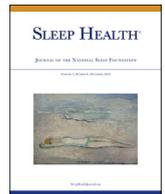


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Changes in sleep difficulties among the U.S. population from 2013 to 2017: results from the National Health Interview Survey

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ABSTRACT

Objectives: This study sought to evaluate how sleep difficulties have changed over time and to evaluate if these changes relate to changes in sleep duration.

Design: National Health Interview Survey administered annually from 2013 to 2017 by the National Center for Health Statistics.

Setting: U.S. national adult population.

Participants: 164,696 U.S. adults sampled across the nation using multistage area probability design.

Measurements: Self-reports of difficulties falling asleep, trouble staying asleep, use of sleep medication, feelings of restorative sleep, and sleep duration collected each year.

Results: From 2013 to 2017, the prevalence of reporting any days with difficulty falling asleep ($B = .01$, $p < .01$), trouble staying asleep ($B = .02$, $p < .001$), increased, yet waking feeling rested also increased ($B = .01$, $p = .004$), while average sleep duration decreased ($B = -.02$, $p < .001$). Moreover, changes in these sleep difficulties were independent of sleep duration and primarily occurred in healthy sleepers.

Conclusions: Multiple aspects of sleep difficulties show an undesirable trajectory in the U.S. adult population. Moreover, these trends appear to be independent of sleep duration and are primarily occurring in healthy sleepers. Future research should simultaneously consider how multiple aspects of sleep are changing and further examine the sources of these changes.

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Insufficient or disturbed sleep has been linked to a variety of adverse health, social, and economic consequences.^{1–3} Because of these significant repercussions of poor sleep, it is important to monitor any societal trends in sleep over time. In general, sleep duration seems to have decreased over the past three decades for both adolescents and adults^{4–6} (see the study by Basner and Dinges⁷ and the study by Knutson and Lauderdale⁸ for contrary findings which may be due to differences in measurement of sleep duration). Although such findings inform the understanding of societal trends in sleep health, sleep duration is just one aspect of sleep. To accurately understand the population's sleep health, it is important to consider other sleep characteristics, such as sleep quality or continuity. Indeed, a recent editorial in *Sleep* noted the multidimensional nature of sleep and the need for assessing whether aspects of sleep beyond sleep duration are changing in the general U.S. population over time.⁹ To

this end, this study uses data from the National Health Interview Survey (NHIS) to examine whether multiple characteristics of sleep health (difficulty falling asleep, trouble staying asleep, feeling unrested upon awakening, and sleep medication use) have changed from 2013 to 2017. We collectively refer to these indices as sleep difficulties for the sake of brevity. Moreover, we also assess whether sleep duration has continued to change over this time and whether these changes are occurring independently from other sleep health characteristics. Note that data from the NHIS has been used in prior studies examining changes in short sleep duration, insomnia, and excessive daytime sleepiness, finding that the all three seem to be on the rise over the past 20 years.^{4,6,10}

Recently, a multidimensional definition of sleep health has been proposed.¹¹ Specifically, sleep health is indicated by an individual's sleep duration (amount of sleep in a day), sleep continuity (ease of falling asleep and staying asleep), timing (placement of sleep within the day), alertness/sleepiness (ability to maintain attentive wakefulness), and sleep quality (subjective perceptions of whether sleep is good or bad). Within this definition of sleep health, the present study focuses on the duration, continuity, and subjective quality of sleep in a large nationally representative sample to more

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comprehensively examine trends in the sleep health of adults in the U.S. All three of these dimensions are linked to various health outcomes and have been linked to cardiovascular disease, diabetes, and mortality.¹¹ Although all of these characteristics of sleep are associated with similar health outcomes, some dimensions independently contribute to health outcomes^{12–15}. For instance, insufficient sleep duration is associated with increased odds of cardiovascular disease, but insufficient sleep duration in conjunction with poor sleep quality further increases the odds of cardiovascular disease.¹³ Sleep quality also seems to be more strongly tied to daily affect, well-being, and subjective health assessments than sleep duration and predicts these outcomes even after controlling sleep duration.¹⁵ Finally, in one study, the quality and continuity of sleep predicted mortality, whereas sleep duration did not predict when duration, continuity, timing, alertness, and quality of sleep were simultaneously used to predict mortality.¹⁶ In that study, the number of extreme sleep characteristics (e.g., insufficient sleep duration and very bad sleep quality) additively predicted mortality. Although the specific measures of sleep duration, continuity, and subjective quality vary across these studies, the findings collectively suggest that focusing on multiple dimensions of sleep health rather than one specific dimension (i.e., sleep duration) can improve the understanding of the influence of sleep on health outcomes.

So far, only one study has examined how aspects of sleep besides sleep duration have changed over time, finding that self-reported insomnia or trouble sleeping and excessive daytime sleepiness increased from 2002 to 2012.¹⁰ Combining this evidence with prior work suggests that trends in the sleep health of the U.S. may be more troubling than originally estimated because sleep duration is decreasing, whereas sleep difficulties and daytime sleepiness are simultaneously increasing. However, before arriving at such a conclusion, it is important to consider the overlap sleep duration and other characteristics of sleep; for instance, sleep duration may decline over time because sleep difficulties are increasing.

Sleep duration is dependent on other dimensions of sleep when the timing of sleep is held constant. For instance, a person who goes to bed around 11 pm and wakes up at 7 am would get eight hours of sleep assuming he or she fell asleep immediately upon getting into bed and did not wake up at all during the night. If the person experiences difficulty falling asleep or wakes up during the night, then sleep duration would necessarily decrease by one minute for each minute of sleep onset latency and wakefulness during the night. Any difficulty falling asleep and staying asleep would likely be reflected in perceptions of lower sleep quality.¹⁷ However, such a tight connection of sleep duration with other sleep characteristics is not always true. If someone falls asleep 30 minutes later than normal or stays awake for 30 minutes during the night, if conditions allow, they may be able to sleep in for 30 extra minutes to circumvent a potential loss in sleep duration. Alternatively, if a person knows they have difficulty falling asleep they could attempt to go to bed early to prevent any loss in sleep duration. Thus, minutes to fall asleep and to awake during the night can increase, whereas sleep duration remains the same. Overall, in order to better understand how the sleep characteristics of the U.S. population are changing and whether these changes are occurring uniquely from one another, it is necessary to consider and account for their interrelations.

It is also important to note that when sleep is measured by self-report, as is typical in prior population trend studies, a variety of self-report biases (e.g., negative reporting styles) may enhance the overlap between evaluative sleep reports.¹⁸ In the case of sleep, negative reporting styles would lead to reports of sleep duration partially mirroring reports of other sleep dimensions as some participants over-report negative events including short or poor sleep.

Altogether, the conceptual and methodological overlap makes it unclear whether self-reported sleep difficulties and self-reported sleep duration are both uniquely changing from each other. If such changes are occurring independently, this suggests that the sources of the change may also be independent and that efforts to improve sleep health may need to target each aspect separately. Alternatively, if changes in sleep difficulties are not occurring independently of sleep duration, there may be a common source of change, and intervention efforts may be able to hone in one particular aspect of sleep.

In brief, there is a lack of evidence regarding whether sleep characteristics beyond sleep duration have changed over time and whether such changes are occurring independently of sleep duration. To address this gap, this study had two key objectives. First, this study examined how difficulties falling asleep, problems staying asleep, sleep medication use, and subjective perceptions of restorative sleep have changed in the U.S. adult population from 2013 to 2017. Second, this study examined whether changes in these sleep characteristics were occurring independently of sleep duration.

Method

To examine these changes in sleep over time, cross-sectional data from the NHIS from 2013 to 2017 were used. The years 2013 to 2017 were selected because 2013 was when the questions of interest were first introduced into the survey and because 2017 is the most recent year of data released. The NHIS is conducted by the National Center for Health Statistics to track the health of the general U.S. population. To do so, the NHIS uses a multistage area probability design to draw a representative sample of noninstitutionalized U.S. citizens. Data are collected through a personal household interview conducted by trained U.S. Census Bureau employees and the annual response rate for the survey in the mid 2010s is approximately 70%, although the rates appear to be declining over time.¹⁹ Further details of sampling design can be found at <https://www.cdc.gov/nchs/nhis/methods.htm>. From 2013 to 2017, 164,696 participants completed the survey (34,557 in 2013, 36,697 in 2014, 33,672 in 2015, 33,028 in 2016, and 26,742 in 2017).

In the survey, participants answered several questions of interest related to sleep. Participants reported the number of times in the past week they (1) had trouble falling asleep, (2) had trouble staying asleep, (3) took sleep medication for sleep, and (4) woke up feeling rested. Response options ranged from zero times (0) to seven or more times (7) per week. These sleep items had excessive responses of zero and were highly skewed (20–80% reported 0 days). To simplify analyses and reporting of results, these variables were dichotomized into 0 (no days) and 1 (any days). Missing data on the sleep questions varied minimally from 2013 to 2017 (from 3 to 4%).

In addition, participants reported, on average, how many hours of sleep they get in a 24-hour period. Responses ranged from 1 to 24, but responses were capped at 4 on the lower end of the scale and 12 at the higher end of the scale to reduce the influence of outliers and erroneous answers.

Analytic strategy

Data were analyzed in MPLUS v6 using its complex survey feature to account for the stratification and clustering of participants.²⁰ In addition, the NHIS includes participant weights to allow for estimates that are representatives of the U.S. population. In addition to this weight, a second weight was created to apply direct age standardization to provide age-adjusted estimates based on a standardized population age distribution, in this case the Census Bureau's 2010 population. By doing so, the confound of differences in sample

Table 1

Sample correlations and descriptive statistics of sleep variables each year after weight adjustments

Year	Variable	1	2	3	4	% or M (SD)
2013	1. Difficulty falling asleep	–				41.07%
	2. Trouble staying asleep	.71*	–			42.51%
	3. Using sleep medication	.50*	.48*	–		25.76%
	4. Waking feeling rested	–.31*	–.35*	–.21*	–	70.72%
	5. Sleep duration	–.39*	–.32*	–.10*	.30*	7.09 (1.28)
2014	1. Difficulty falling asleep	–				40.56%
	2. Trouble staying asleep	.68*	–			42.50%
	3. Using sleep medication	.49*	.44*	–		25.44%
	4. Waking feeling rested	–.35*	–.39*	–.24*	–	72.17%
	5. Sleep duration	–.27*	–.31*	–.09*	.32*	7.10 (1.26)
2015	1. Difficulty falling asleep	–				41.70%
	2. Trouble staying asleep	.68*	–			43.76%
	3. Using sleep medication	.47*	.44*	–		25.84%
	4. Waking feeling rested	–.36*	–.42*	–.25*	–	71.59%
	5. Sleep duration	–.28*	–.32*	–.09*	.32*	7.07 (1.28)
2016	1. Difficulty falling asleep	–				41.85%
	2. Trouble staying asleep	.65*	–			43.76%
	3. Using sleep medication	.48*	.43*	–		25.85%
	4. Waking feeling rested	–.34*	–.41*	–.21*	–	71.59%
	5. Sleep duration	–.27*	–.30*	–.08*	.32*	7.05 (1.26)
2017	1. Difficulty falling asleep	–				41.85%
	2. Trouble staying asleep	.65*	–			44.38%
	3. Using sleep medication	.45*	.41*	–		26.33%
	4. Waking feeling rested	–.34*	–.38*	–.21*	–	71.71%
	5. Sleep duration	–.28*	–.30*	–.09*	.33*	7.04 (1.25)

Note. Numbers on top row refer to a variable of same number in the second column.
* $p < .05$. M = Mean, SD = Standard deviation.

age compositions can be removed when comparing results from this study with those from other studies which also use this standardized population age distribution. This second weight was created by using the Census Bureau's 2010 population age distribution and weighting each age group in accordance with its proportion within this projected age distribution. This second weight was multiplied with the first weight to provide each participant with a single-weighting score that allows for estimates which are nationally representative and that accounts for the different age distributions of the different survey years.

To first analyze overall trends in sleep from 2013 to 2017, all sleep characteristics were simultaneously regressed upon year of survey (recoded from 0 [2013] to 4 [2017]) to evaluate any linear trends in sleep over time. Logistic models were used to predict the prevalence of reporting any days of difficulty falling asleep, trouble staying asleep, sleep medication use, and waking feeling rested. Sleep duration was treated as a continuous outcome. Next, this analysis was repeated, but with sleep duration entered as a covariate instead to examine if trends in sleep difficulties were independent of sleep duration. Because a person's sleep duration would partially be influenced by any existing population trends in sleep duration, accounting for sleep duration should take into consideration these trends. Finally, further analyses examined whether trends in sleep difficulties occurred similarly in short (>7 hours, $n = 51,474$), healthy (between 7 and 9 hours, $n = 94,848$), and long sleepers (9+ hours, $n = 13,544$). All analyses controlled for age, gender, and whether the participant was of European American ethnicity or not (0 = European American, 1 = non-European American).

Results

The mean age of participants was 43.01 years in 2013 and the sample age exhibited a very small yet significant increase in age

Table 2

Changes in sleep from 2013 to 2017 across sleep groups

Age group	Short sleepers		Healthy sleepers		Long sleepers		All sleepers	
	I	II	I	II	I	II	I	II
Model								
Difficulty falling asleep	.01	.00	.02*	.02*	.01	.01	.01*	.01*
Trouble staying asleep	.00	.00	.02*	.02*	.02	.02	.02*	.01*
Using sleep medication	–.01	–.01	.00	.00	.00	.00	.00	.00
Waking feeling rested	.01*	.02*	.02*	.02*	.03 [†]	.02	.01*	.02*
Sleep duration	–	–	–	–	–	–	–.02*	–.02*

Note. Coefficients are unstandardized betas. Model one includes age, gender, and ethnicity as covariates. Model two includes age, gender, ethnicity, and sleep duration as covariates when predicting sleep difficulty variables and includes age, gender, ethnicity, and all sleep difficulty variables when predicting sleep duration.

* $p < .05$.† $p < .10$.

across survey years ($B = .08$, $p = .09$). Fifty-one percent of the sample was female and 36% was an ethnic minority in 2013. The gender composition remained stable over time ($p = .90$), whereas the composition of respondents with minority ethnicities slightly increased ($B = .006$, $p < .04$, approximately .02% each year).

Overall trends in the U.S. population

Correlations and descriptive statistics of sleep characteristics within each year are presented in Table 1. From 2013 to 2017, age-adjusted probability of reporting any days of difficulty falling asleep ($B = .01$, $p < .001$) and trouble staying asleep increased ($B = .02$, $p < .001$; see Table 2). These age-adjusted trends are plotted in Figure 1. This figure shows relatively steady increases in both of these sleep difficulties over time. Sleep medication use did not change over time ($p = .95$). Converging with the findings by Sheehan et al.,⁶ average sleep duration also decreased over this time period ($B = -.02$, $p < .001$). In contrast, waking feeling rested also increased over this time period ($B = .01$, $p = .004$). This effect, however, seemed largely due to an increase between 2013 and 2014 as prevalence of waking feeling rested was fairly stable from 2014 to 2017 (see Fig. 1). To examine if the overall trend for increases in waking feeling rested from 2013 to 2017 was driven by the substantial increase observed from 2013 to 2014, the time trends were re-examined after removing the year 2013 from analyses. Removing the 2013 survey year from the analysis revealed that the trend for feeling rested when waking disappeared, whereas the time trends for all other sleep characteristics remained the same, suggesting that waking feeling rested only increased from 2013 to 2014. Overall, there was a year-specific increase in the number of people feeling rested upon awakening during 2013, alongside broader and more consistent trends of more people experiencing sleep initiation and maintenance difficulties from 2013 to 2017.

Are trends in sleep duration and sleep difficulties occurring independently of each other?

Sleep duration exhibited small to moderate correlations with other aspects of sleep ($|r|s| \leq .39$, see Table 1), demonstrating the interdependence of sleep duration with sleep difficulties and the need to account for these interrelations. After adding sleep duration as a covariate, all trends in sleep difficulty items remained (see Table 2). In addition, sleep duration still significantly declined over time even after accounting for all sleep difficulties ($B = -.02$, $p < .001$). Thus, changes in sleep duration and sleep difficulties from 2013 to 2017 were occurring at least partially independent of each other.

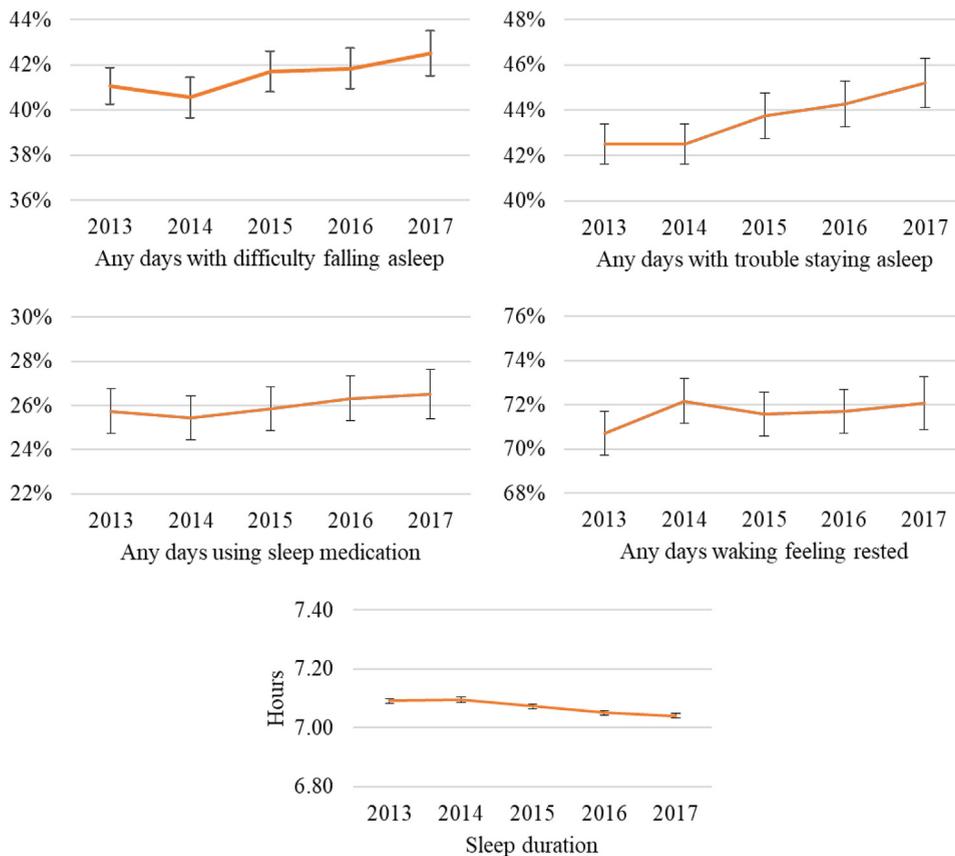


Fig. 1. Estimated sleep trends from 2013 to 2017 trends from age-adjusted models. Bars depict the standard error.

Are trends in sleep difficulties occurring within short, healthy, and long sleepers?

Next, subpopulation analyses were performed to determine if sleep difficulty trends were occurring equally across the short, healthy, and long sleepers. Short, healthy, and long sleepers all observed an increased probability of reporting restfulness upon awakening over time ($B = .01, p = .04$; $B = .02, p < .001$; and $B = .03, p = .06$, respectively; see Table 2). Only within healthy sleepers did the probability of reporting difficulty falling asleep ($B = .02, p < .001$) and trouble staying asleep ($B = .02, p < .001$) significantly increase over time, although all groups indicated an increase. Only the estimated time trend slopes for difficulties staying asleep between the short and healthy sleepers were significantly different from each other ($p = .009$). All other slope estimates of sleep difficulty time trends across sleep duration groups were not significantly different from each other (all p values $> .11$).

Discussion

These results are the first to show that not only does sleep duration appear to be decreasing in the U.S. adult population, as found by prior studies^{4–6}, but also the prevalence of adults reporting at least one day of difficulty falling asleep, staying asleep, and, ironically, waking feeling rested are also increasing. The findings regarding increase in trouble initiating and staying asleep mirror Ford and colleagues¹⁰ findings that report of insomnia in U.S. adults increased from 2002 to 2012. Difficulty falling asleep and maintaining sleep are integral components of insomnia and the findings of the present study point to more specific characteristics of sleep that may be changing over time. Paradoxically, waking feeling rested also increased

alongside difficulty falling asleep and staying asleep, although only during 2013. As depicted in Figure 1, difficulty falling asleep and trouble staying asleep both steadily increased over the survey years. In contrast, waking feeling rested appeared to only substantially increase from 2013 to 2014. When removing 2013 data from the analyses, the time trend in waking feeling rested disappeared, whereas all other trends in sleep remained. This sensitivity analysis suggests that the increase in the prevalence of restfulness was driven by fluctuations isolated from 2013 to 2014. It is unclear if findings regarding restfulness reflect a real fluctuation or random sampling error, so caution is warranted regarding the validity of this finding. Future analysis of the NHIS data when more data are collected is needed to reach firmer conclusions about long-term changes in feelings of restfulness.

These increases in difficulty falling asleep, staying asleep, and waking feeling rested were not accounted for by sleep duration, suggesting that changes in these sleep characteristics are occurring independently of self-reported sleep duration. On one hand, this is partially surprising given that problems falling asleep and trouble staying asleep are likely to result in reduced sleep duration. On the other hand, sleep is a multidimensional construct and characteristics such as time to fall asleep, awakenings during the night, and perceived sleep quality have been established as separate constructs with important and often independent implications for health.^{11,13,15,16} Indeed, sleep duration in this study only correlated with the sleep difficulty items between $-.09$ and $-.39$. Changes in sleep duration also remained significant even after accounting for sleep difficulties, revealing that some of the changes in sleep duration are occurring independently of sleep difficulties. Together, the independence of time trends in sleep difficulties from sleep duration in this study suggests that trends in problems initiating and maintaining sleep are not necessarily captured in prior studies finding decreases in sleep

duration over time.^{4–6} This evidence also suggests that intervention efforts might be more effective by targeting factors that influence the initiation and maintenance of sleep and the length of sleep. However, more research is certainly needed to tease apart how the simultaneous changes in sleep duration and other sleep characteristics are related. For instance, not all studies find significant decreases in sleep duration over time in the U.S. adult population, and findings may vary depending on how sleep is measured (e.g., time use survey vs. report of usual sleep duration).

Although sleep duration did not account for the temporal trends in sleep difficulty, the increasing prevalence of trouble falling asleep and staying asleep were most evident in people with healthy sleep. Thus, sleep difficulties got worse mainly in U.S. adults who had a healthy sleep length and less so in short or long sleepers who may already have existing sleep problems. The negligible time trends in the short and long sleepers may be because these populations are already experiencing sleep difficulties and changes in sleep that are occurring over time may not influence the sleep in individuals who already have sleep difficulties. In contrast, individuals with healthy sleep durations may be the least likely to currently be experiencing sleep difficulties and therefore be the most sensitive to developing sleep difficulties because they don't have any yet. Over time, these deleterious trends in sleep difficulties in healthy sleepers may manifest in the increased prevalence of unhealthy sleep among U.S. adults and implicate the need for preventative care as it is the healthy sleepers who are on an adverse sleep health trajectory.

A final issue to consider is whether the observed time trends are practically meaningful. Although the time trends reported here are statistically significant, the effects are small (B 's = .01 or .02). Admittedly, these small effects do demonstrate that sleep difficulties in the U.S. population only got slightly worse from 2013 to 2014. However, it is critical to consider the context in which these estimates apply.²¹ These time trend estimates are derived from a large sample designed to examine health characteristics in the U.S. adult population at large. In other words, these time trends ideally apply to how the average U.S. adults' sleep changed from 2013 to 2017. Based on the U.S. Census Bureau's 2010 population estimate, there are approximately 230 million adults in the U.S. Within these 230 million adults, the percentage of adults reporting difficulties falling asleep and difficulties staying asleep increased by 1.43% and 2.70%, respectively, from 2013 to 2017. Applying these changes to the U.S. population reveals that approximately 3 million and 6 million more adults reported difficulties falling asleep and difficulties staying asleep from 2013 to 2017, respectively. In turn, considering that deteriorations in sleep carry important health and economic costs, deteriorations in the sleep of millions of people can have further repercussions for economics and public health.³ Thus, although the magnitude of the time trends observed in this study appears small, considering the number of people they invoke demonstrates that such effects can have widespread and important implications.

Study Limitations

Study findings have several notable limitations. First, sleep characteristics were self-reported and self-reports of sleep have limited convergence with polysomnographic measures of sleep.²² The subjective nature of these reports may bias the estimates of sleep trends and create artificial links between the measures. For instance, trends in both increases in difficulty falling asleep and staying asleep may reflect a general tendency to report insomnia symptoms or experience sleep state misperception. Along these lines, because the reports are subjective, they could be biased by other perceptual influences, such as an increasing awareness of sleep and sleep problems. Perhaps, owing to increased awareness of the importance of sleep over

time, people have become more aware of or sensitive to sleep problems.

The self-reported nature of the sleep items has a second notable limitation. Prior studies examining changes in sleep duration found varying results, potentially because of differences in how sleep is measured across studies. Studies using self-reports of daily-time use have found no changes or increases in average sleep duration of the U.S. population, whereas studies utilizing estimates of typical sleep duration have found increases in the prevalence of short sleep.^{5–8,23} Such inconsistencies across mode of measurement may also apply to other dimensions of sleep, and attempts should be made to replicate the findings of the present study with other measurement formats to increase the confidence in the existence of these trends.

Finally, the observed trends in sleep may be specific – 2013 to 2017 and may not generalize to before or after this time period. Perhaps the deteriorations in sleep are specific – 2013 to 2017 and a larger timeframe may actually reveal overall improvements in sleep. Unfortunately, this possibility cannot be assessed as the sleep difficulty items only began to be included in the NHIS in 2013. Hopefully, the NHIS will continue to keep the sleep difficulty items in its annual survey, and future studies can continue examining the U.S. population trends on multiple dimensions of sleep to examine whether these trends continue. However, considering the health and economic implications of poor sleep and that findings from this study and others support deteriorations in sleep in the U.S. adult population, it is wise to address such changes before they are pronounced more.^{3–6,10} In other words, an ounce of prevention may be worth a pound of cure. Furthermore, if more years of data are included, more sophisticated modeling strategies can be applied to the data. For instance, age-period-cohort models could be used to tease apart how sleep is changing because of trends over time, biological changes over age, and factors associated with belonging to a particular cohort.²⁴ Only one prior study has attempted to separate out these influences, so using such models could make valuable contributions to the understanding of how sleep changes over time.⁵

Conclusion

In summary, the prevalence of sleep difficulties has slightly increased in recent years, paralleling decreases in sleep duration. These trends in sleep difficulties and sleep duration appear to be independent of one another and both warrant attention in future research. Moreover, increases in difficulty initiating and maintaining seem to be only occurring in healthy sleepers, implicating this population as the most at risk for developing worse sleep over time and the potential need to prevent deterioration of their sleep. Overall, study findings suggest that sleep difficulties in addition to sleep duration are on an undesirable trajectory within U.S. adults and future population-level interventions and research should target and consider these multiple characteristics of sleep.

Conflict of interest

All authors declare that they have no conflict of interest.

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