HHS Public Access

Author manuscript

Int J Behav Med. Author manuscript; available in PMC 2023 October 01.

Published in final edited form as:

Int J Behav Med. 2022 October ; 29(5): 648–658. doi:10.1007/s12529-021-10048-4.

Characterizing Patterns of Nurses' Daily Sleep Health: A Latent Profile Analysis

Danica C. Slavish, Ph.D.[1], **Ateka A. Contractor, Ph.D.**[1], **Jessica R. Dietch, Ph.D.**[2], **Brett Messman, B.A.**[1], **Heather R. Lucke, M.S.**[1], **Madasen Briggs, B.S.**[1], **James Thornton**[3], **Camilo Ruggero, Ph.D.**[1], **Kimberly Kelly, Ph.D.**[1], **Marian Kohut, Ph.D.**[4], **Daniel J. Taylor, Ph.D.**[5]

[1]University of North Texas

[2]Oregon State University

[3]Dallas Fire-Rescue

[4]Iowa State University

[5]University of Arizona

Abstract

Background: Nursing is a demanding occupation characterized by dramatic sleep disruptions. Yet most studies on nurses' sleep treat sleep disturbances as a homogenous construct and do not use daily measures to address recall biases. Using person-centered analyses, we examined heterogeneity in daily sleep patterns in relation to psychological and physical health.

Methods: Nurses (N = 392; 92% female, mean age = 39.54) completed 14 daily sleep diaries to assess sleep duration, efficiency, quality, and nightmare severity; as well as measures of psychological functioning and a blood draw to assess inflammatory markers interleukin-6 (IL-6) and C-reactive protein (CRP). Using recommended fit indices and a 3-step approach, latent profile analysis was used to identify the best-fitting class solution.

Results: The best-fitting solution suggested three classes: 1) "Poor Overall Sleep" (11.2%), 2) "Nightmares Only" (8.4%), 3) "Good Overall Sleep" (80.4%). Compared to nurses in the Good Overall Sleep class, nurses in the Poor Overall Sleep or Nightmares Only classes were more likely to be shift workers, and had greater stress, PTSD symptoms, depression, anxiety, and insomnia severity. In multivariate models, every one-unit increase in insomnia severity and IL-6 was associated with a 33% and a 21% increase in the odds of being in the Poor Overall Sleep compared to the Good Overall Sleep class, respectively.

Conclusion: Nurses with more severe and diverse sleep disturbances experience worse health and may be in greatest need of sleep-related and other clinical interventions.

Corresponding author: Danica C. Slavish, danica.slavish@gmail.com; danica.slavish@unt.edu; 1155 Union Circle, Denton, TX, USA.

Conflicts of interest: Author Slavish has received research grants from Canopy Growth Corporation that are outside the scope of the current work. The authors declare that they have no conflict of interest.

Keywords

latent profile analysis; nurses; sleep diary; longitudinal; nightmares

Nursing is a demanding occupation characterized by dramatic disruptions in sleep. Nurses frequently experience long hours and rotating shiftwork [1], potentially traumatic events [2], and high levels of burnout [3], all of which may hinder their ability to obtain sufficient, good quality sleep. Sleep disturbances among nurses are associated with a variety of poor health outcomes, including lower quality of life [4], substance misuse [4], and cardiometabolic health risk [5]. This represents a critical public health issue, as sleep may impact not only nurses' own health and well-being, but also their ability to provide effective patient care [6,7]. Understanding which patterns of sleep disturbances among nurses are most predictive of health may identify nurses in greatest need of supportive health interventions.

Several theoretical models support the idea that nurses' work experiences may strongly shape or be influenced by sleep. The *effort-recovery model* postulates effort expended on work demands without sufficient opportunity for recovery may cause psychophysiological arousal, which can interfere with the ability to fall asleep, stay asleep, or obtain good quality or sufficient duration of sleep [8]. Relatedly, the *conservation of resources theory* postulates individuals who do not replenish their cognitive or affective resources after work may show poorer recovery, more fatigue, and poorer downstream health outcomes [9]. Sleep may thus serve as one important source of recovery from nurses' stressful experiences.

Although studies have delineated the importance of sleep for nurses' occupational health and well-being, there are some critical limitations in the literature. First, most studies have treated sleep health as a homogenous construct. It is highly likely that specific types of sleep disturbances vary among nurses. According to Buysse's [10] model of sleep health, sleep consists of multiple facets, including duration (i.e., time spent asleep), efficiency (i.e., ratio of time spent asleep to time in bed), and subjective quality. Nightmares are also increasingly recognized as an important facet of sleep [11,12], especially among those with frequent exposure to potentially traumatic events, such as nurses [13]. An individual may experience disruptions in one, multiple, or all these facets of sleep on any given night. For example, an individual may obtain sufficient sleep duration (e.g., 7–9 hours), but may experience highly fragmented sleep characterized by many nighttime awakenings, poor sleep quality, nightmares, and/or increased time to fall asleep. Different types of sleep disturbances may be more impactful for subsequent health outcomes than others [10].

Another limitation of the literature is that most studies on nurses' sleep have not considered population-level heterogeneity in sleep patterns. Person-centered analytic approaches (e.g., latent profile analysis [LPA] or latent class analysis [LCA]) can address this heterogeneity, identifying subgroups of individuals based on co-occurring symptom or behavior patterns. LPA/LCA techniques are particularly powerful in that they can identify "hidden groups" within a population, which may be useful for informing more personalized intervention efforts [14].

Some limited work has examined heterogeneity in sleep patterns among nurses, indicating two to three class solutions [15–17]. Nurses with shorter sleep duration and worse sleep quality experience higher turnover and resignation rates than nurses with only one or none of these sleep problems [16]. Other studies show nurses with more sleep problems (e.g., bad dreams, trouble breathing, sleep disorders) also report higher suicidal ideation [18] and psychiatric disorder symptoms [17] than those with none or one of these sleep problems. Nurses experiencing higher fatigue and lower recovery between shifts report more sleepiness, higher levels of depression, lower resilience, lower flourishing, lower job satisfaction, lower compassion satisfaction, higher burnout, and higher secondary traumatic stress, compared to nurses with lower fatigue or better shift recovery [15]. Overall, these studies highlight that greater severity, frequency, and/or diversity of sleep problems may confer greatest risk for a variety of poor mental and physical health outcomes among nurses.

A final limitation of the literature is that most studies have not incorporated daily sleep measures. Only one study to our knowledge has examined heterogeneity in daily accelerometer-based rest-activity patterns among middle aged community women, some of whom were nurses [19]. However, this study did not report subjective measures of daily sleep, which may have important clinical utility beyond objective measures, particularly for conditions such as insomnia and nightmare disorder. Given that sleep fluctuates from night-to-night within the same individual [20], one-time retrospective measures of typical sleep may provide unreliable estimates of sleep and are subject to recall bias. Repeated measures of sleep, such as sleep assessed each morning via daily sleep diaries, can provide more accurate estimates of typical sleep patterns across time [21,22]. Studies show a minimum of six to seven days are needed to provide reliable mean estimates of most self-reported sleep parameters [23,24]. However, more days may be needed among those experiencing high variability in sleep schedules (e.g., shift-working nurses), or when measuring less frequent sleep behaviors (e.g., nightmares) [23].

To address these gaps, the current study had two objectives. First, we used 14 days of self-report measures of sleep duration, efficiency, quality, and nightmare severity to identify the best-fitting class solution to categorize nurses' sleep patterns. Second, we examined the associations between the identified sleep classes with health indices assessed at the beginning (posttraumatic stress disorder [PTSD] severity), middle (inflammatory biomarkers interleukin-6 [IL-6] and C-reactive protein [CRP]), or end (perceived stress and depression, anxiety, and insomnia severity) of the 14-day monitoring period. Based on the literature, we hypothesized we would find 2–3 subgroups with varied sleep patterns among nurses [15–17]. Further, we hypothesized that nurses with more severe and/or a greater diversity of sleep disturbances (e.g., two or three moderate to severe symptoms) would have greater PTSD [15], depression [25], anxiety [25], and insomnia symptom severity, greater perceived stress [15], and higher levels of inflammatory biomarkers IL-6 and CRP [26–28].

Method

Procedure

This study was part of a larger investigation on the effects of sleep on antibody response to the influenza vaccine that occurred between September and November 2018. Participants

were recruited from two regional hospitals through nursing staff presentations, notification through employee email systems, and flyers that directed them to an initial online consent form. Nurses (N = 461) provided online consent and were asked to complete initial online Qualtrics surveys to determine eligibility. Participants were then invited to enroll in the main portion of the study in the early fall (i.e., the start of the influenza season), which included completion of in-person informed consent approximately one month later, as well as a baseline measure of PTSD severity. Of the 461 nurses initially enrolled, 392 nurses enrolled in the main portion of the study, in which they completed daily sleep diaries for 14 consecutive days. On day 7 of the 14-day study period, a blood draw was taken to assess inflammatory biomarkers IL-6 and CRP. Immediately following the 14-day study period, participants completed measures of perceived stress and depression, anxiety, and insomnia severity. The goal of the larger study was to determine the distal and proximal predictors of influenza vaccine response and degradation, which is why the aforementioned measures were taken at different time points. See Figure 1 for a schematic of the study protocol. All study procedures were approved by the University of North Texas and Medical City Plano Institutional Review Boards.

Participants

To be included in the larger study, participants: 1) had not yet received the current season's influenza vaccine, 2) were between ages 18 and 65, and 3) were registered nurses working at least part-time at one of two regional hospitals. Exclusion criteria were: 1) being pregnant or nursing, or planning to become pregnant or 2) having an egg allergy (which was contraindicated for the influenza vaccine being administered as part of the larger study). Table 1 reports demographic characteristics for the entire sample and by class membership. Generally, participants matched national demographics of nurses in the United States [29]. Most participants were female (92%), White (78%), and non-Hispanic/Latinx (89%).

Measures

Sleep diary-determined sleep.—An electronic version of the Consensus Sleep Diary – Core [21] was completed by participants upon awakening using REDCap [30,31]. Diaries were used to determine total sleep time (time in bed [with the intention of sleeping] minus the sum of sleep onset latency [SOL], wake after sleep onset [WASO], and terminal wakefulness [TWAK]) and sleep efficiency (total sleep time divided by time in bed, multiplied by 100). Because SOL, WASO, and TWAK are used in the calculation of sleep efficiency, for the sake of parsimony and to avoid construct overlap and inflated experiment-wise error, these variables were not examined as separate indicators. Nightmare severity was only reported if participants endorsed experiencing at least one nightmare and was assessed using the item: "How would you rate the overall severity of your nightmares?" on a scale of 0 (not at all) to 3 (very). Sleep quality was assessed by having participants rate their subjective sleep quality on a scale of 0 (very poor) to 4 (very good). For all sleep variables, daily values across the 14 days were averaged together for each person. Sleep diaries provide more reliable and valid assessments of sleep than single-time point retrospective questionnaires [23,24,32,33], and correlate significantly with actigraphy (rs = .36 to .60), EEG (rs = .18 to .63), and ambulatory PSG (rs = .36 to .59) measures [32–34].

PTSD symptom severity.—Past month PTSD symptom severity was assessed using the PTSD Checklist for DSM-5 (PCL-5), a 20-item self-report measure [35]. We used the version of the PCL-5 that examines past month PTSD symptoms without assessing Criterion A trauma exposure [35]. The measure is summed to obtain a total score ranging from 0 to 80, with higher scores indicating greater symptom severity. A score ≥ 33 indicates a positive screen for potential PTSD [36]. The PCL-5 has good psychometrics [37]. In the current study, the PCL-5 demonstrated excellent internal consistency (α = .94).

Depressive symptom severity.—Depressive symptom severity was assessed using the Patient Health Questionnaire-9 (PHQ-9), a 9-item self-report measure [38]. It assesses both affective and somatic symptoms related to depression and depressive disorders and corresponds to the diagnostic criteria for *DSM-5* Major Depressive Disorder. The PHQ-9 is summed to obtain a total score ranging from 0 to 27, with greater scores indicating greater depressive symptomatology. The PHQ-9 has been well-validated and demonstrated good sensitivity and specificity (88% for both) compared to a structured clinical interview [38]. In the current study, the PHQ-9 had good internal consistency (α = .87).

Anxiety symptom severity.—Anxiety symptom severity was assessed using the Generalized Anxiety Disorder Screener (GAD-7), a 7-item self-report measure [39]. The GAD-7 is summed to obtain a total score ranging from 0 to 21, with greater scores indicating greater anxiety symptoms. The GAD-7 has been well-validated and has demonstrated good sensitivity (89%) and specificity (82%) compared to a structured clinical interview [39]. In the current study, the GAD-7 demonstrated good internal consistency (α = .89).

Insomnia symptom severity.—Insomnia symptom severity was assessed using the Insomnia Severity Index (ISI), a 7-item self-report measure [40]. Each item uses a 4-point Likert type scale from 0 (e.g., very satisfied/not all worried/none) to 4 (e.g., very dissatisfied/very much worried/very severe), with higher scores indicating greater insomnia symptom severity. The ISI has acceptable internal consistency (α = .74) and has shown convergent validity with sleep diaries (range from .32-.91) and polysomnography [41]. In the current study, the ISI demonstrated good internal consistency (α = .86).

Perceived stress.—Perceived stress was assessed using the Perceived Stress Scale (PSS), a 10-item self-report questionnaire assessing the stress domains of unpredictability, lack of control, burden overload, and stressful life circumstances [42]. The measure is summed to obtain a total score ranging from 0 to 40, with greater scores indicating greater perceived stress. A score ≥ 27 indicates clinically significant stress (i.e., severe stress symptoms). The PSS has previously demonstrated good internal consistency, factor reliability, and hypothesis validity [42]. In the current study, the PSS demonstrated good internal consistency (α = .85).

Inflammatory biomarkers.—To assess inflammatory biomarkers IL-6 and CRP, serum blood was drawn by trained phlebotomists. All blood draws occurred between 7 AM and 12 PM to control for circadian rhythmicity of inflammation. Samples sat for 60 minutes to clot and then were centrifuged at 3000 rpms for 30 minutes and aliquoted into cryovials. Samples were temporarily frozen on dry ice and then frozen at −80°C until assaying. All

inflammation samples were assayed using high-sensitivity enzyme-linked immunosorbent assays from R&D Systems, Inc. (Minneapolis, MN) within 1 year after collection. The lower limit of detection (LLD) for CRP was 0.010 ng/ml and 0.039 pg/ml for IL-6. All IL-6 samples were within detectable limits, and for CRP, only one sample was outside of detectable limits, which was excluded from analyses. Intra-assay coefficients of variation were 1.60% for CRP and 3.26% for IL-6. Inter-assay coefficients of variation were 6.73% for CRP and 7.21% for IL-6.

Baseline demographic variables and recent night shift work.—Age, gender, race, and ethnicity were self-reported by nurses at baseline. Recent night shift work was determined through the 14 days of sleep diaries, where participants reported on their previous day's work schedule. If nurses reported working at least one shift between 9pm and 6am during the 14 days, they were classified as a recent night shift worker.

Data Analysis Plan

R code and data used for the current analyses is available in Electronic Supplementary Material 1 and 2. To account for misspecification bias [43,44], a three-step latent profile analysis (LPA) approach was taken in alignment with recommendations from Bolck, Croon, and Hagenaars [45], using the R package *tidyLPA* with MPlus automation [46]. First, latent class models were built from the four sleep variables (14-day mean scores of daily sleep diary-determined total sleep time, sleep efficiency, nightmare severity, and sleep quality). For each sleep variable, each participant's raw score was transformed into z-scores ([participant mean - sample mean]/sample standard deviation). One-through four-class models were analyzed based on prior research findings [15–17]. Second, participants were assigned to latent classes and classification information was retained. In terms of recommended fit indices, the optimal class solution had lower Akaike Information Criterion (AIC) values, Bayesian Information Criterion (BIC) values, and sample-size adjusted BIC values (SSABIC); significant Bootstrapped Likelihood Ratio Test (BLRT) p value; relatively higher entropy values; parsimony; and conceptual meaning [47,48]. A model with a 10-point lower BIC value has a 150:1 likelihood to be the better fitting model [49]. Third, after identifying the best-fitting class solution, we examined any potential differences across classes on demographic (age, gender, race, ethnicity), psychological (perceived stress and depression, anxiety, PTSD, and insomnia severity), and inflammatory biomarker levels (IL-6 and CRP) using chi-square analyses and one-way ANOVAs. Depression severity, anxiety severity, PTSD severity, insomnia severity, perceived stress, and levels of IL-6 and CRP were also used as correlates of class membership using multinomial logistic regression models.

Results

On average, nurses completed 13.07 (SD = 1.60) of 14 daily surveys, for an average compliance rate of 93%. The 14-day means of the four sleep indicator variables were relatively normally distributed: total sleep time (range: 275.64 to 553.44; skew: −0.25; kurtosis: 0.18); sleep efficiency (range: 65.29 to 98.76; skew: −1.41, kurtosis: 3.01); sleep

quality (range: 0.73 to 4.00; skew: −0.03, kurtosis: 0.12); and nightmare severity (range: 0 to 0.93; skew: 2.16, kurtosis: 5.58).

Table 2 indicates model fit indices for LPA results. Based on established guidelines, we selected the 3-class solution as optimal. According to AIC, BIC, and SABIC value guidelines, the 4-class solution would be the best-fitting model. However, we chose the 3-class solution as the optimal model based on subsequently declining BIC values, a relatively smaller difference in BIC values between the 3- and 4-class models, conceptual meaning, and class-based sample sizes (the 4-class solution had at least 1 class with <5% of the total sample) [47,48,50]. Further, entropy values indicated the 3-class model had the best fit, although values were similar for all models tested.

See Figure 2 for a graphical depiction of all examined class solutions. Notably, class descriptions are based on relative comparisons between sleep indicators. Sleep indicators are presented as z-scores, so they represent the number of standard deviations from the sample mean. The three classes from the optimal model included: 1) nurses reporting below average sleep duration, sleep efficiency, and sleep quality, but average levels of nightmare severity ("Poor Overall Sleep" class; 11.2% of the sample), 2) nurses reporting above average levels of nightmare severity, but average sleep duration, and slightly below average sleep efficiency and sleep quality ("Nightmares Only" class; 8.4% of the sample), and 3) nurses reporting below average levels of nightmare severity, average sleep duration, and slightly above average sleep efficiency and sleep quality ("Good Overall Sleep" class; 80.4% of the sample).

Chi-square analyses and one-way ANOVAs (Table 1) revealed nurses across classes were not different in terms of age, gender, or ethnicity. However, nurses in the Poor Overall Sleep class were more likely to identify as Black, less likely to identify as White, and more likely to be recent night shift workers compared to nurses in the Good Overall Sleep class. Nurses in the Poor Overall Sleep class also had lower sleep efficiency, shorter total sleep time, and lower sleep quality, as well as greater PTSD, depression, insomnia, and anxiety severity, greater perceived stress, and higher IL-6 compared to nurses in the Good Overall Sleep class. Compared to the Good Overall Sleep class, nurses in the Nightmares Only class were more likely to be recent night shift workers, and had lower sleep efficiency, lower sleep quality, and greater nightmare severity, as well as greater PTSD, depression, insomnia, and anxiety severity, and greater perceived stress. Lastly, compared to the Poor Overall Sleep class, nurses in the Nightmares Only class had higher sleep efficiency, longer total sleep time, and higher nightmare severity, but did not differ in terms of any psychological variables or levels of inflammation.

Multinomial logistic regression results (Table 3) revealed that every one-unit increase in anxiety severity was associated with a 27% increase in the odds of being in the Nightmares Only class compared to the Poor Overall Sleep class (OR = 1.27, $p = 0.040$), and a 18% decrease in the odds of being in the Poor Overall Sleep compared to the Good Overall Sleep class (OR = 0.82, $p = 0.037$). Every one-unit increase in IL-6 levels and every one-unit increase in insomnia symptom severity was associated with a 21% (OR = 1.21, $p = .022$) and a 33% (OR = 1.33, $p < .001$) increase in the odds of being in the Poor Overall Sleep class

compared to the Good Overall Sleep class, respectively. Every one-unit increase in insomnia symptom severity was associated with a 23% increase in the odds of being in the Nightmares Only class compared to the Good Overall Sleep class (OR = 1.23, $p < .001$).

Discussion

Nursing entails high-stakes decision-making, long work hours, high caseloads, emotional labor, and exposure to potentially dangerous and stressful situations, all of which may impair nurses' sleep. In this study, we used 14 days of repeated sleep diaries to characterize unique patterns of sleep among nurses. Sleep health profiles of nurses varied across several domains. Most nurses in our sample (80%) reported good overall sleep, characterized by sufficient sleep duration (7.3 hours), good sleep efficiency (92%), good sleep quality (scores of 2.71 out of 4), and low nightmare severity (scores of 0.05 out of 3). However, 11% of the sample reported poor overall sleep but average levels of nightmare severity (Poor Overall Sleep), and 8% reported above average levels of nightmare severity but otherwise better sleep than the Poor Overall Sleep group across all other sleep domains (Nightmares Only). The number of classes we found aligns with other studies, which have similarly observed three classes of sleep disturbances among nurses [15] and cancer patients [26,28].

In alignment with the *effort-recovery model* and *conservation of resources theory*, our results provide support for the idea that sleep disturbances may prevent adequate recovery from work or other stressful experiences, increasing risk for negative health consequences. We found different patterns of sleep and related health correlates among nurses, reiterating the importance of a multi-faceted approach to assessing sleep health [10]. Specifically, nurses with more severe and diverse sleep disturbances (e.g., lower quality, shorter duration, lower efficiency) had the worst psychological and physical health, including higher stress, higher PTSD, depression, anxiety, and insomnia severity, and higher IL-6. In multivariate models, greater insomnia severity and higher IL-6 were uniquely associated with increased odds of being in the Poor Overall Sleep class compared to the Good Overall Sleep class, although these effects were small. These findings support results from other studies showing that more diverse and severe sleep disturbances are associated with poorer health, including poorer self-rated health, greater depressive symptoms, secondary traumatic stress, and burnout, and higher levels of IL-6 [15,25,28,51]. Together, our results highlight that although most nurses may be resilient to sleep disturbances, those who do endorse poorer sleep report poorer health and well-being.

Poorer quality sleep, more fragmented sleep, and/or shorter sleep may directly impair health through alterations in autonomic nervous system (ANS) and hypothalamic-pituitary-adrenal axis (HPA) activity [52]. Alternatively, disturbed sleep, poorer mental health, and elevated levels of inflammation may all be caused by unmeasured third variables, such as substance use, stress, physical activity levels, type of coping strategies, and/or dietary patterns [53,54]. This cluster of symptoms may also reflect a partially overlapping phenotype with shared genetic components [26,27]. For example, sleep disturbances and mood and anxiety-related disorders are often all characterized by a heightened pro-inflammatory state [52,55]. Last, poorer mental health and elevated inflammation may cause short sleep, poor quality sleep, and sleep fragmentation via increases in arousal, rumination, and hyperactivation of the HPA

and ANS [56,57]. Future longitudinal and experimental studies are needed to untangle the directionality of these effects.

In terms of demographic differences in sleep disturbances, we found Black nurses were more likely to be in the Poor Overall Sleep class. Black nurses comprised only 7% of the total sample, but 23% of those in the Poor Overall Sleep class. These findings suggest a potential health disparity in self-reported sleep by race. Across several studies, Black adults have shorter self-report and actigraphy-determined sleep duration, lower sleep efficiency, and poorer sleep quality compared to White adults [58–60]. Despite similar professions, educational backgrounds, and income levels, compared to White nurses, Black nurses face greater interpersonal and institutional racism, discrimination, and racism-related vigilance which may negatively impact their sleep [61].

Recent night shift workers were also disproportionately represented in the Poor Overall Sleep (50%) and Nightmares Only (42%) classes compared to the Good Overall Sleep class (21%). Other studies have shown both insomnia symptoms and nightmares are more commonly reported by nurses working rotating night shift work schedules than nurses working day shifts only [62,63]. This may be attributed to circadian misalignment and sleep deprivation caused by night shift schedules [62].

Our results also indicate greater anxiety and insomnia severity may be unique characteristics of nurses experiencing nightmares. There is a high prevalence of nightmares in both insomnia and anxiety-related disorders such as PTSD [12,64,65]. Anxiety and insomnia may increase daytime arousal that carries over into sleep, leading to emotional distress and more fragmented sleep. As many as 35% of nurses report work-related nightmares, which may be triggered by performing end-of-life care, feeling overextended, caring for difficult patients, being assaulted or threatened, or treating open wounds or massive bleeding [13]. Nightmares often go unmeasured in sleep studies and are not a feature of most sleep-related treatments [11]. However, our findings highlight that measuring nightmares may have unique clinical utility for predicting adverse health beyond more commonly assessed sleep parameters, such as sleep duration, efficiency, and quality.

Somewhat surprisingly, in multivariate models, we found that higher anxiety was associated with higher odds of being in the Good Overall Sleep vs. Poor Overall Sleep class. However, these results should be interpreted cautiously, as univariate mean differences revealed an opposite effect: nurses in the Poor Overall Sleep class reported higher mean anxiety than nurses in the Good Overall Sleep class. Our multivariate findings tentatively suggest higher levels of anxiety may be somewhat protective for sleep. Other studies have observed a similar “healthy neuroticism” effect, whereby some degree of anxiety and worry, particularly when coupled with high conscientiousness, is associated with better health outcomes or behaviors [66,67]. Individuals with higher anxiety may devote more attention to maintaining and monitoring their health, proactively engaging in behaviors that promote good overall sleep (e.g., exercising regularly, not smoking) [66,67].

Limitations

Although this study has several strengths (e.g., 14 days of repeated sleep measures, large sample of nurses, subjective and objective health indices), there are some limitations warranting discussion. First, we had a relatively small sample size for two of our three classes (8% and 11% of the data). However, these classes still represent 31 and 43 people, respectively. It is also important to note that all LPA studies provide sample-specific profiles, and thus, it will be important to examine if these profiles replicate in other studies. Future work should incorporate more objective or behavioral indices of sleep to estimate latent profiles. Although there is good agreement between sleep diary and actigraphy measures of total sleep time among nurses, there is poorer agreement among other facets of sleep (e.g., sleep efficiency) [68]. Studies have shown that individuals who report insomnia symptoms and have objective short sleep duration are at greater risk for morbidity and mortality than individuals who only report insomnia symptoms with normal objective sleep duration [69]. It would also be informative for future studies to assess how different sleep symptoms are related to specific occupational stressors and experiences that we did not assess in the current study (e.g., job duties, seniority, field of specialization, work setting). We also only assessed sleep during the primary sleep interval. Future studies should examine the impact of naps and 24-hour sleep duration. Nurses may use naps to compensate for lost sleep during the primary sleep interval or between rotating shift transitions. Finally, we did not prohibit use of medications or substance use that may affect sleep patterns, which will be important to assess in future studies.

Conclusion

Nurses play a crucial role in maintaining a functioning healthcare system, and their health and well-being may impact patient care. We found that sleep patterns are heterogenous among nurses. Although most nurses in our sample reported good overall sleep, a substantial proportion reported relatively poorer overall sleep (below average sleep duration, efficiency, and quality) or higher nightmare severity. These two groups of nurses had greater impairment in mental and physical health than nurses reporting better sleep. Overall, our results highlight it may be important to screen for sleep health across multiple dimensions, as these different profiles may warrant different clinical approaches. Although future studies should replicate these results, it may be important to identify and support those nurses with more severe and diverse sleep disturbances to improve downstream health and occupational outcomes. Nursing is one of the fastest growing professions in the United States [29], so fostering nurses' well-being represents a critical occupational issue to address.

Statement Regarding Informed Consent: Informed consent was obtained from all individual participants included in the study.

Statement Regarding Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

This research supported by grant National Institutes of Allergy and Infectious Diseases R01AI128359-01 (PIs: Taylor & Kelly). We would like to thank all nurse participants and research assistants who contributed to this project.

References

1. Zverev YP, Misiri HE. Perceived effects of rotating shift work on nurses' sleep quality and duration. Malawi Med J J Med Assoc Malawi. 2009;21:19–21.
2. Adriaenssens J, de Gucht V, Maes S. The impact of traumatic events on emergency room nurses: Findings from a questionnaire survey. Int J Nurs Stud. 2012;49:1411–22. [PubMed: 22871313]
3. Chin W, Guo YL, Hung Y-J, Yang C-Y, Shiao JS-C. Short sleep duration is dose-dependently related to job strain and burnout in nurses: A cross sectional survey. Int J Nurs Stud. 2015;52:297–306. [PubMed: 25311378]
4. Lu L, Lok K-I, Zhang Q, Zhang L, Xiang Y, Ungvari GS, et al. Sleep disturbance and its association with quality of life among psychiatric nurses in China. PeerJ. 2021;9:e10659.
5. Gangwisch JE, Rexrode K, Forman JP, Mukamal K, Malaspina D, Feskanich D. Daytime sleepiness and risk of coronary heart disease and stroke: results from the Nurses' Health Study II. Sleep Med. 2014;15:782–8. [PubMed: 24841111]
6. Dorrian J, Tolley C, Lamond N, van den Heuvel C, Pincombe J, Rogers AE, et al. Sleep and errors in a group of Australian hospital nurses at work and during the commute. Appl Ergon. 2008;39:605–13. [PubMed: 18395183]
7. Gold DR, Rogacz S, Bock N, Tosteson TD, Baum TM, Speizer FE, et al. Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. Am J Public Health. 1992;82:1011–4. [PubMed: 1609900]
8. Meijman TF, Mulder G. Psychological aspects of workload. Handb Work Organ Work Psychol Vol 2 2nd Ed. Hove, England: Psychology Press/Erlbaum (UK) Taylor & Francis; 1998. p. 5–33.
9. Hobfoll SE. Conservation of resources. A new attempt at conceptualizing stress. Am Psychol. 1989;44:513–24. [PubMed: 2648906]
10. Buysse DJ. Sleep health: Can we define it? Does it matter? Sleep. 2014;37:9–17. [PubMed: 24470692]
11. Nadorff MR, Nadorff DK, Germain A. Nightmares: Under-Reported, Undetected, and Therefore Untreated. J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med. 2015;11:747–50.
12. Ohayon MM, Morselli PL, Guilleminault C. Prevalence of Nightmares and Their Relationship to Psychopathology and Daytime Functioning in Insomnia Subjects. Sleep. 1997;20:340–8. [PubMed: 9381055]
13. Mealer M, Burnham EL, Goode CJ, Rothbaum B, Moss M. The prevalence and impact of post traumatic stress disorder and burnout syndrome in nurses. Depress Anxiety. 2009;26:1118–26. [PubMed: 19918928]
14. Nylund-Gibson K, Choi AY. Ten frequently asked questions about latent class analysis. Transl Issues Psychol Sci. US: Educational Publishing Foundation; 2018;4:440–61.
15. Drake DA, Steege LMB. Interpretation of Hospital Nurse Fatigue Using Latent Profile Analysis. Adv Nurs Sci. 2016;39:E1–16.
16. Han K, Kim Y, Lee H, Lim S. Novice nurses' sleep disturbance trajectories within the first 2 years of work and actual turnover: A prospective longitudinal study. Int J Nurs Stud. 2020;112:103575–103575.
17. Jamali J, Roustaei N, Ayatollahi SMT, Sadeghi E. Factors affecting minor psychiatric disorder in southern Iranian nurses: A latent class regression analysis. Nurs Midwifery Stud. 2015;4:e28017.

18. Wang J, Zhang X, Yang B, Li J, Li Y, Chen Q, et al. Suicidal ideation among nurses: Unique and cumulative effects of different subtypes of sleep problems. J Affect Disord. 2020;276:600–7. [PubMed: 32871691]
19. Full KM, Moran K, Carlson J, Godbole S, Natarajan L, Hipp A, et al. Latent profile analysis of accelerometer-measured sleep, physical activity, and sedentary time and differences in health characteristics in adult women. PLOS ONE. Public Library of Science; 2019;14:e0218595.
20. Slavish DC, Taylor DJ, Lichstein KL. Intraindividual variability in sleep and comorbid medical and mental health conditions. Sleep. 2019;42.
21. Carney CE, Buysse DJ, Ancoli-Israel S, Edinger JD, Krystal AD, Lichstein KL, et al. The consensus sleep diary: standardizing prospective sleep self-monitoring. Sleep. 2012;35:287–302. [PubMed: 22294820]
22. Dietch JR, Sethi K, Slavish DC, Taylor DJ. Validity of two retrospective questionnaire versions of the Consensus Sleep Diary: the whole week and split week Self-Assessment of Sleep Surveys. Sleep Med. 2019;63:127–36. [PubMed: 31622954]
23. Aili K, Åström-Paulsson S, Stoetzer U, Svartengren M, Hillert L. Reliability of Actigraphy and Subjective Sleep Measurements in Adults: The Design of Sleep Assessments. J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med. 2017;13:39–47.
24. Wohlgemuth WK, Edinger JD, Fins AI, Sullivan RJ. How many nights are enough? The short-term stability of sleep parameters in elderly insomniacs and normal sleepers. Psychophysiology. 1999;36:233–44. [PubMed: 10194970]
25. Yu J, Mahendran R, Abdullah FNM, Kua E-H, Feng L. Self-reported sleep problems among the elderly: A latent class analysis. Psychiatry Res. 2017;258:415–20. [PubMed: 28867406]
26. Doong S-H, Dhruva A, Dunn LB, West C, Paul SM, Cooper BA, et al. Associations Between Cytokine Genes and a Symptom Cluster of Pain, Fatigue, Sleep Disturbance, and Depression in Patients Prior to Breast Cancer Surgery. Biol Res Nurs. SAGE Publications; 2015;17:237–47. [PubMed: 25304131]
27. Illi J, Miaskowski C, Cooper B, Levine JD, Dunn L, West C, et al. Association between pro- and anti-inflammatory cytokine genes and a symptom cluster of pain, fatigue, sleep disturbance, and depression. Cytokine. 2012;58:437–47. [PubMed: 22450224]
28. Ji Y-B, Bo C-L, Xue X-J, Weng E-M, Gao G-C, Dai B-B, et al. Association of Inflammatory Cytokines With the Symptom Cluster of Pain, Fatigue, Depression, and Sleep Disturbance in Chinese Patients With Cancer. J Pain Symptom Manage. 2017;54:843–52. [PubMed: 28797869]
29. Bureau of Labor Statistics. Occupational Outlook Handbook, Registered Nurses. 2018.
30. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42:377–81. [PubMed: 18929686]
31. Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O'Neal L, et al. The REDCap consortium: Building an international community of software platform partners. J Biomed Inform. 2019;95:103208.
32. Dietch JR, Taylor DJ. Evaluation of the Consensus Sleep Diary in a community sample: comparison with single-channel EEG, actigraphy, and retrospective questionnaire. J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med. 2021;
33. Williams JM, Taylor DJ, Slavish DC, Gardner CE, Zimmerman MR, Patel K, et al. Validity of Actigraphy in Young Adults With Insomnia. Behav Sleep Med. 2020;1–16. [PubMed: 30380915]
34. Lichstein KL, Stone KC, Donaldson J, Nau SD, Soeffing JP, Murray D, et al. Actigraphy validation with insomnia. Sleep. 2006;29:232–9. [PubMed: 16494091]
35. Weathers FW, Litz BT, Keane TM, Palmieri PA, Marx BP, Schnurr PP. The PTSD Checklist for DSM-5 (PCL-5). Scale available from the National Center for PTSD at www.ptsd.va.gov. 2013;
36. Bovin MJ, Marx BP, Weathers FW, Gallagher MW, Rodriguez P, Schnurr PP, et al. Psychometric properties of the PTSD checklist for diagnostic and statistical manual of mental disorders–fifth edition (PCL-5) in veterans. Psychol Assess. 2016;28:1379. [PubMed: 26653052]
37. Blevins CA, Weathers FW, Davis MT, Witte TK, Domino JL. The posttraumatic stress disorder checklist for DSM-5 (PCL-5): Development and initial psychometric evaluation. J Trauma Stress. 2015;28:489–98. [PubMed: 26606250]

38. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med. 2001;16:606–13. [PubMed: 11556941]
39. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A Brief Measure for Assessing Generalized Anxiety Disorder: The GAD-7. Arch Intern Med. American Medical Association; 2006;166:1092–7. [PubMed: 16717171]
40. Morin CM. Insomnia: Psychological assessment and management. New York: Guilford Press; 1993.
41. Bastien CH, Vallieres A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. Sleep Med. 2001;2:297–307. [PubMed: 11438246]
42. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983;24:385–96. [PubMed: 6668417]
43. Asparouhov T, Muthén B. Auxiliary Variables in Mixture Modeling: Three-Step Approaches Using Mplus. Struct Equ Model Multidiscip J. Routledge; 2014;21:329–41.
44. Vermunt JK. Latent Class Modeling with Covariates: Two Improved Three-Step Approaches. Polit Anal. [Oxford University Press, Society for Political Methodology]; 2010;18:450–69.
45. Bolck A, Croon M, Hagenaars J. Estimating Latent Structure Models with Categorical Variables: One-Step Versus Three-Step Estimators. Polit Anal. [Oxford University Press, Society for Political Methodology]; 2004;12:3–27.
46. Rosenberg JM, Beymer PN, Anderson DJ, Lissa C j van, Schmidt JA. tidyLPA: An R Package to Easily Carry Out Latent Profile Analysis (LPA) Using Open-Source or Commercial Software. J Open Source Softw. 2019;3:978.
47. DiStefano C, Kamphaus RW. Investigating Subtypes of Child Development: A Comparison of Cluster Analysis and Latent Class Cluster Analysis in Typology Creation. Educ Psychol Meas. SAGE Publications Inc; 2006;66:778–94.
48. Nylund KL, Asparouhov T, Muthén BO. Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study. Struct Equ Model Multidiscip J. Routledge; 2007;14:535–69.
49. Raftery AE. Bayesian Model Selection in Social Research. Sociol Methodol. [American Sociological Association, Wiley, Sage Publications, Inc.]; 1995;25:111–63.
50. Hipp JR, Bauer DJ. Local solutions in the estimation of growth mixture models. Psychol Methods. 2006;11:36–53. [PubMed: 16594766]
51. DeMartini KS, Fucito LM. Variations in Sleep Characteristics and Sleep-Related Impairment in At-Risk College Drinkers: A Latent Profile Analysis. Health Psychol Off J Div Health Psychol Am Psychol Assoc. 2014;33:1164–73.
52. Irwin MR. Why sleep is important for health: A psychoneuroimmunology perspective. Annu Rev Psychol. 2015;66:143–72. [PubMed: 25061767]
53. Loprinzi PD. Health Behavior Combinations and Their Association With Inflammation. Am J Health Promot AJHP. 2016;30:331–4. [PubMed: 27404641]
54. Okun ML, Reynolds CF, Buysse DJ, Monk TH, Mazumdar S, Begley A, et al. Sleep variability, health-related practices and inflammatory markers in a community dwelling sample of older adults. Psychosom Med. 2011;73:142–50. [PubMed: 21097658]
55. Michopoulos V, Powers A, Gillespie CF, Ressler KJ, Jovanovic T. Inflammation in Fear- and Anxiety-Based Disorders: PTSD, GAD, and Beyond. Neuropsychopharmacology. Nature Publishing Group; 2017;42:254–70. [PubMed: 27510423]
56. Bjurström MF, Olmstead R, Irwin MR. Reciprocal Relationship Between Sleep Macrostructure and Evening and Morning Cellular Inflammation in Rheumatoid Arthritis. Psychosom Med. 2017;79:24–33. [PubMed: 27428854]
57. Weinberger JF, Raison CL, Rye DB, Montague AR, Woolwine BJ, Felger JC, et al. Inhibition of tumor necrosis factor improves sleep continuity in patients with treatment resistant depression and high inflammation. Brain Behav Immun. 2015;47:193–200. [PubMed: 25529904]
58. Carnethon MR, De Chavez PJ, Zee PC, Kim K-YA, Liu K, Goldberger JJ, et al. Disparities in sleep characteristics by race/ethnicity in a population-based sample: Chicago Area Sleep Study. Sleep Med. 2016;18:50–5. [PubMed: 26459680]

59. Fuller-Rowell TE, Curtis DS, El-Sheikh M, Chae DH, Boylan JM, Ryff CD. Racial disparities in sleep: the role of neighborhood disadvantage. Sleep Med. 2016;27–28:1–8.
60. Fuller-Rowell TE, Nichols OI, Robinson AT, Boylan JM, Chae DH, El-Sheikh M. Racial disparities in sleep health between Black and White young adults: The role of neighborhood safety in childhood. Sleep Med. 2021;81:341–9. [PubMed: 33798979]
61. Hicken MT, Lee H, Ailshire J, Burgard SA, Williams DR. "Every shut eye, ain't sleep": The role of racism-related vigilance in racial/ethnic disparities in sleep difficulty. Race Soc Probl. 2013;5:100–12. [PubMed: 23894254]
62. Bjorvatn B, Magerøy N, Moen BE, Pallesen S, Waage S. Parasomnias are more frequent in shift workers than in day workers. Chronobiol Int. 2015;32:1352–8. [PubMed: 26540469]
63. Härmä M, Tenkanen L, Sjöblom T, Alikoski T, Heinsalmi P. Combined effects of shift work and life-style on the prevalence of insomnia, sleep deprivation and daytime sleepiness. Scand J Work Environ Health. Scandinavian Journal of Work, Environment & Health; 1998;24:300–7.
64. Leskin GA, Woodward SH, Young HE, Sheikh JI. Effects of comorbid diagnoses on sleep disturbance in PTSD. J Psychiatr Res. 2002;36:449–52. [PubMed: 12393315]
65. Park D, Kim S, Shin C, Suh S. Prevalence of and factors associated with nightmares in the elderly in a population based cohort study. Sleep Med. 2021;78:15–23. [PubMed: 33373930]
66. Graham EK, Weston SJ, Turiano NA, Aschwanden D, Booth T, Harrison F, et al. Is Healthy Neuroticism Associated with Health Behaviors? A Coordinated Integrative Data Analysis. Donnellan MB, Donnellan MB, editors. Collabra Psychol [Internet]. 2020 [cited 2021 May 10];6. Available from: 10.1525/collabra.266
67. Stieger M, Robinson SA, Bisson AN, Lachman ME. The relationship of personality and behavior change in a physical activity intervention: The role of conscientiousness and healthy neuroticism. Personal Individ Differ. 2020;166:110224.
68. Baek J, Han K, Choi-Kwon S. Sleep diary- and actigraphy-derived sleep parameters of 8-hour fast-rotating shift work nurses: A prospective descriptive study. Int J Nurs Stud. 2020;112:103719.
69. Fernandez-Mendoza J, Vgontzas AN, Liao D, Shaffer ML, Vela-Bueno A, Basta M, et al. Insomnia with objective short sleep duration and incident hypertension: The Penn State Cohort. Hypertension. 2012;60:929–35. [PubMed: 22892811]

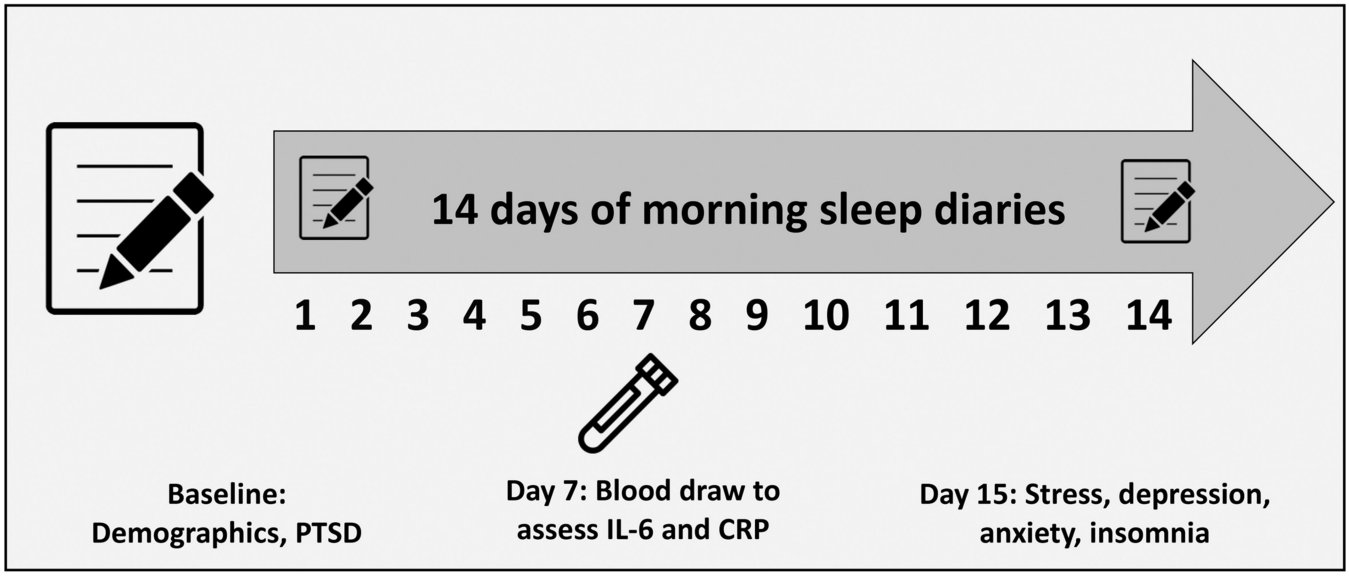

Figure 1.
Study Protocol Schematic
Note. PTSD: posttraumatic stress disorder, IL-6: interleukin-6, CRP: C-reactive protein.

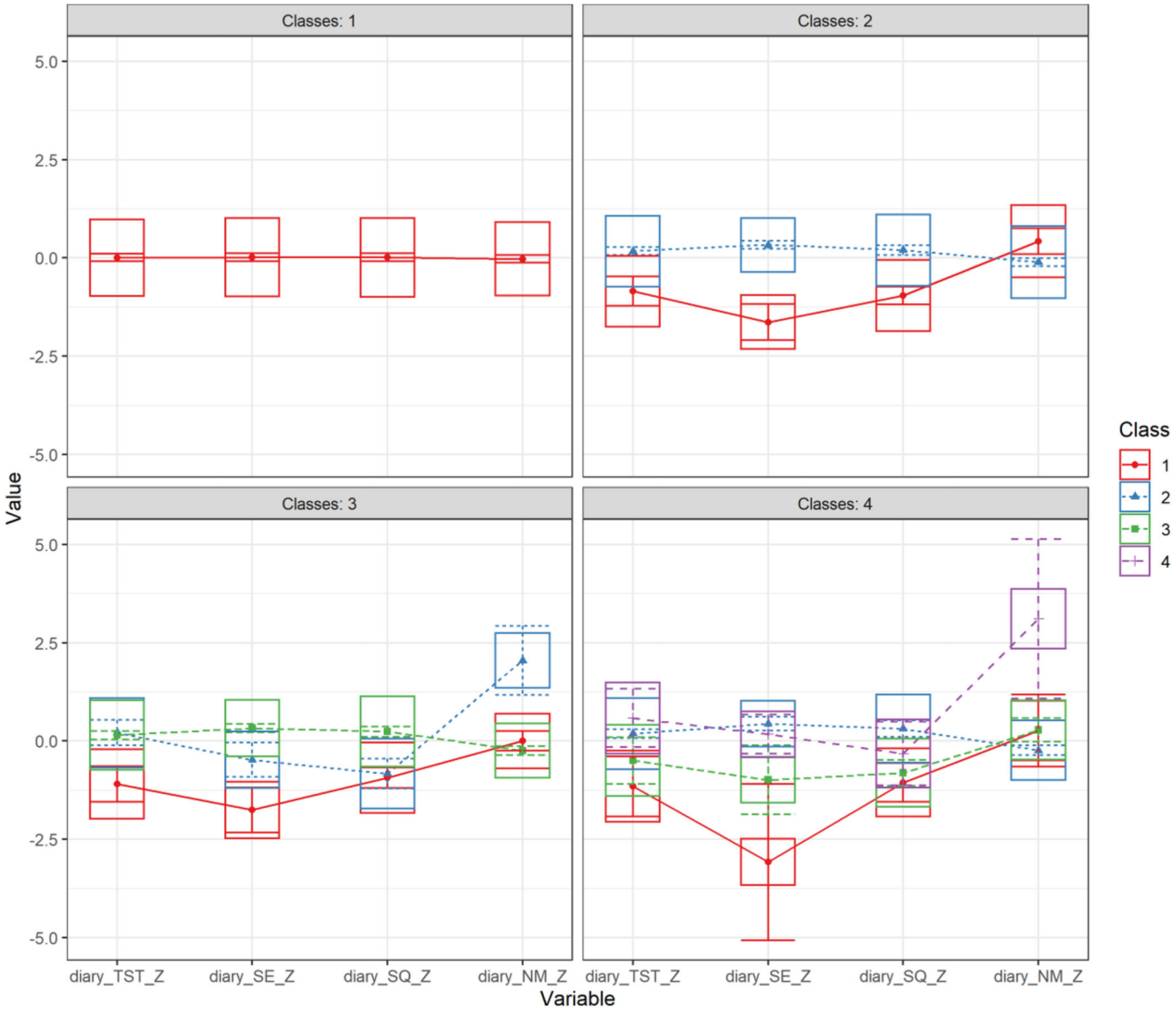

Figure 2.

One-, Two-, Three-, and Four-Class Latent Profile Solutions Using Means of Daily Sleep Indicator Variables

Note. diary_TST_Z = sleep diary total sleep time (i.e., sleep duration; z-score); diary_SE_Z = sleep diary sleep efficiency (z-score); diary_SQ_Z = sleep diary sleep quality (z-score); diary_NM_Z = sleep diary nightmare severity (z-score).The 3-class solution (bottom left figure) was chosen as the final, best-fitting model, where Class 1: Poor Overall Sleep (i.e., below average sleep duration; below average sleep efficiency, below average sleep quality, and average levels of nightmare severity); Class 2: Nightmares Only (i.e., average sleep duration; slightly below average sleep efficiency, slightly below average sleep quality, and above average levels of nightmare severity); Class 3: Good Overall Sleep (i.e., average sleep duration; slightly above average sleep efficiency, slightly above average sleep quality, and

slightly below average levels of nightmare severity). All values are z-scores (i.e., number of standard deviations away from the sample mean).

Table 1

Sample Demographics and Mean Differences by Class Membership

	Entire Sample	Class 1: Poor Overall Sleep	Class 2: Nightmares Only	Class 3: Good Overall Sleep	F(df), p-value, eta squared (η^2) or χ^2(df) and p-value	Significant post-hoc comparisons
n	392	44 (11.2%)	33 (8.4%)	315 (80.4%)		
Mean sleep efficiency (%)	91.04 (5.14)	81.55 (5.22)	88.33 (4.81)	92.65 (3.28)	184.6(2,389), $p < .001$, $\eta^2 = 0.49$	Class 2:1; 3:1; 3:2
Mean total sleep time (min.)	432.36 (48.54)	372.76 (45.08)	442.28 (41.99)	439.65 (43.75)	46.03(2,389), $p < .001$, $\eta^2 = 0.19$	Class 2:1; 3:1
Mean nightmare severity	0.10 (0.16)	0.09 (0.08)	0.46 (0.17)	0.05 (0.08)	186.2(2,217), $p < .001$, $\eta^2 = 0.63$	Class 2:1; 3:2
Mean sleep quality	2.58 (0.57)	2.01 (0.41)	2.07 (0.51)	2.71 (0.51)	56.2(2,389), $p < .001$, $\eta^2 = 0.22$	Class 3:1; 3:2
Age	39.54 (11.15)	41.43 (11.51)	36.30 (11.00)	39.63 (11.08)	2.02(2,386), $p < .135$, $\eta^2 = 0.49$	n/a
Gender (% female)	360 (91.8%)	40 (90.9%)	31 (93.9%)	289 (91.7%)	0.25(2, 392), $p = 0.883$	n/a
Race						
White	305 (77.8%)	27 (61.4%)	27 (81.8%)	251 (79.7%)	7.84(2, 392), $p = .020$	Class 3:1
Black	26 (6.6%)	10 (22.7%)	2 (6.1%)	14 (4.4%)	20.86(2,392), $p < .001$	Class 3:1
Native American	6 (1.5%)	1 (2.3%)	0 (0.0%)	5 (1.6%)	--	--
Asian	41 (10.5%)	5 (11.4%)	2 (6.1%)	34 (10.8%)	0.76(2,392), $p = .685$	n/a
Multiracial	7 (1.8%)	1 (2.3%)	2 (6.1%)	4 (1.3%)	--	--
Other	7 (1.8%)	0 (0.0%)	0 (0.0%)	7 (2.2%)	--	--
Ethnicity (% Hispanic/ Latinx)	42 (10.8%)	5 (11.4%)	5 (15.2%)	32 (10.3%)	0.76(2, 389), $p = 0.684$	n/a
Recent night shift worker	101 (25.8%)	22 (50.0%)	14 (42.4%)	65 (20.6%)	22.63(2, 392), $p < .001$	Class 3:1; 3:2
PTSD severity	19.07 (10.51)	24.21 (11.65)	24.97 (14.54)	17.73 (9.39)	13.87(2,388), $p < .001$, $\eta^2 = 0.07$	Class 3:1; 3:2
Depression severity	3.08 (3.70)	6.21 (4.62)	4.79 (3.85)	2.48 (3.25)	26.12(2,386), $p < .001$, $\eta^2 = 0.12$	Class 3:1; 3:2
Anxiety severity	2.72 (3.15)	3.93 (3.57)	4.59 (3.90)	2.36 (2.90)	11.32(2,385), $p < .001$, $\eta^2 = 0.06$	Class 3:1; 3:2
Insomnia severity	5.76 (4.51)	10.63 (4.63)	9.00 (3.86)	4.75 (3.93)	52.4(2,387), $p < .001$, $\eta^2 = 0.21$	Class 3:1; 3:2
Perceived stress	10.89 (6.32)	14.05 (6.27)	13.97 (7.24)	10.13 (6.01)	12.16(2,385), $p < .001$, $\eta^2 = 0.06$	Class 3:1; 3:2
IL-6 (pg/mL)	2.18 (2.15)	3.19 (3.49)	2.05 (1.53)	2.06 (1.93)	5.49(2,386), $p = .004$, $\eta^2 = 0.03$	Class 3:1
CRP (ng/mL)	30.57 (25.32)	31.54 (25.82)	30.15 (24.66)	30.48 (25.39)	0.04(2,387), $p = .962$, $\eta^2 = <0.01$	n/a

Note. Class 1: Poor Overall Sleep; Class 2: Nightmares Only; Class 3: Good Overall Sleep; PTSD = post-traumatic stress disorder; IL-6 = interleukin-6; CRP = C-reactive protein. All mean sleep variables represent daily values averaged across the 14 days for each person. Chi-square analyses were not examined for racial groups that constituted <5% of the total sample (i.e., Native American, Multiracial, Other).

Table 2

Model Fit Indices

Model	AIC	BIC	SABIC	Min. Prob.	Max. Prob.	Entropy	BLRT value	BLRT p-value
1 class	4388.63	4420.40	4395.02	1	1	1	n/a	n/a
2 classes	4218.74	4270.36	4229.12	0.87	0.98	0.86	179.89	<0.001
3 classes	**4153.87**	**4225.35**	**4168.24**	**0.84**	**0.97**	**0.88**	**74.87**	**<0.001**
4 classes	4122.82	4214.16	4141.19	0.79	0.96	0.87	41.04	<0.001

Note. Bold values indicate best model fit. SABIC: Sample size-adjusted Bayesian information criterion. AIC: Aikake information criterion; based on −2 log-likelihood, and penalized by number of parameters. BIC: Bayesian information criterion; based on −2 log-likelihood, and penalized by number of parameters adjusted by sample size. Entropy: A measure of classification uncertainty, reverse-coded so that 1 reflects complete certainty of classification, and 0 complete uncertainty. BLRT: bootstrap likelihood ratio test.

Table 3

Multinomial Logistic Regression Results of Associations between Health Variables and Class Membership

	Poor Overall Sleep* vs. Nightmares Only			**Poor Overall Sleep vs. Good Overall Sleep***			**Nightmares Only vs. Good Overall Sleep***		
Predictors	***Odds Ratio***	***CI***	***p***	***Odds Ratio***	***CI***	***p***	***Odds Ratio***	***CI***	***p***
(Intercept)	2.03	0.39 – 10.52	0.399	**0.01**	**0.00 – 0.03**	**<0.001**	**0.02**	**0.00 – 0.06**	**<0.001**
Depression severity	0.87	0.72 – 1.05	0.147	1.07	0.92 – 1.25	0.352	0.93	0.79 – 1.10	0.416
Anxiety severity	**1.27**	**1.01 – 1.60**	**0.040**	**0.82**	**0.68 – 0.99**	**0.037**	1.04	0.87 – 1.25	0.655
Insomnia severity	0.93	0.82 – 1.05	0.228	**1.33**	**1.19 – 1.47**	**<0.001**	**1.23**	**1.10 – 1.37**	**<0.001**
Perceived stress	0.98	0.88 – 1.10	0.790	1.04	0.95 – 1.13	0.420	1.02	0.93 – 1.12	0.654
PTSD severity	1.00	0.95 – 1.05	0.990	1.02	0.98 – 1.06	0.385	1.02	0.98 – 1.06	0.367
IL-6 (pg/mL)	0.82	0.63 – 1.05	0.113	**1.21**	**1.03 – 1.43**	**0.022**	0.99	0.78 – 1.25	0.927
CRP (ng/mL)	1.01	0.99 – 1.03	0.474	0.99	0.98 – 1.01	0.420	1.00	0.98 – 1.02	0.905
Observations	381			381			381		
R^2 Tjur	0.341			0.341			0.341		

Note.

*indicates the reference group. IL-6: interleukin-6; CRP: C-reactive protein. Bold values indicate statistically significant ($p < .05$) predictors.