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Latent classes of sleep problems and subjective cognitive decline among middle-aged and older adults in the United States

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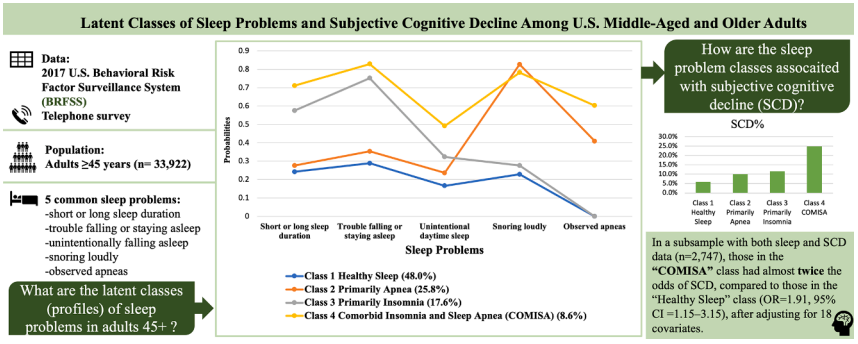
HIGHLIGHTS

- Four distinct profiles of self-reported sleep problems were identified in U.S. middle-aged and older adults.
- Individuals with the "Comorbid Insomnia and Sleep Apnea" profile may experience a higher risk of subjective cognitive decline.
- Self-reported sleep problems were key in their association with subjective cognitive decline, offering a cost-effective and practical tool for clinical and research settings.
- If findings are replicated, screening for sleep problems and developing targeted interventions for middle-aged and older adults may contribute to dementia prevention efforts.

GRAPHICAL ABSTRACT



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ABSTRACT

Objective: Previous studies have linked sleep problems to subjective cognitive decline (SCD) using a variable-centered approach (e.g., adding sleep symptoms to form a score); however, sleep problems may cluster differently between individuals. Thus, employing a person-centered approach, we aimed to: 1) identify profiles of self-reported sleep problems among U.S. middle-aged and older adults; 2) examine the cross-sectional association between these classes and SCD.

Methods: We studied 33,922 adults aged 45+ years from the 2017 U.S. Behavioral Risk Factor Surveillance System (BRFSS) with data on sleep problems, including short or long sleep duration, trouble falling or staying asleep, unintentionally falling asleep, snoring loudly, and observed apneas. Latent class analysis classified participants based on their responses to sleep items. We then used a subsample from Oregon, the only state that administered both sleep and SCD modules (n = 2,747), to examine the association between class membership and SCD using logistic regression, adjusting for sociodemographic and health-related characteristics.

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Results: We identified and labeled four classes: "Healthy Sleep" (48.0 %); "Primarily Apnea" (25.8 %); "Primarily Insomnia" (17.6 %); and "Comorbid Insomnia and Sleep Apnea (COMISA)" (8.6 %). In adjusted models, individuals in the "COMISA" class had almost twice the odds of SCD, compared to those in the "Healthy Sleep" class (OR=1.91, 95 % CI =1.15–3.15).
Conclusions: Compared to U.S. middle-aged and older adults with healthy sleep, those with COMISA were significantly more likely to report SCD, which is a risk factor for dementia. Studies are needed investigating whether sleep interventions delay cognitive decline in these individuals.

1. Introduction

A considerable proportion of U.S. middle-aged and older adults experience sleep problems, such as inadequate sleep duration, insomnia symptoms, sleep apnea symptoms, and daytime sleepiness, with prevalence rates ranging from 17 % to 50 % among this population (Gordon et al., 2022; Liu et al., 2021; Sivertsen et al., 2021; Thompson et al., 2022; Yun et al., 2015). These sleep problems are linked to a wide range of adverse health outcomes, such as fatigue, frailty, cardiovascular diseases, mental disorders, and even mortality (Bentham & Eaves, 2022; Cai et al., 2023; Lao et al., 2018; Nakagawa et al., 2023; Svensson et al., 2021). Further, research increasingly supports the connection between sleep problems and cognitive decline in middle-aged and older adults, particularly among epidemiological studies (Bubu et al., 2020; Devore et al., 2016; Li et al., 2022; Shi et al., 2018; Smith et al., 2022; Xu et al., 2020). Multiple meta-analyses tie sleep problems to all-cause cognitive decline, Alzheimer's Disease (AD), and all-cause dementia (Bubu et al., 2020; Devore et al., 2016; Shi et al., 2018; Xu et al., 2020). Furthermore, a few studies have shown that sleep problems are associated with higher rates of subjective cognitive decline (SCD) among middle-aged and older adults (Kang et al., 2017; Smith et al., 2022; Stocker et al., 2017; Tsapanou et al., 2019; Vaessen et al., 2015).

SCD refers to an individual's perception of decline in their own cognitive ability (ALzheimer's Association, 2018). According to the 2015–16 Behavioral Risk Factor Surveillance System (BRFSS) survey, 11.2 % of adults aged ≥45 in the United States (U.S.) reported experiencing SCD in the past year (Taylor et al., 2018). A growing literature suggests SCD is a key predictor of objective cognitive decline and an important aspect of well-being in middle age and older adulthood (ALzheimer's Association, 2018). SCD can manifest earlier than the onset of objective cognitive impairment (Jessen et al., 2014), and some studies suggest it might appear >10 years prior to dementia onset (Amieva et al., 2008; Verlinden et al., 2016). Meta-analyses of longitudinal studies consistently show that individuals with SCD have a raised likelihood of developing mild cognitive impairment (MCI) and dementia (Mitchell et al., 2014; Pike et al., 2022). In addition to its association with accelerated cognitive decline, SCD also negatively impacts individuals' quality of life, mental well-being, and social function (Rabin et al., 2017). As revealed by the BRFSS, about half of people with SCD experience related functional limitations, requiring assistance with daily life activities such as paying bills and taking medications (Taylor et al., 2018).

Previous studies of sleep and SCD in middle-aged and older adults mostly have examined sleep problems using variable-centered approaches in which each individual sleep problem (e.g., short sleep duration, difficulty falling asleep) is studied in relation to SCD (Mascherek et al., 2020; Reynolds et al., 2023), regardless of the co-existence of other sleep problems. Other studies have attempted to capture all sleep problems experienced by an individual by generating a total score or total number of sleep problems (Smith et al., 2022; Tsapanou et al., 2019). While these approaches have provided valuable insights, they are limited in terms of capturing the common patterns of sleep problems among individuals. Persons with the same total score or the same number of sleep problems can still have differing levels of risk for cognitive impairment because their combinations of problems are different. Adopting a person-centered approach that identifies subgroups of people with distinct profiles of sleep problems/symptoms and investigates their associations with SCD can address this knowledge gap.

Latent class analysis (LCA) is one such person-centered approach, which classifies individuals based on an unobserved (latent) variable using a set of observed variables (Porcu & Giambona, 2017). Specifically, using this statistical method, individuals can be classified based on the homogeneity of their responses to the sleep problems, revealing the various sleep problem profiles prevalent in a population. Furthermore, LCA allows for model-based class characterizations using conditional probabilities (Lanza & Rhoades, 2013), enabling comparisons of characteristics across classes and estimation of the association between class membership and specific outcomes.

Therefore, this study aimed to identify profiles (latent classes) based on self-reported sleep problems among U.S. community-dwelling middle-aged and older adults. The cross-sectional association between sleep problem profiles and SCD was then examined. To our knowledge, this is the first study to examine the association of sleep problem profiles with SCD. Understanding this association helps identify subgroups of people with heightened odds of SCD, who are at greater risks for objective cognitive decline and dementia.

2. Methods

2.1. Sample and data

We used the data from the 2017 wave of BRFSS. BRFSS is a random-digit dialed telephone (landlines and cell phones) survey about health-related risk behaviors, chronic health conditions, and use of preventive services (Rolle-Lake & Robbins, 2022). Respondents are noninstitutionalized adults aged 18 years or older across all 50 states, the District of Columbia, and U.S. territories. In 2017, a sleep problem module was administered in 8 states (Arizona, Kansas, Minnesota, Nebraska, Nevada, North Dakota, Oregon, Tennessee), as well as in the District of Columbia. The SCD module was administered in 9 states (Georgia, Hawaii, Mississippi, Oregon, Michigan, New Jersey, New York, Utah, Maryland) and Puerto Rico.

To identify latent classes based on self-reported sleep problems, we selected all respondents aged 45 years and older with complete data on sleep problems (n = 33,922). We then examined associations of latent classes with SCD among participants from Oregon (n = 2747), the only state that administered both the sleep problem and SCD modules.

2.2. Measures

2.2.1. Sleep problems

The BRFSS survey contained items on 1) sleep duration in hours. Respondents were then asked how many days in the past 14 days they have experienced 2) insomnia symptoms including "trouble falling asleep, staying asleep, or sleeping too much", or 3) daytime sleepiness: "unintentionally falling asleep during the day". Respondents also responded to sleep-disordered breathing-related symptoms: 4) whether have been told they snore loudly, and 5) whether anyone ever observed the respondent stop breathing during sleep. For latent class analysis, sleep duration was dichotomized based on whether they had obtained a sleep duration outside the recommended duration for older adults (7–8 h

coded as no, <7 or >8 h coded as yes) (Hirshkowitz et al., 2015); and insomnia symptoms and daytime sleepiness were each dichotomized into whether or not they have experienced the problems in the past 14 days, which is consistent with the previous study using the same data (Liu et al., 2021). For all the questions, yes (coded as 1) means the participant has the sleep problem; no (coded as 0) means they do not.

2.2.2. SCD

In BRFSS, SCD was determined by the question "During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?". The responses were dichotomous, with a "yes" classified as having SCD. The SCD measure was developed by a panel of experts in response to the growing recognition of its association with an increased risk of cognitive decline and dementia (Mitchell et al., 2014; Olivari et al., 2021). This SCD question was found to correlate with objective cognitive assessment results and demonstrated good specificity, indicating that individuals reported no SCD were unlikely to score lower on objective cognitive assessments (Brody et al., 2019).

2.2.3. Demographic, socioeconomic and health characteristics

Demographic characteristics included age groups (45–65 years; >65 years), sex, and race/ethnicity. Socioeconomic characteristics included marital status (married; unmarried), education (less than high school; high school graduate; some college or higher), employment status (unemployed; employed; retired), annual household income (<$15,000; $15,000–$50,000; >$50,000), and health care access. Health care access was assessed by three questions, asking whether they have a health care coverage, whether they have a personal doctor or a health care professional, and whether they experienced not seeing a doctor due to cost in the last year.

For lifestyle and health-related characteristics, we included smoking, drinking, physical activity, depression, hypertension, number of other chronic conditions, and self-reported physical and mental health. Smoking was assessed by whether the respondent smoked at least 100 cigarettes in their entire life. Drinking was determined by whether the respondent had at least one drink of any alcoholic beverage in the past 30 days. Level of physical activity was categorized based on whether they have met aerobic or strengthening guidelines for adults (Centers for Disease Control and Prevention (CDC) 2013), which entail engaging in at least 300 min of moderate aerobic activity per week (or vigorous equivalent) and performing muscle-strengthening exercises at least twice weekly. The number of other chronic conditions was the sum of the number of the following conditions: heart disease, stroke or other cerebrovascular disease, asthma, lung disease, cancer, arthritis, and diabetes. Moreover, the respondents were asked about how many days in the past 30 days their physical health was not good, which includes physical illness and injury, and how many days their mental health was not good, which includes stress, depression, and problems with emotions. The answers were categorized into "0 day," "1–13 days," and "14+ days."

2.3. Statistical analysis

LCA was used to classify participants into different classes of heterogenous sleep problem profiles based on their responses to the five sleep problems. Latent class models with different numbers of classes were performed, from 2 classes to the optimal number of classes. Best fitting model was determined based on a comprehensive consideration on the following criteria (McCutcheon, 1987): (1) Information Criterion, including the Bayes Information Criterion (BIC) and the Akaike Information Criterion (AIC), which ascribe lower values to better models; (2) the adjusted Vuong-Lo-Mendell-Rubin test (VLMR) and the Bootstrap Likelihood Ratio Test (BLRT), which are the two tests that compare between *k*-1 class and *k* class models, with a nonsignificant p-value supporting the *k* class model; (3) entropy, while not a primary criterion for model selection, serves as an indicator for classification quality, with a value closer to 1 indicating better class separation; (4) interpretability, which suggests that the identified classes to be qualitatively distinct and theoretically plausible.

After identifying the optimal model, participants were classified into the latent class with the maximum posterior class membership probability. Descriptive statistics were used to describe the demographic, socioeconomic, and health-related characteristics of each class. While categorical variables were described using frequencies and percentages, continuous variables were described using means and standard deviations (SD). Between-class differences were examined using chi-square test (for categorical variables) or analysis of variance (ANOVA; for continuous variables). Multinomial logistic regression was used to examine the associations between these characteristics and class membership, with the former as the independent variables and the latter as the dependent variable.

Lastly, logistic regression was conducted to examine the associations of latent classes of sleep problem profiles with SCD; class membership was the independent variable and SCD was the dependent variable. Three models were performed: Model I was unadjusted; Model II was adjusted for age group, sex, and education; Model III was adjusted for all the demographic, socioeconomic, and health characteristics that were found significantly different between classes, as informed by the chi-square tests and ANOVAs. Additionally, an interaction term of class membership and age groups (45–65 years and ≥65 years) was added to the Model III to explore whether the association differed between middle-aged and older adults.

LCA was performed on RStudio version 4.3.2 with the poLCA package (Linzer & Lewis, 2011). All other statistical analyses were performed in SPSS, version 26 (IBM Corporation, New York, NY, 2019) using the dataset exported from RStudio with class membership.

3. Results

3.1. Sample characteristics

About half of the 33,922 participants were middle-aged (51.6 %) and 56.7 % were females (Table 1). The majority of the sample was non-Hispanic white (85.1 %), had some college or higher education (70.3 %), was married (56.5 %), and employed (42.8 %) or retired (42.5 %), and reported an annual household income exceeding $50,000 (52.0 %). Participants generally had healthcare coverage (95.1 %) and had a personal doctor (88.2 %), while a small portion of them reported an inability to seek medical attention due to cost (7.7 %). In terms of health behaviors, 54.8 % of them reported drinking in the past month, 46.7 % had smoked at least 100 cigarettes, and 38.3 % did not meet either aerobic or strengthening physical activity guidelines. Most of the samples had good self-reported mental or physical health in the past month (72.9 % and 63.0 %, respectively). Regarding chronic conditions, 18.9 % reported depression, 46.9 % had hypertension, and the mean number of other chronic conditions (except for depression and hypertension) was 1.57 (SD = 1.45).

3.2. Latent classes of sleep problems

The model fit statistics of LCA are shown in Table 2. We chose the 4-class model as it exhibited the lowest values for both AIC and BIC. Also, both the VLMR and BLRT indicated that it significantly outperformed the 3-class model, while not displaying inferiority compared to the 5-class model. Although the entropy of the 3-class model was better than the 4-class model, it is not a key measure of determining the best model fit (Sinha et al., 2021).

Fig. 1 illustrates the distribution of the four latent classes of sleep problems. Class 1, encompassing the majority at 48.0 % of the sample (*n* = 16,287), demonstrated good sleep health overall. This class showed no observed apneas and low probabilities (16.6 % to 28.9 %) of

Table 1
Descriptive variables for the total sample and each class.

Variables	Total sample (n = 33,922) n (%)	Class 1 "Healthy Sleep" (48.0 %, n = 16,287) n (%)	Class 2 "Primarily Apnea" (25.8 %, n = 8750) n (%)	Class 3 "Primarily Insomnia" (17.6 %, n = 5964) n (%)	Class 4 "COMISA" (8.6 %, n = 2921) n (%)	P-value [a]
Age						< 0.001
45–64 years	17,484 (51.5 %)	8095 (49.7 %)	4540 (51.9 %)	3163 (53.0 %)	1686 (57.7 %)	
>65 years	16,438 (48.5 %)	8192 (50.3 %)	4210 (48.1 %)	2801 (47.0 %)	1235 (42.3 %)	
Gender						< 0.001
Females	19,229 (56.7 %)	9697 (59.6 %)	3986 (45.6 %)	4037 (67.8 %)	1509 (51.7 %)	
Males	14,679 (43.3 %)	6584 (40.4 %)	4764 (54.4 %)	1920 (32.2 %)	1411 (48.3 %)	
Race						< 0.001
White, Non Hispanic	28,869 (85.1 %)	13,953 (85.7 %)	7522 (86.0 %)	5028 (84.3 %)	2366 (81.0 %)	
Black, Non Hispanic	2002 (5.9 %)	898 (5.5 %)	473 (5.4 %)	402 (6.7 %)	229 (7.8 %)	
Asian, Non Hispanic	260 (0.8 %)	132 (0.8 %)	71 (0.8 %)	45 (0.8 %)	12 (0.4 %)	
Native, Non Hispanic	569 (1.7 %)	252 (1.5 %)	125 (1.4 %)	110 (1.8 %)	82 (2.8 %)	
Hispanic	1501 (4.4 %)	760 (4.7 %)	371 (4.2 %)	234 (3.9 %)	136 (4.7 %)	
Other, Non Hispanic	721 (2.1 %)	292 (1.8 %)	188 (2.1 %)	145 (2.4 %)	96 (3.3 %)	
Education						< 0.001
Less than high school	1812 (5.4 %)	793 (4.9 %)	425 (4.9 %)	356 (6.0 %)	238 (8.2 %)	
High school graduate	8257 (24.2 %)	3814 (23.5 %)	2102 (24.1 %)	1550 (26.0 %)	791 (27.2 %)	
Some college or higher	23,782 (70.3 %)	11,644 (71.7 %)	6209 (71.1 %)	4045 (68.0 %)	1884 (64.7 %)	
Marital status						< 0.001
Married	19,079 (56.5 %)	9348 (57.7 %)	5453 (62.6 %)	2884 (48.6 %)	1394 (48.0 %)	
Unmarried	14,681 (43.5 %)	6860 (42.3 %)	3262 (37.4 %)	3051 (51.4 %)	1508 (52.0 %)	
Job status						< 0.001
Unemployed	4967 (14.7 %)	1843 (11.4 %)	1075 (12.4 %)	1195 (20.1 %)	854 (29.3 %)	
Employed	14,450 (42.8 %)	7231 (44.6 %)	3935 (45.2 %)	2333 (39.3 %)	951 (32.7 %)	
Retired	14,335 (42.5 %)	7125 (44.0 %)	3694 (42.4 %)	2410 (40.6 %)	1106 (38.0 %)	
Annual Household Income						< 0.001
< $15,000	2261 (7.8 %)	845 (6.1 %)	465 (6.1 %)	547 (10.8 %)	404 (15.7 %)	
$15,000–50,000	11,678 (40.2 %)	5321 (38.6 %)	2953 (38.7 %)	2209 (43.5 %)	1195 (46.5 %)	
$50,000 or more	15,111 (52.0 %)	7608 (55.2 %)	4209 (55.2 %)	2324 (45.7 %)	970 (37.8 %)	
Have Healthcare Coverage						< 0.021
Yes	32,188 (95.1 %)	15,445 (95.1 %)	8349 (95.7 %)	5648 (94.9 %)	2746 (94.4 %)	
No	1645 (4.9 %)	798 (4.9 %)	379 (4.3 %)	304 (5.1 %)	164 (5.6 %)	
Have Specific Healthcare Professionals						< 0.001
Yes	29,817 (88.2 %)	14,171 (87.3 %)	7808 (89.5 %)	5228 (87.8 %)	2610 (89.7 %)	
No	4006 (11.8 %)	2068 (12.7 %)	915 (10.5 %)	724 (12.2 %)	299 (10.3 %)	
Could Not See Doctor Because of Cost						< 0.001
Yes	2620 (7.7 %)	862 (5.3 %)	669 (7.7 %)	624 (10.5 %)	465 (16.0 %)	
No	31,209 (92.3 %)	15,385 (94.7 %)	8055 (92.3 %)	5322 (89.5 %)	2447 (84.0 %)	
Physical Activity Recommendations						< 0.001
Did not meet either guideline	12,528 (38.3 %)	5208 (33.3 %)	3419 (40.4 %)	2433 (42.1 %)	1468 (51.8 %)	
Met aerobic guidelines only	2316 (7.1 %)	1077 (6.9 %)	621 (7.3 %)	423 (7.3 %)	195 (6.9 %)	
Met strengthening guidelines only	11,411 (34.9 %)	5771 (36.9 %)	2943 (34.8 %)	1903 (32.9 %)	794 (28.0 %)	
Met both guidelines	6458 (19.7 %)	3584 (22.9 %)	1480 (17.5 %)	1018 (17.6 %)	376 (13.3 %)	
Smoking						< 0.001
Yes	15,756 (46.7 %)	7018 (43.4 %)	4304 (49.4 %)	2839 (47.9 %)	1595 (54.8 %)	
No	17,980 (53.3 %)	9171 (56.6 %)	4407 (50.6 %)	3089 (52.1 %)	1313 (45.2 %)	
Drinking						< 0.001
Yes	18,406 (54.8 %)	8935 (55.4 %)	5028 (58.0 %)	3083 (52.1 %)	1360 (46.8 %)	
No	15,198 (45.2 %)	7179 (44.6 %)	3647 (42.0 %)	2829 (47.9 %)	1543 (53.2 %)	
Poor Mental Health in the Past Month						< 0.001
14+ days	3013 (9.0 %)	710 (4.4 %)	699 (8.1 %)	896 (15.2 %)	708 (24.7 %)	
1–13 days	6074 (18.1 %)	2229 (13.8 %)	1618 (18.7 %)	1447 (24.6 %)	780 (27.2 %)	
0 day	24,423 (72.9 %)	13,185 (81.8 %)	6329 (73.2 %)	3534 (60.1 %)	1375 (48.0 %)	
Poor Physical Health in the Past Month						< 0.001
14+ days	4835 (14.5 %)	1407 (8.8 %)	1174 (13.7 %)	1239 (21.3 %)	1015 (35.6 %)	

(*continued on next page*)

Table 1 (*continued*)

Variables	Total sample (n = 33,922) n (%)	Class 1 "Healthy Sleep" (48.0 %, n = 16,287) n (%)	Class 2 "Primarily Apnea" (25.8 %, n = 8750) n (%)	Class 3 "Primarily Insomnia" (17.6 %, n = 5964) n (%)	Class 4 "COMISA" (8.6 %, n = 2921) n (%)	P-value [a]
1–13 days	7482 (22.5 %)	2969 (18.6 %)	2168 (25.2 %)	1550 (26.6 %)	795 (27.9 %)	
0 day	20,929 (63.0 %)	11,613 (72.6 %)	5246 (61.1 %)	3032 (52.1 %)	1038 (36.4 %)	
Hypertension						< 0.001
Yes	15,902 (46.9 %)	6510 (40.0 %)	4691 (53.6 %)	2871 (48.1 %)	1830 (62.6 %)	
No	18,020 (53.1 %)	9777 (60.0 %)	4059 (46.4 %)	3093 (51.9 %)	1091 (37.4 %)	
Depression						< 0.001
Yes	6411 (18.9 %)	1870 (11.5 %)	1772 (20.3 %)	1561 (26.2 %)	1208 (41.4 %)	
No	27,511 (81.1 %)	14,417 (88.5 %)	6978 (79.7 %)	4403 (73.8 %)	1713 (58.6 %)	
Number of Chronic Conditions (M±SD)	1.57 ± 1.45	1.25 ± 1.27	1.74 ± 1.48	1.72 ± 1.47	2.50 ± 1.76	< 0.001

Note: M = Mean; SD = Standard Deviation; COMISA = Combined Insomnia and Apnea; P-values were from chi-square tests and ANOVA

Table 2
Model fit statistics.

Classes	BIC	AIC	VLMRT p value	BLRT p value	Entropy
2	203,064.0	202,971.3	<0.001	<0.001	0.56
3	202,217.4	202,074.1	<0.001	<0.001	**0.61**
4[a]	**202,015.5**	**201,821.6**	**<0.001**	**<0.001**	0.43
5	202,070.0	201,825.4	0.138	0.143	0.44

Note: BIC = Bayesian Information Criterion; AIC = Akaike Information Criterion; VLMRT = Vuong-Lo-Mendell-Rubin Test; BLRT=Bootstrapped Likelihood Ratio Test; Bold = best choice within the criterion.
[a] Chosen model.

reporting the other sleep problems compared with other classes, including short or long sleep duration, trouble falling or staying asleep, unintentional daytime sleep, and loud snoring. Thus, Class 1 was labeled as "Healthy Sleep."

Class 2, accounting for 25.8 % of the sample (n = 8750), was labeled as "Primarily Apnea" because individuals in this class predominantly reported symptoms of sleep apnea. They exhibited the highest probabilities of reporting snoring (82.6 %), with half of them experiencing observed apneas. The probabilities of other sleep problems were similar to those in the "Healthy Sleep" class.

Class 3, constituting 17.6 % of the sample (n = 5964), was characterized by a high probability of a key symptom of insomnia — having trouble falling or staying asleep (75.1 %). Additionally, individuals in this class displayed a higher probability of experiencing short or long sleep duration, a common feature in individuals with insomnia. Meanwhile, their probability of apnea symptoms was as low as those in the "Healthy" class. Hence, Class 3 was labeled as "Primarily Insomnia."

Class 4, the smallest class at 8.6 % (n = 2921), exhibited the poorest overall sleep health, with the highest probability of reporting almost all sleep problems. Given its elevated probabilities of both insomnia and apnea symptoms, this class was labeled as "Comorbid Insomnia and Sleep Apnea (COMISA)," which is a term describing the coexisting of insomnia and sleep apnea (Meira e Cruz et al., 2021).

3.3. Characteristic of sleep problem latent classes

As shown in Table 1, the latent classes of sleep problems varied statistically significantly in terms of all the included demographics, socioeconomics, and health-related characteristics. Particularly, compared with the other three classes, the COMISA class (which had the most severe sleep problems) were more likely to be middle-aged group, report Black race, have less than a high school education, be unmarried and unemployed, and have a lower annual household income and a higher likelihood of being unable to see a doctor due to cost (16 % vs. 5.3

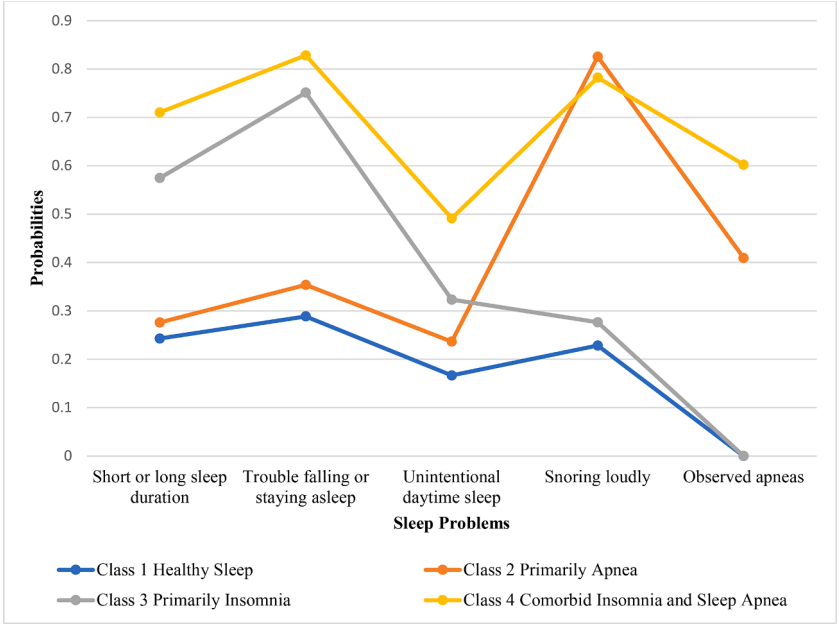

Fig. 1. Latent Classes of Sleep Problems.

%–10.5 %). Individuals in this class also reported lower levels of physical activity, higher rates of smoking, poorer self-reported mental and physical health, higher rates of hypertension (62.6 % vs. 40.0 %–53.6 %) and self-reported depression (41.4 % vs. 11.5 %–26.2 %), and a greater number of other chronic conditions (mean = 2.5 vs. mean = 1.25–1.72). In the multinomial logistic regression, being middle-aged, male, non-White, unemployed, unable to see a doctor due to cost, having lower physical activity, poorer self-reported mental and physical health, more hypertension, more depression, and a higher number of other chronic conditions remained significant when comparing the COMISA class to the Healthy Sleep class. Detailed logistic regression results for the characteristics of each class are available in Supplementary Table 1.

3.4. Sleep problem latent classes and SCD

Among the 2747 samples included for logistic regression, 43.4 % were classified into the Class 1–"Healthy Sleep" ($n = 1192$), 25.9 % were in the Class 2–"Primarily Apnea" ($n = 711$), 20.6 % were in the Class 3–"Primarily Insomnia" ($n = 567$), and 10.1 % were in the Class 4 "COMISA"– ($n = 277$), which are consistent with the total sample. The results of logistic regression were presented in Table 3. In the unadjusted model (Model I), compared to the Healthy Sleep Class, the Primarily Apnea, Primarily Insomnia, and COMISA classes showed significantly increased odds for SCD (OR = 1.73, 95 % CI = 1.23–2.43; OR = 2.05, 95 % CI = 1.44–2.91; OR = 5.16, 95 % CI = 3.59–7.41). Similar results were observed in Model II after adjusting for age group, sex, and education. In the fully adjusted model (Model III), the COMISA class showed a significantly higher odds of having SCD, compared to the Healthy Sleep class (OR = 1.89, 95 % CI = 1.15–3.13), after adjusting for age group, sex, race/ethnicity, marital status, household income, health care access, smoking, drinking, physical activity, depression, hypertension, number of other chronic conditions, and self-reported physical and mental health. The odds of SCD in Primarily Apnea and Primarily Insomnia classes were no longer significantly different from the Healthy Sleep class. In addition, when adding an interaction term of sleep class membership and age groups into the logistic regression model, it did not reach statistical significance, which indicates that the association between sleep class membership and SCD did not significantly differ between the age groups of 45–65 years and ≥ 65 years.

4. Discussion

This study has identified four latent classes (profiles) of sleep problems among community-dwelling middle-aged and older adults in the US: "Healthy Sleep" (48.0 %), "Primarily Apnea" (25.8 %); "Primarily Insomnia" (17.6 %); and "COMISA" (8.6 %). We found that compared to the Healthy Sleep class, adults in the COMISA class were significantly more likely to report SCD.

Consistent with previous studies (Heinzer et al., 2016; McArdle et al., 2022; Sivertsen et al., 2021), we found that about half of the middle-aged and older population exhibited an unhealthy sleep profile, driven by symptoms of insomnia and sleep apnea. This is not surprising, given insomnia and sleep apnea are two of the most common sleep disorders in middle-aged and older adults (Brewster et al., 2018; McArdle et al., 2022; Yaremchuk, 2018). Approximately 20 % of middle-aged and older adults have insomnia disorder and up to 75 % of this population may report insomnia symptoms (Brewster et al., 2018; Sivertsen et al., 2021). A large-scale study using polysomnography reported that 50 % of men and 23 % of women aged 40 years and over had sleep apnea (Heinzer et al., 2016).

Insomnia and sleep apnea often coexist (Sweetman, 2023). A meta-analysis suggested that 38 % of sleep apnea patients reported insomnia symptoms and 29 %–35 % insomnia patients also met OSA diagnostic criteria, spanning both clinic and community settings (Zhang et al., 2019). Given the high prevalence and its association with heightened risks of morbidity and mortality, COMISA has gained

Table 3
The association between sleep problem class membership and SCD ($n = 2747$).

Variables	Model I OR (95 %CI)	Model II OR (95 %CI)	Model III OR (95 %CI)
Latent Classes of Sleep Problems (vs. Healthy Sleep)			
Primarily Apnea	1.73 (1.23, 2.43) **	1.62 (1.15, 2.29) **	1.12 (0.72, 1.73)
Primarily Insomnia	2.05 (1.44, 2.91) ***	2.12 (1.49, 3.02) ***	1.20 (0.75, 1.91)
COMISA	5.16 (3.59, 7.41) ***	5.13 (3.55, 7.39) ***	1.89 (1.15, 3.13) *
Age group (vs. 45–64 years)			
>65 years		1.44 (1.12, 1.87) **	1.70 (1.09, 2.67) *
Males (vs. Females)		1.29 (1.00, 1.67)	2.01 (1.42, 2.85) ***
Education (vs. some college or higher)			
Less than high school		2.14 (1.33, 3.46) **	1.59 (0.80, 3.18)
High school graduate		1.23 (0.91, 1.67)	1.11 (0.74, 1.66)
Non-White (vs. White)			1.30 (0.81, 2.10)
Married vs. Unmarried			0.76 (0.53, 1.10)
Job status (vs. Retired)			
Unemployed			1.40 (0.82, 2.40)
Employed			0.99 (0.62, 1.58)
Annual Household Income (vs. >$50,000)			
< $15,000			0.65 (0.34, 1.26)
$15,000–$50,000			0.77 (0.51, 1.15)
No Healthcare Coverage (vs. Has)			1.63 (0.79, 3.36)
No Specific Healthcare Professionals (vs. Has)			0.88 (0.48, 1.62)
Could Not See Doctor Because of Cost (vs. No)			2.26 (1.39, 3.68) **
Smoking (vs. No)			0.91 (0.65, 1.28)
Drinking (vs. No)			0.94 (0.67, 1.32)
Physical Activity Recommendations (vs. Met both guidelines)			
Did not meet either guideline			0.99 (0.61, 1.59)
Met aerobic guidelines only			1.10 (0.51, 2.25)
Met strengthening guidelines only			0.96 (0.60, 1.53)
Poor Mental Health in the Past Month (vs. 0 day)			
14+ days			2.68 (1.61, 4.43) ***
1–13 days			1.58 (1.04, 2.39) *
Poor Physical Health in the Past Month (vs. 0 day)			
14+ days			1.94 (1.23, 3.04) ***
1–13 days			1.68 (1.13, 2.50) *
Hypertension (vs. No)			0.90 (0.64, 1.26)
Depression (vs. No)			2.02 (1.38, 2.96) ***
Number of Other Chronic Conditions			1.27 (1.12,1.42) ***

Note: CI = Confidence Intervals; vs. = versus; COMISA = Combined Insomnia and Apnea; Model I was unadjusted; Model II was adjusted for age, sex, and education; Model III was fully adjusted.

* $p < 0.05$;.
** $p < 0.01$;.
*** $p < 0.001$; p-values were from logistic regression.

increasing interest in the area of sleep research (Meira e Cruz et al., 2021; Sweetman et al., 2019).

Research indicates that COMISA is associated with shorter total sleep time and increased daytime impairment, compared to insomnia or sleep apnea alone (Cho et al., 2018; Gooneratne et al., 2006). This aligns with our findings regarding the COMISA class, which exhibited the highest probabilities of experiencing both short or long sleep duration and daytime sleepiness, in addition to insomnia and apnea symptoms. Individuals with COMISA were also reported to have poorer quality of life and higher rates of psychiatric and medical conditions, including depression and cardiovascular diseases (Cho et al., 2018; Gooneratne et al., 2006). This echoes our findings that the COMISA class was characterized by the highest average number of chronic conditions, the highest percentages of depression and hypertension. Additionally, they had poorer self-reported mental and physical health in the past month, compared to the other three classes.

In terms of cognitive health, only two previous studies have investigated the associations between cognitive function and COMISA (Gooneratne et al., 2006; Stone et al., 1994). One study revealed that those with COMISA had longer psychomotor reaction times compared with those without either insomnia or sleep apnea (Gooneratne et al., 2006). The other study, focusing on individuals with insomnia, found that those with sleep apnea simultaneously demonstrated poorer psychomotor performance than those without, although this was no longer significant after adjusting for covariates (Stone et al., 1994). This study adds to the existing literature by examining SCD and found that a COMISA profile, as identified by LCA, was associated with a higher likelihood of SCD compared with a healthy sleep profile, even after adjusting for a series of covariates.

The findings support a relationship between sleep and cognitive health and contribute to the literature by identifying vulnerable subgroups susceptible to cognitive decline. Emerging research indicates that SCD may be an early sign of AD, as it has been linked to increased AD biomarkers and may occur before objective cognitive deficits manifest (Jessen et al., 2014). All respondents completed the telephone surveys independently (Centers for Disease Control and Prevention (CDC) 2022), we therefore assumed that they did not have significant cognitive impairment due to the nature of telephone surveys. However, we could not confirm whether the reported SCD reflects an early stage of AD, as no objective cognitive measure was available in the 2017 BRFSS data. Despite these, given the evidence that SCD is associated with higher risks for cognitive impairment and dementia regardless of objective cognitive status (Pike et al., 2022), it remains plausible to consider that a profile characterized by COMISA may relate to a higher risk for cognitive impairment.

As SCD is common not only in older adults, but also in those middle-aged (10.4 % in adults aged 45–54 years) (Taylor et al., 2018), this study investigated the latent classes of sleep problems in both middle-aged and older adults. We acknowledge the possibility that the sleep problem profiles vary between middle-aged and older adults, due to lifestyle changes and physiological changes (Li et al., 2018). Given our primary focus on the association between sleep problems and SCD, we examined whether this association differed between the age groups of 45–65 years and $\geq$ 65 years and our finding indicated a non-significant difference. While prior research on this issue mostly focused on older adults (Kang et al., 2017; Tsapanou et al., 2019), our study suggests that the potential risk of cognitive impairment associated with sleep problems is not limited to older adulthood, but also middle-aged adulthood.

Moreover, adults in the COMISA class were also more likely to be unemployed, and had lower educational attainment, lower household income, and to report that they could not see a doctor due to cost. This is consistent with the previous studies that lower socioeconomic status is associated with a higher likelihood of sleep problems (Grandner et al., 2010; Mazzotti et al., 2012; Zhang et al., 2017). Individuals with lower economic status are more likely to have unhealthy sleep behaviors and face an increased level of stress, which may contribute to their sleep problems (Papadopoulos & Sosso, 2023). They may also encounter more difficulties in accessing healthcare, leading to underdiagnosis or untreated sleep problems (Papadopoulos & Sosso, 2023). Such disparities may result in further disparities in health outcomes associated with sleep problems, including cognitive decline (Girardin et al., 2022).

This study holds significant implications for clinical practice and future research. The findings highlight the value of self-reported assessments of sleep problems in relation to cognitive health. These measures hold significance for both clinical practice and research, providing a cost-effective and feasible alternative, especially when formal assessments or diagnoses are costly and not easily accessible (Gutiérrez et al., 2024). The importance of screening and addressing sleep problems in older adults is also underscored. Furthermore, it is important to extend screening and treatment health services to middle-aged adults and those who are socioeconomically disadvantaged. Future longitudinal studies are needed to further understand the role of sleep problem profiles in the trajectories of cognitive decline over time. Also, the identified sleep problem profiles may inform the development of more tailored and effective sleep interventions, which may be explored in future research. Additionally, future research is needed to better understand the association of COMISA with cognitive health and AD pathology.

Our study is subject to several limitations. First, the selected LCA model exhibits low entropy, indicating suboptimal class separation. This could be attributed to the large sample size and the insufficient ability of the five sleep problem variables to fully capture the heterogeneity within the sample (Sinha et al., 2021). To assess the robustness of the model, we repeated the LCA on a random half of the sample, and similar results and class patterns were observed. This suggests that the class structure is stable and supports the validity of the identified classes despite lower entropy. We also examined the item-response probabilities and class sizes in both analyses, which confirmed the meaningfulness of the classes in distinguishing different sleep problem profiles. Furthermore, post-hoc comparisons with external covariates (e.g., age, SCD) provided additional validation of the distinct patterns observed in the latent classes. Future research needs to develop better indicators for identifying the latent classes of sleep problems, to implement this LCA approach at a population level. Second, BRFSS is a telephone survey with a response rate of 45 % in 2017, potentially introducing selection bias. For instance, those who are not comfortable with telephone surveys or without access to telephone might be underrepresented. Also, since all data are self-reported, report bias and recall bias are possible. Moreover, since this is a secondary data analysis, there may be unadjusted confounders that were not available in the current dataset such as anxiety and sleep medication usage. Finally, given the cross-sectional nature of this study, causal inference is not possible. Despite these limitations, this study adopted a person-centered approach and is the first attempt to explore the association between the latent classes of sleep problems and SCD. The large sample size provided a powerful estimation of the latent classes of sleep problems among general community-dwelling middle-aged and older adults.

5. Conclusion

In conclusion, we identified four latent classes of self-reported sleep problems in U.S. middle-aged and older adults. Among these classes, the COMISA class exhibited significantly higher rates of SCD than the class with healthy sleep, even after controlling for sociodemographic and health-related characteristics. Our findings provide new insights into the relationship between sleep problems and SCD through the utilization of a person-centered approach. Findings also highlight the importance of screening sleep problems in middle-aged and older adults and

developing targeted interventions, which may have the potential to alleviate the burden of cognitive decline experienced by this population.

CRediT authorship contribution statement

Jing Huang: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Adam P. Spira:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Nancy A. Perrin:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Aisha Ellis:** Writing – review & editing, Visualization, Validation. **Erh-Chi Hsu:** Writing – review & editing, Writing – original draft. **Christopher N. Kaufmann:** Writing – review & editing. **Junxin Li:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization.

Declaration of competing interest

Adam Spira received payment for serving as a consultant for Merck, received honoraria from Springer Nature Switzerland AG for guest editing special issues of *Current Sleep Medicine Reports*, and is a paid consultant to Sequoia Neurovitality, BellSant, Inc., and Amissa, Inc. The remaining authors have no conflicts of interest to declare

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2024.105657.

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