there is still lack of research assessing change in sleep health and its effects on common chronic conditions over the course of aging.

Multidimensional Sleep Health Over Time

There is increasing awareness that one's sleep health needs to be measured across multiple dimensions, rather than any one individual sleep characteristic (e.g., sleep duration only). For instance, Buysse (13) suggests that six dimensions defined in his Ru-SATED framework are critical for an average adult's optimal functioning and health. Those are: **Reg**ularity in sleep timing and quantity, **Sat**isfaction in sleep, **Al**ertness during daytime, appropriate sleep **Tim**ing, **Eff**iciency of initiating and maintaining sleep, and optimal sleep **Dur**ation. These sleep dimensions exist in the context of each other and may simultaneously influence health. Co-occurring short sleep duration and poor sleep quality, for example, are risk factors for chronic conditions including hypertension (14), type 2 diabetes (15), and cardiovascular disease (16). Recently, researchers have taken a more comprehensive approach to identify several different empirically derived phenotypes of sleep health based on combinations of multiple sleep dimensions. For instance, participants with suboptimal sleep health phenotypes (e.g., “dissatisfied/inefficient sleepers” or “high sleep propensity”) have higher concurrent risks of cardiovascular disease (17), chronic physical conditions (10), and future risk of mortality (18,19). Yet, most of these studies do not capture changes in sleep health over time, despite theoretical propositions that the connection between sleep disturbances and disease end points may take years to develop (20).

Changes in Sleep Health and Changes in Chronic Conditions

Although there is an overall lack of longitudinal studies on sleep health and chronic conditions, the few existing studies do

associate changes in sleep with health outcomes. For example, worsening sleep problems (e.g., sleep quality, refreshing sleep, sleep problems, and difficulty falling asleep) during COVID-19 were each associated with reduced mobility throughout one's community (21). Moreover, compared to people with consistently optimal nighttime sleep duration (7–8 h/d), those with consistently short sleep duration and inconsistent, variable sleep duration (e.g., short to long/long to short) exhibited an increased risk of multimorbidity progression (22). Based on the longitudinal associations of individual sleep dimensions with health and well-being, we now need to understand how sleep health phenotypes (within-person combinations of multiple sleep dimensions) over time relate to subsequent chronic conditions. In this study, to capture diverse chronic conditions prevalent in adulthood, we assess the number of total chronic conditions based on a comprehensive list and six specific types of chronic conditions across physical, mental, and functional domains: a) four common chronic physical disease categories (i.e., cardiovascular diseases, cancers, respiratory diseases, and diabetes; (23)), b) the most common mental health condition (i.e., depression; (24)), and c) frailty, or age-related declines in physical function often associated with chronic conditions and symptoms (25,26).

Present Study

The current study examined the connection between transitions in sleep health phenotypes and chronic condition development over time. We had three aims in this study. First, we aimed to identify sleep health phenotypes that characterize one's overall sleep characteristics across five key dimensions (i.e., regularity, satisfaction, alertness, efficiency, and duration) at two time points approximately 10 years apart. We examined how many and which sleep health phenotypes emerge among middle-aged adults and how stable the phenotypes are over the 10 years. Second, we examined sociodemographic correlates of sleep health phenotypes to understand the characteristics of people who have optimal or relatively suboptimal phenotypes over time. Third, we tested whether sleep health phenotype transitions over time relate to new development of chronic conditions.

METHODS

Participants and Procedure

Our sample is drawn from archival data from the Midlife in the United States (MIDUS) study. MIDUS is a multi-institutional, longitudinal study that used random digit dialing to obtain a large, nationally representative sample of adults and follow their life experiences and well-being throughout adulthood (27). We used the two existing follow-ups to the core MIDUS I (1995–1996) survey, MIDUS II (2004–2006) and MIDUS III (2013–2014), as well as the corresponding Milwaukee samples, MIDUS II Milwaukee (2005–2006) and MIDUS III Milwaukee (2016–2017), which aimed at oversampling Black participants to better understand aging and health in minority populations. Data from the self-administered questionnaire (SAQ) were used. Data and documentation for all MIDUS projects are available to other researchers at the Inter-university Consortium for Political and Social Research. In addition to the publicly available data at the Inter-university Consortium for Political and Social Research, a MIDUS-Colectica Portal (midus.colectica.org) contains rich

searchable metadata, links to helpful documentation, and the ability to download customized datasets.

To be included in our sleep transition analysis, respondents had to answer the sleep health questions within the SAQ. Out of the complete core and Milwaukee sample ($N = 5555$), 529 did not provide sufficient sleep health data. Of the remaining 5026 respondents, 73.28% responded to full demographic and health items at both MIDUS II and III, resulting in a longitudinal sample (i.e., responded at both time points) of $N = 3683$. In comparing those from the subgroup of the full sample that was excluded from analyses (i.e., baseline-only sample; $N = 1872$) with the final analytic sample (i.e., longitudinal sample; $N = 3683$),^a the two samples did not significantly differ on sex ($F(1,5553) = 3.12, p = .081$) or number of children ($F(1,5553) = 6.11, p = .17$). However, compared to the longitudinal sample, the baseline-only sample was older ($M = 56.96$ versus 54.05 years, $F(1,5552) = 68.93, p < .001$) and less educated ($M = 6.66$ versus 7.39, $F(1,5552) = 40.94, p < .001$), and had a lower percentage of workers (55% versus 68%, $F(1,5532) = 93.74, p < .001$), a lower percentage of married/cohabitating people (66% versus 73%, $F(1,5553) = 23.89, p < .001$), a higher percentage of racial and ethnic minorities (23% versus 19%, $F(1,5553) = 14.15, p < .001$), and more chronic conditions ($M = 3.01$ versus 2.39, $F(1,4631) = 51.86, p < .001$). Of note, though, all differences were small in size (r^2 ranging from 0.0001 to 0.016). In this manuscript, we refer to MIDUS II as time 1 (T1) and MIDUS III as time 2 (T2).

The final analytic sample ($N = 3683$) included slightly more women than men (66% women), was majority non-Hispanic White (80%), and had a relatively high level of formal education ($M = 7.31$ out of a 12-point scale; 7 corresponds to some college-level education). At both time points, participants had about 2.5 children on average and about 70% were partnered (i.e., married and/or cohabitating with a romantic partner). Participants were 55 years old on average ($SD = 12.45$; range = 28–85) at T1 and 63 years old on average ($SD = 11.30$; range = 39–94) at T2. Most participants worked a paid job outside of the home (around 60% at both time points, although some were unemployed (10–15%) and some were retired (25–30%)).

Chronic conditions were fairly common at both time points but generally increased over time ($M_{T1} = 2.54$ conditions; $M_{T2} = 2.99$ conditions), including prevalence of cardiovascular conditions (15.82% at T1; 21.59% at T2), diabetes (11.16% at T1; 14.50% at T2), respiratory conditions (13.71% at T1; 15.27% at T2), cancers (12.58% at T1; 19.34% at T2), depression (8.75% at T1; 7.63% at T2), and number of frailty symptoms ($M_{T1} = 0.67$ symptoms out of 5 possible; $M_{T2} = 0.80$).

Measures

All items were measured consistently at both time points via self-report surveys (i.e., the SAQ).

Sleep Health

Due to the skewed and/or ordinal nature of self-report sleep variables^b (28), we used categorical versions of six sleep variables that represent five sleep health dimensions (i.e., regularity, satisfaction, alertness, efficiency, and duration) collected as

^aNote that degrees of freedom differ slightly across comparisons due to differences in sample sizes on the comparison variables.

two time points as inputs for sleep health phenotypes. Sleep timing dimension was not captured through MIDUS surveys. Cutoff criteria, based on existing empirical evidence, are displayed in Table S1, Supplemental Digital Content, <http://links.lww.com/PSYMED/B3>.

Regularity

We operationalized sleep regularity in terms of consistency of sleep duration over the week. To do this, we took the absolute difference between workday/weekday sleep duration and non-workday/weekend sleep duration. Sleep is considered irregular if there is 1 hour or more of a difference between workday/weekday and non-workday/weekend sleep duration and regular if the difference is less than 1 hour (17).

Satisfaction (Insomnia Symptoms)

To assess subjective sleep issues, we used three items of insomnia symptoms that align with the *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition) for clinical insomnia. Participants responded to the prompt “Please indicate how often you experience each of the following...” for “trouble falling asleep,” “trouble staying asleep,” and “waking up too early” on a frequency scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = almost always). Because the *Diagnostic and Statistical Manual of Mental Disorders* requires that insomnia symptoms be present “often or always” for diagnosis (29), participants who reported a 4+ frequency score for one or more symptoms were considered to have subjective insomnia symptoms, whereas those who sometimes to never reported any symptoms were considered to have minimal symptoms.

Alertness (Daytime Tiredness and Nap Frequency)

To measure daytime tiredness, participants were asked to “Please indicate how often you experience each of the following...feeling unrefreshed during the day” on a frequency response scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = almost always). Consistent with the insomnia symptom cutoff, participants who reported a 4+ frequency score for the item were considered to be high on daytime tiredness, whereas a score of 3 or lower indicated low daytime tiredness. To measure daytime nap frequency, participants responded to the prompt “During a usual week, how many times do you nap for 5 minutes or more?” Excessive napping is regarded unhealthy for adults (30), particularly for chronic condition incidence (31). Thus, we considered three categories of nap frequency (30) including never (0/week), sometimes (1–3/week), and frequent napping (4+/week, indicating naps most days).

Efficiency (Sleep Onset Latency)

Participants answered one question about their sleep onset latency: “How long does it usually take you to fall asleep

at bedtime?” More than 30 minutes to fall asleep was considered suboptimal, whereas 30 minutes or less was considered optimal (30).

Duration

Sleep duration was assessed using two items, asking “How much sleep do you usually get at night (or in your main sleep period) on weekdays or workdays?” and “...on weekends or your non-workdays?” reported in hours and minutes. We calculated a weighted average of workday duration ($\times 5/7$) and non-workday duration ($\times 2/7$) based on a standard 5-day work week to estimate overall average sleep duration. Using recommendations from the National Sleep Foundation (32), we categorized sleep duration into short (7 or fewer hours), optimal (between 7 and 9 hours), or long (9 or more hours).

Chronic Conditions

To assess chronic conditions across physical, mental, and functional domains, we measured the number of total chronic conditions and six specific types of chronic conditions, including four chronic physical diseases, depression, and frailty.

Number of Total Chronic Conditions

Participants reported at both T1 and T2 how many chronic conditions they experienced or been treated by a medical doctor in the past 12 months by responding to a checklist of 30 items. We excluded three items (chronic sleep problems, anxiety/depression, and alcohol/drug problems) to a) avoid conceptual overlap with our predictor that might inflate relationships (i.e., sleep health phenotypes and transitions with sleep problems), b) minimize redundancy with one of the chronic condition outcomes we already included (i.e., depression), and c) focus on chronic physical conditions that may relate to sleep transitions rather than behavioral health outcomes (alcohol/drug problems and sleep conditions may have different etiology) (9,33). The full list of conditions includes the following: asthma/bronchitis/emphysema, tuberculosis, other lung problems, joint or bone disease, sciatica/lumbago/recurring backache, persistent skin trouble, thyroid disease, hay fever, recurring stomach trouble, urinary or bladder problems, constipated all or most of the time, gall bladder trouble, persistent foot trouble, varicose veins requiring medical treatment, AIDs or HIV infection, lupus or other autoimmune disease, persistent trouble with gums or mouth, persistent trouble with teeth, high blood pressure or hypertension, migraine headaches, diabetes or high blood sugar, multiple sclerosis/epilepsy/other neurological disorder, stroke, ulcer, hernia/rupture, piles/hemorrhoids, and swallowing problems.

Four Specific Chronic Physical Diseases

We assessed four common chronic physical disease categories based on previous research (23): cardiovascular diseases, diabetes, cancers, and respiratory diseases. Participants were asked “In the past 12 months, have you experienced or been treated for any of the following” for a variety of health conditions on a binary response scale (yes/no). *Cardiovascular diseases* were assessed using 10 items: “heart attack,” “angina,” “high blood pressure,” “valve disease (including mitral valve prolapse, aortic insufficiency, bicuspid aortic valve),” “hole in heart (including atrial septal defect, ventricular septal

^bSleep dimensions generally did not conform to properties of continuous variables, and a half of the sleep dimensions exhibited nonnormal distributions (i.e., skewness $> |2|$ and/or kurtosis $> |7|$) at both time points which could not be effectively corrected using conventional methods. Irregularity (T1: skew = 2.47, kurtosis = 11.74; T2: skew = 2.78, kurtosis = 13.34), nap frequency (T1: skew = 10.30, kurtosis = 54.40; T2: skew = 3.90, kurtosis = 32.80), and sleep onset latency (T1: skew = 9.03, kurtosis = 65.39; T2: skew = 5.92, kurtosis = 68.35).

defect),” “blocked artery (including blocked/closed artery, coronary artery disease, coronary heart disease, and ischemia),” “irregular heartbeat,” “heart murmur,” “heart failure,” and “other.” *Diabetes* was assessed using one item “diabetes or high blood sugar.” *Cancers* included “breast,” “cervical,” “colon,” “lung,” “lymphoma or leukemia,” “ovarian,” “prostate,” “skin or melanoma,” “uterine,” or “other.” *Respiratory diseases* were assessed using three items—“asthma, bronchitis, or emphysema”; “tuberculosis”; and “other lung problems.” We created a binary variable for each of the four categories such that presence of any condition within that category was coded as 1, whereas absence of condition was coded as 0.

Depressive Symptoms

Because depression is underdiagnosed relative to depression symptom prevalence (34), we used a binary (yes/no) item assessing depressive symptoms, “During the past 12 months, was there ever a time when you felt sad, blue, or depressed for two weeks or more in a row?”

Frailty

We created a count of frailty symptoms guided by the five dimensions outlined by Fried et al. and guided by cutoffs in the empirical literature (35,36), weight loss, exhaustion, low physical activity, slowness, and weakness. *Weight loss* was assessed by one binary (yes/no) item “During the past 12 months, did you lose 10 pounds or more because of illness or health problems.” *Exhaustion* was assessed by one binary (yes/no) item “During two weeks in the past 12 months, did you feel more tired out or low on energy than usual?” *Low physical activity* was by asking participants “How much does your health limit you in doing each of the following?” for five physical activity items (i.e., climbing one flight of stairs, climbing several flights of stairs, walking more than a mile, walking one block vigorous activities, moderate activities) on a frequency scale (1 = a lot, 2 = some, 3 = a little, 4 = not at all); participants reporting “a lot” of limitations on two or more activities were considered to have low physical activity symptoms. *Slowness* was assessed via two items focused on walking short distances (i.e., “How much does your health limit you...walking one block? Walking several blocks”; again, those reporting “a lot” of limitations on either (on a 1 to 4 frequency scale) were considered to have slowness symptoms. Finally, *weakness* was assessed via one item “How much does your health limit you lifting or carrying groceries” on the same frequency scale (1–4), with “a lot” again being the cutoff for weakness symptoms present. We then calculated a total frailty symptom score from 0 to 5 based on the number of symptoms present.

Analytic Approach

We used latent transition analysis (LTA) to extract common sleep health phenotypes over time. LTA extends cross-sectional clustering techniques like latent class analysis to a longitudinal context (37). Latent class analysis explores how multiple dimensions of sleep health co-occur within a person and, as a result, potential subgroups within an overall population (i.e., sleep health phenotypes indicated by common within-person patterns of sleep health dimensions), whereas LTA additionally describes how a person’s membership to a subgroup may be stable or change over time.

We used the three-step approach to LTA (38). Step 1 estimates latent class or transition models using only the latent class indicators, or variables considered part of the focal within-person pattern (i.e., sleep health dimensions here). Guided by previous studies (39–41), a good-fitting solution was determined by, in order of importance, lowest BIC and SSA-BIC statistics, theoretical interpretability of the classes, sufficient class sizes (i.e., >1% and/or >25 cases), lowest AIC statistic, and sufficient entropy (>0.60 is acceptable)^c. The LTA was run in Mplus, which extracted latent classes from the two time points simultaneously. Step 2 creates a latent transition variable, indicating whether a person remains in the same group or transition to a new one over time, based on the latent class posterior distribution output from step 1.

In step 3, the latent transition groups are linked to expected covariates and outcomes. Here, we first used multinomial logistic regression to test how background characteristics including sociodemographics (age, sex, race/ethnicity, education, partnered status, and number of children), work status (working, retired and not employed), and health behaviors (smoking status, alcohol consumption frequency, and physical activity) concurrently relate to sleep health phenotypes. Considering the potential nonlinear relationship between age and sleep, we also used life stage categories (i.e., young adult: 18–29 years, established adult: 30–44 years, midlife adult: 44–64 years, and older adult: 65+ years), instead of continuous age, to our analysis of background characteristics. We next used Poisson regression (for the number of total chronic conditions) or log-binomial regression (for each specific chronic condition type) to test the latent transition variable (i.e., sleep health phenotype transitions) as a predictor of each chronic condition outcome at T2, controlling for T1. In this model, we also adjusted for sample identifier (core versus Milwaukee sample) and aforementioned sociodemographics, work status, and health covariates. The largest transition group identified in steps 1 and 2 was used as the reference group, outputting a risk ratio for the focal group compared to the reference.

RESULTS

Identifying Sleep Health Phenotypes and Transitions

Four common sleep health phenotypes were identified at both time points, based on lowest BIC and SSA-BIC model fit statistics and sufficient entropy (see Table S2, Supplemental Digital Content, <http://links.lww.com/PSYMED/B3>). The characteristics of the phenotypes can be found in Table S3A, <http://links.lww.com/PSYMED/B3>, and Figure 1. The first phenotype, *good sleepers* (44% at T1; 33% at T2), was characterized by optimal sleep health across all dimensions. The second phenotype, *insomnia sleepers* (25% at T1; 27% at T2), was characterized by four co-occurring sleep problems that map onto clinical insomnia symptoms: short sleep duration, high daytime tiredness, frequent insomnia symptoms, and long time to fall asleep. The third phenotype, *weekend catch-up sleepers* (18% at T1; 5% at T2), was characterized by irregular sleep (specifically,

^cModel fit statistics with significance testing (e.g., LMR, BLRT) are not available when class indicators are all categorical.

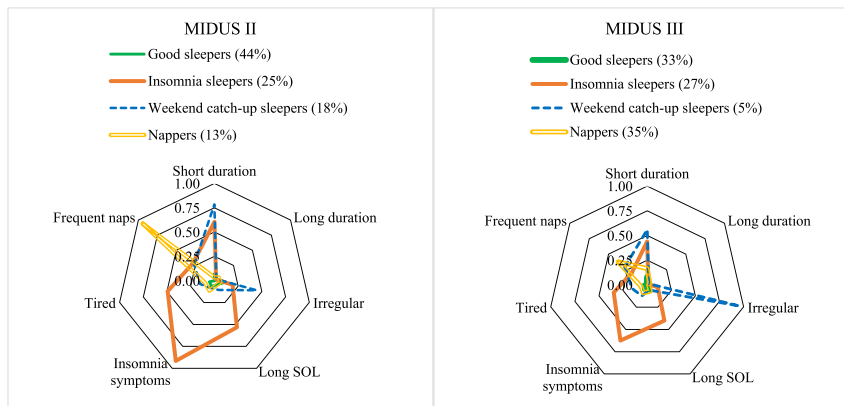


FIGURE 1. Latent sleep health classes at time 1 (MIDUS II) and time 2 (MIDUS III). Notes. $N = 3683$. MIDUS = Midlife in the United States study; Tired = subjective feelings of tiredness; SOL = sleep onset latency. Color image is available only in the online edition at the journal’s website.

short average sleep duration but longer sleep on non-workdays/weekends). The final phenotype, *nappers* (13% at T1; 35% at T2), was characterized by mostly good sleep but frequent daytime naps.

Notably, although the same phenotypes were identified at both time points, their prevalence at each time point differed. Namely, nappers became much more common at T2 (perhaps because napping is common as adults age), and weekend catch-up sleepers became much less common at T2 (perhaps because this phenotype has been associated with varying work schedules in the past, which may become less common as adults age). As shown in Supplemental Table S3B, Supplemental Digital Content, <http://links.lww.com/PSYMED/B3>, insomnia sleepers and nappers were largely stable; respectively, 92% and 97% remained in the same phenotype approximately 10 years later. In fact, nappers never transitioned to good or weekend catch-up sleepers. Approximately two-thirds of good sleepers remained in the same phenotype (68%), but the rest transitioned to nappers (28%) or to other phenotypes. Weekend catch-up sleepers were highly unstable (only 27% remained in the same phenotype) and most likely to transition to nappers (52%).

Background Characteristics of the Sleep Health Phenotypes Over Time

Full results are reported in Table S4, <http://links.lww.com/PSYMED/B3>, but we also summarize notable findings significant at both time points. Age, education, and work status were consistently associated with the sleep health phenotypes across both T1 and T2. Older people were less likely to be weekend catch-up sleepers (T1: $B = -0.022$, $SE = 0.010$, $p = .048$; T2: $B = -0.041$, $SE = 0.010$, $p < .001$) and more likely to be nappers (T1: $B = 0.051$, $SE = 0.010$, $p < .001$; T2: $B = 0.042$, $SE = 0.002$, $p < .001$) at both time points. These age-related results remained consistent when we used life stage categories instead of continuous age (Table S5, <http://links.lww.com/PSYMED/B3>). Higher education was associated with lesser likelihood of being an insomnia sleeper than a good sleeper at both time points (T1: $B = -0.070$, $SE = 0.030$, $p = .020$; T2: $B = -0.11$, $SE = 0.020$, $p < .001$). Retirees were more likely to be nappers at both time points (T1: $B = 0.71$, $SE = 0.24$, $p < .001$; T2: $B = 0.53$, $SE = 0.19$, $p = .010$). Workers were less likely to be insomnia

sleepers than they were good sleepers at both time points (T1: $B = -0.44$, $SE = 0.17$, $p = .010$; T2: $B = -0.49$, $SE = 0.12$, $p < .001$), whereas people who were not employed were more likely to be insomnia sleepers at both time points (T1: $B = 0.61$, $SE = 0.22$, $p = .010$; T2: $B = 0.85$, $SE = 0.18$, $p < .001$).

Relative Risk for Chronic Conditions Based on Sleep Health Phenotype Transitions

Number of Total Chronic Conditions

Table 1 shows results testing whether count of total chronic conditions at T2 differed across the sleep health phenotype transition groups, controlling for T1 count and all other covariates. Average number of total chronic conditions per transition group is reported in Supplemental Table S6, <http://links.lww.com/PSYMED/B3>. Relative to the largest and most optimal group (i.e., good sleeper → good sleeper), five transition groups were at a higher risk for more chronic physical conditions, ranging from 28% to 81% greater risk. Four of the five at-risk groups involved belonging to the insomnia sleeper phenotype at one or both time points (i.e., good sleeper → insomnia sleeper, insomnia sleeper → good sleeper, insomnia sleeper → insomnia sleeper, and weekend catch-up sleeper → insomnia sleeper). Good sleeper → napper transition group also exhibited slightly heightened risk, although the lowest risk of the five groups (28%). These associations were found after controlling for sociodemographic, health, and work covariates. Table S7, <http://links.lww.com/PSYMED/B3>, shows that the associations of the covariates with the number of total chronic conditions at each time point, which were all in the expected directions.

Specific Types of Chronic Conditions

Results are reported in Table 2 as well as Figure S1, <http://links.lww.com/PSYMED/B3>. At least one sleep health phenotype transition group was at heightened risk for three of the four chronic physical condition categories, relative to consistently good sleepers (i.e., good → good). For cardiovascular conditions, consistent insomnia sleepers (i.e., insomnia sleeper → insomnia sleeper) were at 72% higher risk (95% CI = 1.04–2.82) than consistently good sleepers. For diabetes, consistent insomnia sleepers again were at higher risk (188%; 95% CI = 1.72–4.79) as were consistent nappers (128%; 95% CI = 1.26–4.09) and

TABLE 1. Results From Poisson Regression Models Examining the Number of Total Chronic Conditions by Each Sleep Health Phenotype Transition Group

Transition Group	B	SE	p	Exp(B)	95% CI
Good → Insomnia	0.37	0.12	.002	1.45	[0.13 to 0.61]
Good → WCU	0.38	0.41	.36	1.47	[-0.43 to 1.19]
Good → Napper	0.25	0.09	.005	1.28	[0.07 to 0.42]
Insomnia → Good	0.52	0.19	.01	1.67	[0.13 to 0.90]
Insomnia → Insomnia	0.33	0.07	<.001	1.39	[0.18 to 0.47]
Insomnia → WCU	-0.40	0.37	.27	0.67	[-1.12 to 0.32]
Insomnia → Napper	-0.016	0.17	.95	0.99	[-0.34 to 0.32]
WCU → Good	0.17	0.14	.21	1.19	[-0.10 to 0.45]
WCU → Insomnia	0.59	0.12	<.001	1.81	[0.36 to 0.83]
WCU → WCU	0.13	0.10	.20	1.14	[-0.07 to 0.33]
WCU → Napper	0.17	0.10	.08	1.19	[-0.02 to 0.37]
Napper → Good					
Napper → Insomnia	0.29	0.46	.52	1.05	[-0.61 to 1.20]
Napper → WCU					
Napper → Napper	0.05	0.10	.60	1.34	[-0.14 to 0.24]

CI = confidence interval; Good = good sleeper; WCU = weekend catch-up sleeper.

N = 2706. Reference group: Good → Good. Bold values indicate statistically significant results (p < .05). Gray cells indicate a transition group with no members (N = 0) or too few to make comparisons. Covariates included age, sex, race (i.e., White and non-Hispanic versus non-White and/or Hispanic), education, core versus Milwaukee Midlife in the United States study sample, work hours, relationship status (i.e., married and/or cohabitating versus not), smoking status, alcohol consumption frequency, and physical activity.

weekend catch-up sleepers → nappers (137%; 95% CI = 1.21–4.60). For chronic respiratory diseases, no sleep health phenotype transition group exhibited significantly higher risk for these conditions compared to consistently good sleepers. For cancers, only nappers → insomnia sleepers exhibited higher risk (45%; 95% CI = 1.16–1.83).

For depressive symptoms, consistent insomnia sleepers were at 95% higher risk (95% CI = 1.47–2.59), and good sleepers → insomnia sleepers were at 89% higher risk (95% CI = 1.15–3.11) than consistently good sleepers. For frailty, four groups exhibited higher risk relative to consistently good sleepers: consistent insomnia sleepers (68% higher; 95% CI = 1.22–2.29), good

TABLE 2. Results From Log-Binomial Models Examining the Risk of Specific Chronic Condition Types by Sleep Health Phenotype Transition Group

Transition Group	Cardiovascular Conditions		Diabetes		Cancer		Respiratory Diseases		Depressive Symptoms		Frailty	
	Exp(B)	95% CI	Exp(B)	95% CI	Exp(B)	95% CI	Exp(B)	95% CI	Exp(B)	95% CI	Exp(B)	95% CI
Good → Insom	1.98	[0.91–4.31]	1.96	[0.77–4.97]	1.01	[0.91–1.13]	0.97	[0.86–1.09]	1.89	[1.15–3.11]	2.08	[1.31–3.28]
Good → WCU					0.89	[0.58–1.39]	0.88	[0.54–1.41]	0.71	[0.09–5.25]	1.48	[0.20–10.80]
Good → Nap	1.36	[0.73–2.51]	1.73	[0.90–3.29]	1.03	[0.96–1.11]	1.03	[0.94–1.11]	1.23	[0.88–1.72]	1.62	[1.12–2.33]
Insom → Good	0.8	[0.11–5.95]	0.27	[0.025–2.89]	1.06	[0.86–1.32]	0.9	[0.71–1.13]	0.91	[0.34–2.38]	1.76	[0.80–3.86]
Insom → Insom	1.72	[1.04–2.82]	2.88	[1.72–4.79]	1	[0.94–1.06]	1.05	[0.98–1.12]	1.95	[1.47–2.59]	1.68	[1.22–2.29]
Insom → WCU			0.37	[0.02–5.15]	1.04	[0.73–1.50]	1.37	[0.92–2.02]	0.7	[0.13–3.65]		
Insom → Nap	2.03	[0.77–5.37]	1.57	[0.41–5.91]	0.88	[0.75–1.04]	1.03	[0.86–1.23]	1.42	[0.65–3.08]	1.41	[0.73–2.69]
WCU → Good	1.11	[0.43–2.85]	2.11	[0.85–5.18]	1	[0.89–1.12]	0.91	[0.79–1.02]	0.82	[0.47–1.42]	0.83	[0.39–1.71]
WCU → Insom	1.17	[0.35–3.88]	1.24	[0.38–4.06]	0.91	[0.80–1.04]	0.94	[0.80–1.09]	1.32	[0.67–2.54]	1.52	[0.87–2.64]
WCU → WCU	0.92	[0.38–2.20]	1.11	[0.44–2.78]	1	[0.91–1.09]	0.91	[0.81–1.00]	1.02	[0.66–1.55]	1.39	[0.87–2.21]
WCU → Nap	1.38	[0.72–2.63]	2.37	[1.21–4.60]	1.07	[0.99–1.16]	0.99	[0.90–1.08]	0.92	[0.63–1.34]	0.97	[0.61–1.54]
Nap → Insom	6.77	[0.81–56.15]	3.97	[0.092–6.95]	1.45	[1.16–1.83]	1.16	[0.91–1.48]	1.33	[0.45–3.97]	5.56	[1.29–23.79]
Nap → Nap	1.53	[0.84–2.75]	2.28	[1.26–4.09]	1	[0.93–1.07]	1.06	[0.97–1.14]	1.22	[0.87–1.69]	1.3	[0.87–1.92]

CI = confidence interval; Good = good sleeper; Insom = insomnia sleeper; WCU = weekend catch-up sleeper; Nap = napper.

Reference group: Good → Good. Cells in gray indicate that the focal transition group had an overall N = 0 or that no participants belonging to that group reported the specific health outcome; tests for three groups (napper to good sleeper, napper to insomnia sleeper, and napper to WCU sleeper) did not output results for this reason and are excluded from this table.

sleepers → insomnia sleepers (108% higher; 95% CI = 1.31–3.28), good sleepers → nappers (62% higher; 95% CI = 1.12–2.33), and especially nappers → insomnia sleepers (456% higher; CI = 1.29–23.79).

DISCUSSION

This is the first study to use multidimensional, longitudinal approach examining sleep health as a modifiable risk factor for key chronic conditions, across physical, mental, and functional domains. Building on emerging research that identified several sleep health phenotypes (10,17–19), we identified four sleep health phenotypes in a national sample of midlife adults that emerged consistently over one decade. Common sleep health phenotypes were replicated over time; most participants remained in the same phenotype, but some participants moved in and out of the phenotypes over time. Novel findings from this study include specific constellations of sleep characteristics that indicate increased risks for the development of chronic conditions and sociodemographic groups who may be more vulnerable to both poor sleep health and chronic conditions. Below, we discuss main findings from this study.

The most important findings from this study are that specific constellations of sleep characteristics may increase the risk of subsequent chronic conditions. Being an insomnia sleeper at one or both time points was a consistent risk for more chronic conditions and all types of those examined, except respiratory conditions. The literature reports that insomnia-related characteristics such as short sleep duration combined with poor sleep quality are risk factors for hypertension, type 2 diabetes, cardiovascular disease, and chronic physical conditions (10,15–17). Findings from the current study add to this line of literature by showing how having co-occurring sleep problems across multiple dimensions (i.e., short sleep duration, high daytime tiredness, frequent insomnia symptoms, and long time to fall asleep) that map onto clinical insomnia symptoms at either of the two time points over a decade increases the risk of chronic conditions. Note that many of the chronic condition types that were associated with the insomnia sleeper phenotype are modifiable conditions (cf., chronic respiratory conditions that were not associated with any other sleep health phenotypes may be less modifiable through changes in health behaviors like sleep). The napper phenotype also emerged as a relatively common risk. Appropriate use of napping may be beneficial to compensate for nighttime sleep loss (42). However, our results show that transitioning to the napper phenotype may increase risks for more chronic conditions, especially for diabetes and frailty. This may relate to age-related changes in both sleep and physical conditions, as frequent napping, incident diabetes, weight loss, exhaustion, low physical activity, slowness, and weakness are generally prevalent in later life (43).

We also identify sociodemographic groups who may be more vulnerable to poor sleep health and thus may have higher risk for developing chronic conditions. Younger adults were more likely to be weekend catch-up sleepers, whereas older adults were more likely to be nappers. These results are in line with the literature reporting higher sleep debt in younger individuals and increased napping in older adults, especially after retirement (44,45). Our results also support that one's sleep health may relate to socioeconomic status (46), such that those

with higher socioeconomic status are less likely to have a suboptimal sleep health phenotype. For example, those with higher education were less likely to be insomnia sleepers at either time point. Moreover, work status was an important variable that was associated with sleep health phenotype membership, such that being a retiree was associated with increased risk of being a napper and not being employed was associated with increased risk of being an insomnia sleeper. Paid work provides not only income and life purpose, but also temporal structure that may help maintaining a regular sleep/wake cycle, which may be important for optimal sleep health.

Moreover, our findings show that sleep health phenotypes are largely stable across adulthood. Although some participants (23%) changed membership across the sleep health phenotypes over time, most (77%) remained in the same phenotype. The stability of the sleep health phenotypes was more apparent in those with the two suboptimal phenotypes. Specifically, over 90% of insomnia sleepers stayed in the same phenotype. Moreover, nappers were the least likely to transition to a different phenotype (97% were stayers). Weekend catch-up sleepers that seem to emerge among younger adults mostly due to work were the most likely to transition (only 27% were stayers). The good news is that this phenotype did not significantly increase the risk of chronic conditions in our study. However, risk may go up later because those who belonged to weekend catch-up sleepers were more likely to move to napper or insomnia sleeper phenotypes (60%) rather than to good sleeper phenotype (13%). Overall, this study shows stability of sleep health in general, although the degree of stability may depend on specific phenotypes.

There may be divergent mechanisms that lead to different sleep health phenotypes. Although certain sleep health phenotypes, like weekend catch-up sleepers and good sleepers, appear to be flexible, whereby individuals can shift between them over time, other phenotypes, such as nappers, seem more rigid. Considering the background characteristics of this phenotype (i.e., older age, retirees), the extent of rigidity found in the napper phenotype may relate to irreversible age-related changes in circadian rhythm, physiological decline, or disease pathology such as depression and nocturia (43). Another rigid and suboptimal phenotype is the insomnia sleeper. In the case of this phenotype, stress may be a contributing factor (47), as individuals in this phenotype were more likely to report low resources (e.g., unemployed, lower education). These factors may exhibit greater stability in late adulthood. Although potential mechanisms may differ, membership and transition into these two suboptimal phenotypes (i.e., napper, insomnia sleeper) were associated with heightened risk for multiple chronic conditions. Moreover, the associations were independent of age and other background characteristics, suggesting the unique risk that these sleep health phenotypes may have on chronic conditions. Further research is warranted to investigate specific mechanisms underlying suboptimal sleep health phenotypes and their associations with chronic conditions.

Chronic conditions and sleep phenotypes likely have bidirectional relationships. In this study, we attempted to minimize the possibility of reverse directionality, such as a chronic condition leading to a specific sleep health phenotype (e.g., diabetes contributing to individuals belonging to the napper phenotype) by controlling for baseline chronic conditions (e.g., adjusting

for T1 diabetes when predicting T2 diabetes). Consequently, our results suggest that the transition to the napper phenotype from T1 to T2 is associated with a higher risk of newly developing diabetes at T2 with the likelihood of diabetes at T1 being held constant for the entire analytical sample. Nonetheless, our analysis, based on only two time points fairly far apart (approximately 10 years) cannot completely eliminate the possibility of reverse directionality. Some individuals may have developed chronic conditions during the 10-year interval between T1 and T2, potentially influencing transitions in sleep health phenotypes. More research is needed to see whether the findings are replicated across studies using different samples and employing varied (shorter and more frequent) timescales.

Based on our results, future sleep prevention programs should not be one-size-fits-all. Our findings point to two distinct suboptimal sleep health phenotypes (i.e., insomnia sleeper, napper) that should be targeted due to their increased risks for chronic conditions—but likely targeted differently (i.e., depending on sociodemographic vulnerability and specific phenotype). First and foremost, targeting co-occurring sleep problems found in the insomnia sleeper phenotype may potentially protect against developing a host of chronic conditions. Moreover, future research uncovering nuances in napping—under what circumstances napping is particularly harmful—may also be important, because being a napper at any time point was associated with increased risks for diabetes, cancer, and frailty. Our results further help to identify at-risk sociodemographic groups for each of the suboptimal phenotypes and consider them urgent sleep intervention targets, namely, unemployed or those with lower education (insomnia sleepers) and retirees and older adults (nappers).

Limitations and Future Directions

This study is not without limitations. First, the sleep timing dimension of the Ru-SATED model was not captured through the MIDUS survey and was therefore not accounted for in our sleep health phenotyping. Future research may want to include sleep timing as an indicator of sleep health phenotypes to get an even more comprehensive picture of overall sleep health. Also, insomnia symptoms and sleep onset latency used to capture sleep satisfaction and efficiency, respectively, may not sufficiently capture each dimension. Moreover, only self-reported sleep measures were used due to sleep actigraphy data only being available for a limited number of participants. We also converted the continuous sleep variables to categorical using empirical cutoffs; although artificial categorization loses potentially meaningful variance and should be avoided when possible, psychometric properties of the variables representing sleep dimensions deemed this approach most appropriate—categorization is the recommended strategy to extract accurate and interpretable phenotypes when using nonnormally distributed data. Future research could use combined actigraphy and self-report to best capture each sleep dimension. Additionally, we used only one of the approaches to measure sleep health in this study; there are other approaches, such as creating composite scores of sleep health based on theoretically driven or empirically derived cutoff values (48,49). Second, the MIDUS sample was, on average, relatively privileged in terms of race, education, and health status. Attrition in MIDUS also favored

healthier people, workers, and White individuals. Thus, racial/ethnic minorities, marginalized, and people struggling with health conditions may be undersampled, masking or reducing overall effects. Replication of this study in a sample of adults with greater sociodemographic diversity to better represent the general population may account for possible differences in the relationship between sleep health and chronic conditions for these individuals. Lastly, this study was observational; thus, causality cannot be determined. Furthermore, only two time points limit our ability to examine potential mechanisms of change. Future work may need to include more time points to examine *how and why* changing membership in sleep health phenotypes leads to the development of chronic conditions. In this study, we assessed long-term changes, but sleep health and chronic condition symptoms may fluctuate in conjunction with one another from day to day, and stress and behavioral mechanisms may play roles.

CONCLUSION

This study provides new evidence for the existence of four common sleep health phenotypes (insomnia sleepers, nappers, weekend-catchup sleepers, and good sleepers) in a national sample of adults over one decade. Among the four phenotypes, adults who belong to the two suboptimal phenotypes (insomnia sleepers and nappers) are less likely to transition to a different phenotype. This raises a concern, because those in the two suboptimal sleep health phenotypes at one or both time points separated by 10 years have heightened risks for chronic conditions 10 years later. Future efforts should be focused more on providing targeted sleep prevention or intervention programs to delay the onset of chronic conditions in later life (35).

Since 1995, the Midlife in the United States Study has been funded by the following: John D. and Catherine T. MacArthur Foundation Research Network, National Institute on Aging (P01-AG020166), and National Institute on Aging (U19-AG051426). The larger MIDUS study protocol was approved by the University of Wisconsin-Madison Institutional Review Board (IRB); the current study was exempt from an IRB review because we used publicly available, de-identifiable data. Written informed consent was received for all MIDUS participants.

The current study was supported by Award Numbers R56AG065251 and R01HL163226 (PI Soomi Lee, PhD) and RFIAG056331 (PI Meredith Wallace, PhD) from the NIH/NIA. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Aging or the National Institutes of Health. Ross Anzel was funded by project no. LX22NPO5107 (MEYS): Financed by European Union—Next Generation EU.

Source of Funding and Conflicts of Interest: Outside of the current work, Orfeu M. Buxton discloses that he received sub-contract grants to Penn State from Proactive Life (formerly Mobile Sleep Technologies), doing business as SleepSpace (National Science Foundation grant no. 1622766 and NIH/National Institute on Aging Small Business Innovation Research Program R43AG056250, R44 AG056250); received honoraria/travel support for lectures from Boston University, Boston College, Tufts School of Dental Medicine, Harvard Chan School of Public Health, and Allstate; receives consulting fees from SleepNumber; and receives an honorarium for his role as

the Editor in Chief of Sleep Health sleephealthjournal.org. Meredith L. Wallace discloses that she receives funds as a statistical consultant for Sleep Number Bed, Health Rhythms, and Noctem Health, outside the current work.

REFERENCES

- Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep* 2004;27:1255–73.
- Stephan Y, Sutin AR, Bayard S, Terracciano A. Subjective age and sleep in middle-aged and older adults. *Psychol Health* 2017;32:1140–51.
- Stenholm S, Head J, Kivimäki M, Magnusson Hanson LL, Pentti J, Rod NH, et al. Sleep duration and sleep disturbances as predictors of healthy and chronic disease-free life expectancy between ages 50 and 75: a pooled analysis of three cohorts. *J Gerontol A Biol Sci Med Sci* 2019;74:204–10.
- Hall MH, Brindle RC, Buysse DJ. Sleep and cardiovascular disease: emerging opportunities for psychology. *Am Psychol* 2018;73:994–1006.
- Hall MH, Muldoon M, Jennings JR, Buysse D, Flory J, Manuck S. Self-reported sleep duration is associated with the metabolic syndrome in midlife adults. *Sleep* 2008;31:635–43.
- Davidson JR, MacLean AW, Brundage MD, Schulze K. Sleep disturbance in cancer patients. *Soc Sci Med* 2002;54:1309–21.
- Foley D, Ancoli-Israel S, Britz P, Walsh J. Sleep disturbances and chronic disease in older adults: results of the 2003 National Sleep Foundation sleep in America survey. *J Psychosom Res* 2004;56:497–502.
- Koyanagi A, Garin N, Olaya B, Ayuso-Mateos JL, Chatterji S, Leonardi M, et al. Chronic conditions and sleep problems among adults aged 50 years or over in nine countries: a multi-country study. *PLoS One* 2014;9:1–17.
- Lee S, Lawson KM. Beyond single sleep measures: a composite measure of sleep health and its associations with psychological and physical well-being in adulthood. *Soc Sci Med* 2021; 274:113800.
- Smith CE, Lee S. Identifying diverse forms of (un)healthy sleep: sleep profiles differentiate adults' psychological and physical well-being. *Soc Sci Med* 2022;292:114603.
- Engstrom CA, Strohl RA, Rose L, Lewandowski L, Stefanek ME. Sleep alterations in cancer patients. *Cancer Nurs* 1999;22:143–8.
- Ritterband LM, Bailey ET, Thorndike FP, Lord HR, Farrell-Camahan L, Baum LD. Initial evaluation of an Internet intervention to improve the sleep of cancer survivors with insomnia. *Psychooncology* 2012;21:695–705.
- Buysse DJ. Sleep health: can we define it? Does it matter? *Sleep* 2014;37:9–17.
- Lu K, Chen J, Wu S, Chen J, Hu D. Interaction of sleep duration and sleep quality on hypertension prevalence in adult Chinese males. *J Epidemiol* 2015;25:415–22.
- Lou P, Qin Y, Zhang P, Chen P, Zhang L, Chang G, et al. Association of sleep quality and quality of life in type 2 diabetes mellitus: a cross-sectional study in China. *Diabetes Res Clin Pract* 2015;107:69–76.
- Vgontzas AN, Liao D, Pejovic S, Calhoun S, Karataraki M, Bixler EO. Insomnia with objective short sleep duration is associated with type 2 diabetes a population-based study. *Diabetes Care* [Internet] 2009;32:1980–5. Available at: <https://diabetesjournals.org/care/article/32/11/1980/26005/Insomnia-With-Objective-Short-Sleep-Duration-Is>. Accessed March 28, 2023.
- Lee S, Smith CE, Wallace ML, Andel R, Almeida DM, Patel SR, et al. Cardiovascular risks and sociodemographic correlates of multidimensional sleep phenotypes in two samples of US adults. *SLEEP Advances* [Internet] 2022;3. Available at: <https://academic.oup.com/sleepadvances/article/doi/10.1093/sleepadvances/zpac005/6532038>. Accessed August 16, 2022.
- Wallace ML, Lee S, Hall MH, Stone KL, Langsetmo L, Redline S, et al. Heightened sleep propensity: a novel and high-risk sleep health phenotype in older adults. *Sleep Health* 2019;5: 630–8.
- Wallace ML, Lee S, Stone KL, Hall MH, Smagula SF, Redline S, et al. Actigraphy-derived sleep health profiles and mortality in older men and women. *Sleep* 2022;45:zsac015.
- Ganster DC, Rosen CC. Work stress and employee health: a multidisciplinary review. *J Manage* 2013;39:1085–122.
- Smail EJ, Kaufmann CN, Riehm KE, Mardini MT, Cenko E, Bai C, et al. Worsening sleep predicts lower life space mobility during the onset of the COVID-19 pandemic. *J Am Geriatr Soc* 2022;70:1931–8.
- Zhou Y, Ni Y, Jones M, Dai X, Lim CCW, Zhu A, et al. Sleep behaviors and progression of multimorbidity in middle-aged and older adults: a prospective cohort study from China. *J Gerontol* 2023;78:1871–80.
- Alwan A. *Global Status Report on Noncommunicable Diseases 2010* [Internet]. Geneva, Switzerland: World Health Organization; 2011. Available at: <http://whqlibdoc.who.int/publications>. Accessed April 12, 2023.
- World Health Organization (WHO). Depressive disorder (depression). 2023. Available at: <https://www.who.int/news-room/fact-sheets/detail/depression>. Accessed April 12, 2023.
- Strawbridge WJ, Shema SJ, Balfour JL, Higby HR, Kaplan GA. Antecedents of frailty over three decades in an older cohort. *J Gerontol B Psychol Sci Soc Sci* [Internet] 1998;53B: S9–16. Available at: <https://academic.oup.com/psychsocgerontology/article/53B/1/S9/586938>. Accessed April 12, 2023.
- Shamliyan T, Talley KMC, Ramakrishnan R, Kane RL. Association of frailty with survival: a systematic literature review. *Ageing Res Rev* 2013;12:719–36.
- Brim OG, Ryff CD, Kessler RC. *How Healthy Are We: A National Study of Well-Being at Midlife*. Chicago, IL: University of Chicago Press; 2004.
- Wallace ML, Buysse DJ, Germain A, Hall MH, Iyengar S. Variable selection for skewed model-based clustering: application to the identification of novel sleep phenotypes. *J Am Stat Assoc* [Internet] 2018;113:95–110. Available at: <https://www.tandfonline.com/doi/abs/10.1080/01621459.2017.1330202>. Accessed April 12, 2023.
- Ohayon MM. Epidemiology of insomnia: what we know and what we still need to learn. *Sleep Med Rev* 2002;6:97–111.
- Ohayon MM, Wickwire EM, Hirshkowitz M, Albert SM, Avidan A, Daly FJ, et al. National Sleep Foundation's sleep quality recommendations: first report. *Sleep Health* 2017;3:6–19.
- Jung KI, Song CH, Ancoli-Israel S, Barrett-Connor E. Gender differences in nighttime sleep and daytime napping as predictors of mortality in older adults: the Rancho Bernardo study. *Sleep Med* 2013;14:12–9.
- Hirshkowitz M, Whitton K, Albert SM, Alessi C, Bruni O, DonCarlos L, et al. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health* 2015;1:40–3.
- Keyes CLM. Chronic physical conditions and aging: is mental health a potential protective factor? *Ageing Int* 2005;30:88–104.
- Faisal-Cury A, Ziebold C, Rodrigues DMO, Matijasevich A. Depression underdiagnosis: prevalence and associated factors. A population-based study. *J Psychiatr Res* 2022;151: 157–65.
- Chen TY, Lee S, Buxton OM. Multidimensional sleep health is associated with physical frailty in a national sample of Taiwanese community-dwelling older adults: sex matters. *Sleep Health* 2022;8:528–35.
- Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults. Evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* [Internet] 2001;56: M146–57. Available at: <https://academic.oup.com/biomedgerontology/article/56/3/M146/545770>. Accessed April 12, 2023.
- Nylund-Gibson K, Garber AC, Carter DB, et al. Ten frequently asked questions about latent transition analysis. *Psychol Methods* 2022;28:284–300.
- Bakk Z, Tekle FB, Vermunt JK. Estimating the association between latent class membership and external variables using bias-adjusted three-step approaches. *Sociol Methodol* 2013;43: 272–311.
- Spurk D, Hirschi A, Wang M, Valero D, Kauffeld S. Latent profile analysis: a review and "how to" guide of its application within vocational behavior research. *J Vocat Behav* [Internet] 2020;120:103445. Available at: <https://www.sciencedirect.com/science/article/pii/S0001879120300701>.
- Lubke G, Neale MC. Distinguishing between latent classes and continuous factors: resolution by maximum likelihood? 2010. Available at: <https://www.tandfonline.com/action/journalInformation?journalCode=hmb20>. Accessed September 20, 2023.
- Jung T, Wickrama KAS. An introduction to latent class growth analysis and growth mixture modeling. 2007. Available at: <https://compass.onlinelibrary.wiley.com/doi/10.1111/j.1751-9004.2007.00054.x>. Accessed September 20, 2023.
- Patterson PD, Weaver MD, Guyette FX, Martin-Gill C. Should public safety shift workers be allowed to nap while on duty? *Am J Ind Med* [Internet] 2020;63:843–50. doi:10.1002/ajim.23164.
- Foley DJ, Vitiello MV, Bliwise DL, Ancoli-Israel S, Monjan AA, Walsh JK. Frequent napping is associated with excessive daytime sleepiness, depression, pain, and nocturia in older adults: findings from the National Sleep Foundation '2003 sleep in America' poll. *Am J Geriatr Psychiatry* 2007;15:344–50.
- Harden CM, Peppard PE, Palta M, Barnett JH, Hale L, Nieto FJ, et al. One-year changes in self-reported napping behaviors across the retirement transition. *Sleep Health* 2019;5:639–46.
- Fox EC, Wang K, Aquino M, Grandner MA, Xie D, Branas CC, et al. Sleep debt at the community level: impact of age, sex, race/ethnicity and health. *Sleep Health* 2018;4:317–24.
- Grandner MA, Patel NP, Gehrman PR, Xie D, Sha D, Weaver T, et al. Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Med* 2010;11:470–8.
- Basta M, Chrousos GP, Vela-Bueno A, Vgontzas AN. Chronic insomnia and the stress system. *Sleep Med Clin* 2007;2:279–91.
- Lee S, Mu CX, Wallace ML, Andel R, Almeida DM, Buxton OM, et al. Sleep health composites are associated with the risk of heart disease across sex and race. *Sci Rep* [Internet] 2022;12:1–11. Available at: <https://www.nature.com/articles/s41598-022-05203-0>. Accessed March 10, 2022.
- Brindle RC, Yu L, Buysse DJ, Hall MH. Empirical derivation of cutoff values for the sleep health metric and its relationship to cardiometabolic morbidity: results from the Midlife in the United States (MIDUS) study. *Sleep* 2019;42:1–9.