

Sweet dreams, bright futures: the relationship between sleep duration and health, income and education

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Abstract

Purpose To examine the relationship between sleep duration and health, income, and education.

Methods Sleep, demographic, income, education and wellness data from 49,365 participants aged 18 years and older were sourced from the 2017 Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a cross-sectional telephone survey conducted by state health departments with technical and methodological assistance provided by the Centers for Disease Control and Prevention. Self-reported sleep duration was assessed as well as self-perceptions of health and wellness.

Results Individuals with average daily sleep durations between 7 and 9 h reported significantly better physical and mental wellness as compared to those who reported fewer than 7 h or more than 9 h of sleep per day ($p < 0.001$). Similarly, individuals reporting adequate sleep duration of 7–9 h per day also reported the highest self-ratings of overall health and life satisfaction ($p < 0.001$), the highest levels of income, and the greatest percentage of 4-year college degrees of the three sleep duration groups.

Conclusion This study suggests that adequate sleep is associated with better health, higher income, and higher education. Whether adequate sleep resulted in, or was a result of, better health, higher income and higher education, a relationship between them is clear.

Keywords Sleep · Wellness · Life satisfaction · Health · Well-being · Quality of life · BRFSS

1 Background

A growing body of literature has revealed a connection between sleep duration and various health issues. Studies have linked inadequate sleep to conditions such as metabolic syndrome [1, 2], myocardial infarction [3, 4], stroke [5], chronic renal disease [6], obesity [7], depression [8, 9] and even susceptibility to the common cold [10]. Research indicates that sleep duration plays a vital role in the longitudinal relationship with disease and mortality, as evidenced by recent findings on objectively measured sleep duration and health outcomes [11–13].

Furthermore, research has explored the correlation between sleep and educational attainment [13], academic performance [8, 14, 15], and socioeconomic status [16, 17]. As early as 1974, Finkelstein highlighted the crucial role of brain stem-hypothalamic-pituitary axis activity during sleep in growth and development, validating the belief that adequate sleep contributes to overall well-being [18]. Numerous medical societies, including the American Academy of Sleep

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Medicine, American Heart Association, American Thoracic Society, and Sleep Research Society, have issued statements advocating for 7–9 h of sleep per night as the recommended duration for most adults to promote optimal health [19–21].

Two studies have investigated the impact of sleep timing on health, wealth, and education. Gale conducted a 23-year study involving adults aged 65 or older and found no significant differences in health outcomes, income, or cognitive abilities between "larks" (early risers) and "owls" (night owls) [22]. Similarly, Mukamal followed a group of men who had been hospitalized for acute myocardial infarction and found no associations between sleep and educational attainment, income, or mortality [23].

However, there is currently a lack of research specifically evaluating the recommended sleep duration in relation to health outcomes, income and education within a representative adult population. Therefore, the following study aims to investigate the association between the recommended 7–9 h of sleep and outcomes related to health, income, and education, using a representative sample of adults aged 18–60 in the United States.

2 Methods

Publicly available de-identified data from the 2017 Behavioral Risk Factor Surveillance System (BRFSS) survey was used to examine the relationship between sleep duration and health, income, and education. The BRFSS is a state-based initiative assisted by the Centers for Disease Control and Prevention (CDC) and is the largest continuously conducted survey of health risk behaviors, clinical preventive services, and health care access in the United States. Each year the core survey is augmented with various optional modules (e.g., caregiving, cognitive decline, and firearm safety) as well as state-added questions. The 2017 survey was selected for this study as it was the most recent to include questions regarding sleep as well as physical activity.

Data collection is accomplished monthly by both landline and cellular telephones in all fifty states, the District of Columbia, Guam and Puerto Rico [24]. The survey methodology is designed to provide nationally representative estimates of the non-institutionalized US population. In 2017, the median response rate for the BRFSS was 45.3% among landline telephones and 44.5% among cellular telephones. Despite low response rates, data suggest that weighting of demographic characteristics ensures the veracity of estimates for most measures [25].

The BRFSS utilizes a disproportionate stratified random sampling design, with accompanying weights to ensure that the survey sample is representative of each state's adult aged individuals [24]. The methodological approach minimizes nonresponse bias and error within estimates. Respondents are weighted by age, gender, race/ethnicity, education, marital status, property ownership and telephone ownership [25]. Due to restrictions in survey eligibility, only participants 18 years and older were included in the analysis. Additionally, only those who responded to the question, "On average, how many hours of sleep do you get in a 24-h period?" were retained for analysis. This led to a sample size of 49,365 after the exclusion of 399,171 individuals who did not meet the inclusion criteria. Retained participants were categorized based on self-reported sleep duration into 1 of 3 categories: < 7 h/day, 7–9 h/day or > 9 h/day [26].

The overall wellness of participants was assessed using the CDC's core Healthy Days measures [27]. These are a series of questions, where "Healthy Days" are the number of days in the past 30 days when both physical and mental health were self-rated as "good." These questions are included in the BRFSS and thus provide a way of measuring health. Principal component analysis was used to assess the underlying structure of the Healthy Day measures and compute a composite score for overall health [28]. All items had component loadings over 0.7. Additionally, participants were asked about general life satisfaction and the number of days that poor health limited usual activities. Although not included in the health composite score, these measures are also presented in our results.

Socio-demographic characteristics of interest included age at the time of the survey, gender, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other non-Hispanic including multiracial), marital status (married or member of an unmarried couple; divorced, widowed, or separated; or never married), education level (did not graduate high school, graduated high school or attained a general education development certificate of high school equivalency (GED); some college or technical school or graduated from college or technical school), and annual income (less than \$20,000, \$20,000–\$50,000 or greater than \$50,000). Pooling of demographic categories was conducted.

Variances were estimated with Taylor series linearization [29]. Summary statistics are provided for categorical variables and include the number of participants as well as the weighted prevalence within each category. Weighted prevalence estimates are reported as percentages with 95% Wald confidence intervals (95% CI) [30]. Rao–Scott adjusted chi-square statistics were used for domain analyses [31]. The Pearson correlation coefficient was used to assess the relationship between age and the number of hours spent sleeping per day [32]. Odds ratios (ORs) and adjusted odds ratios (aORs) with

95% CIs were estimated using multivariable logistic regression models [33]. Participant age was included as a covariate in the regression models to assess the relationship between sleep duration and variables of interest. Statistical significance was based on a significance level of $p < 0.05$ threshold for statistical tests. Analyses were conducted using the complex sample package for SPSS 25 (IBM, Armonk, NY, USA).

This study uses publicly available data from the CDC BRFSS. The Womack Army Medical Center, Human Resources Protection Office acknowledges that analysis of deidentified and publicly available data does not constitute human subjects research as defined in federal regulations, and thus this study did not require IRB review.

3 Results

This study analyzed data from 49,365 participants, representing an estimated 17 million individuals in the non-institutionalized US population. On average, participants reported sleeping 7.0 h per day. The low sleep group (< 7 h/day) had an average sleep duration of 5.6 h per day. The recommended sleep group (7–9 h/day) and high sleep group (> 9 h/day) reported average sleep durations of 7.6 h/day and 10.9 h/day, respectively.

Table 1 displays the characteristics of the participants revealing differences related to sleep duration. Overall, women reported slightly more sleep per day compared to men. Sleep duration also varied with age and race/ethnicity, and except for non-Hispanic blacks, most participants reported sleeping within the recommended 7–9 h per day. However, non-Hispanic blacks were significantly more likely to report sleeping less than the recommended amount.

Regardless of age, an individual's relationship status was found to be associated with their daily sleep duration ($p < 0.001$). Divorced, separated, or widowed individuals were more likely to report sleeping fewer than 7 h per day or more than 9 h per day compared to those who were married or living with a romantic partner. There was no difference

Table 1 Demographic characteristics by daily sleep duration

	< 7 h/day		7–9 h/day		> 9 h/day		P^a
	N	Weighted estimate (95% CI)	N	Weighted estimate (95% CI)	N	Weighted estimate (95% CI)	
<i>Gender^b</i>							
Male	7,062	50.0 (48.7–51.3)	14,415	47.8 (46.9–48.7)	725	45.8 (41.7–49.9)	0.01
Female	8,117	50.0 (48.7–51.3)	18,046	52.2 (51.3–53.1)	958	54.2 (50.0–58.3)	
<i>Age^b</i>							
18–29	1,667	19.7 (18.5–20.9)	3,044	18.1 (17.3–19.0)	149	20.2 (16.6–24.2)	< 0.001
30–39	2,106	19.7 (18.6–20.8)	3,394	16.3 (15.6–17.1)	118	12.2 (9.5–15.5)	
40–49	2,182	16.3 (15.4–17.3)	3,767	14.3 (13.7–15.0)	141	10.7 (8.4–13.3)	
50–59	3,265	19.2 (18.3–20.2)	5,642	16.8 (16.2–17.5)	257	15.0 (12.3–18.7)	
60+	5,783	25.1 (24.1–26.0)	16,181	34.4 (33.6–35.1)	1,004	41.9 (38.1–45.8)	
<i>Race/ethnicity</i>							
White, Non-Hispanic	11,441	68.7 (67.5–70.0)	26,836	75.0 (74.2–75.9)	1,263	67.3 (63.0–71.2)	< 0.001
Black, Non-Hispanic	1,486	10.0 (9.1–10.9)	1,783	5.9 (5.4–6.4)	167	11.5 (8.7–15.0)	
Hispanic	1,200	12.9 (12.0–13.8)	2,106	12.6 (12.0–13.3)	136	14.5 (11.7–18.0)	
Other, including Multiracial	1,076	8.3 (7.6–9.2)	1,754	6.5 (6.0–7.0)	117	6.7 (5.2–8.7)	
<i>Marital status^b</i>							
Married or member of unmarried couple	7,701	52.5 (51.3–53.8)	19,102	59.7 (58.8–60.6)	684	44.8 (40.7–48.9)	< 0.001
Divorced, widowed, or separated	4,421	23.1 (22.1–24.1)	8,159	19.4 (18.7–20.0)	671	29.7 (26.5–33.2)	
Never married	2,963	24.3 (23.2–25.5)	5,000	20.9 (20.2–21.8)	314	25.6 (21.8–29.5)	
<i>Veteran</i>							
Yes	1,993	11.6 (10.8–12.4)	4,335	11.4 (10.9–12.0)	285	12.2 (10.2–14.5)	0.78
No	13,191	88.4 (87.6–89.2)	28,110	88.6 (88.0–89.1)	1,395	87.8 (85.5–89.8)	

^aSignificance based on Rao–Scott chi square test

^bDomain does not sum to 49,365 due to non-response

between individuals who reported never being married and married in terms of sleeping fewer than 7 h per day. However, the never-married group was nearly twice as likely as married individuals to sleep more than 9 h per day.

As depicted in Table 2, individuals who reported an average daily sleep duration of 7 to 9 h exhibited better overall health compared to those who slept fewer than 7 h or more than 9 h per day ($p < 0.001$). Among those with a sleep duration of 7–9 h, approximately one third (32.8%) were in the top quartile of the general health composite score. In contrast, only 19.5% of those sleeping fewer than 7 h and 8.7% of those sleeping more than 9 h reached the top quartile. Furthermore, individuals reporting 7–9 h of sleep were 2.2 times more likely to score above the 50th percentile in the overall health composite score compared to those reporting fewer than 7 h and nearly 4 times more likely compared to individuals reporting more than 9 h.

Unsurprisingly, the number of days participants reported poor health impacting their usual activities corresponded to their overall health scores (Fig. 1). Those sleeping 7–9 h per day reported the fewest sick days, while those sleeping more than 9 h per day reported the highest number of sick days, with over half of the previous 30 days affected by poor health. Similarly, when asked about overall life satisfaction, the majority (53.3%) of individuals sleeping 7–9 h per day reported being very satisfied ($p < 0.001$). Among those dissatisfied or very dissatisfied with life, the highest proportion (12.2%) was found among participants sleeping more than 9 h per day.

In addition to better health and life satisfaction, those reporting 7–9 h of sleep per day also had the highest income among the three groups ($p < 0.001$). More than half of these individuals (51.9%) reported earning more than \$50,000 per year. On the other hand, participants sleeping more than 9 h per day had the lowest income, with almost a third (32.3%) earning less than \$20,000 annually. After adjusting for age, the group sleeping more than 9 h was five times more likely than the recommended sleep group (7–9 h per day) to earn less than \$20,000 per year. In contrast, those reporting fewer

Table 2 Health, income, and educational distributions by sleep duration

	< 7 h/day		7–9 h/day		> 9 h/day		P^a
	N	Weighted estimate (95% CI)	N	Weighted estimate (95% CI)	N	Weighted estimate (95% CI)	
<i>General health quartile^b</i>							
Q4	666	19.5 (17.4–21.8)	1,439	32.8 (30.7–35.0)	48	8.7 (5.4–13.8)	< 0.001
Q3	748	22.6 (20.4–25.0)	1,098	27.0 (25.0–29.1)	70	17.3 (11.8–24.8)	
Q2	964	26.3 (24.1–28.6)	1,063	23.3 (21.5–25.3)	132	31.4 (24.0–39.9)	
Q1	1,110	31.6 (29.3–34.0)	762	16.9 (15.2–18.6)	205	42.5 (35.3–50.0)	
<i>No. of days poor health limited usual activities^{b,c}</i>							
0	4,530	50.5 (48.9–52.2)	8,940	59.7 (58.5–61.0)	426	39.1 (34.3–44.2)	< 0.001
1–10	2,431	28.5 (27.1–30.1)	4,276	28.6 (27.4–29.7)	264	29.7 (25.1–34.6)	
11–20	792	9.1 (8.2–10.2)	877	5.6 (5.0–6.2)	147	12.9 (10.2–16.1)	
21–30	1,065	11.8 (10.8–12.8)	1,009	6.1 (5.5–6.7)	218	18.3 (15.2–21.9)	
<i>General life satisfaction^b</i>							
Very satisfied	1,663	41.1 (39.2–43.1)	5,529	53.3 (52.0–54.6)	156	36.3 (30.4–42.5)	< 0.001
Satisfied	2,123	51.9 (49.8–53.8)	4,228	43.8 (42.5–45.0)	209	51.5 (44.9–58.1)	
Dissatisfied or very dissatisfied	310	7.0 (6.1–8.1)	291	2.9 (2.5–3.4)	42	12.2 (7.9–18.3)	
<i>Annual income^b</i>							
Less than \$20,000	2,291	18.5 (17.4–19.6)	3,389	14.3 (13.6–15.0)	418	32.3 (28.1–36.9)	< 0.001
\$20,000 to \$50,000	4,484	36.1 (34.8–37.4)	9,042	33.9 (32.9–34.8)	584	45.2 (40.6–50.0)	
More than \$50,000	6,254	45.4 (44.1–46.8)	15,136	51.9 (50.9–52.8)	350	22.5 (19.0–26.3)	
<i>Education level^b</i>							
Less than high school	980	12.2 (11.2–13.2)	1,626	11.2 (10.5–11.9)	214	25.2 (21.2–29.7)	< 0.001
High school or GED	4,061	29.1 (27.9–30.3)	7,577	26.4 (25.6–27.2)	583	33.9 (30.4–37.7)	
Some college or technical school	4,960	36.2 (35.0–37.5)	9,409	32.7 (31.9–33.6)	487	28.5 (25.0–32.2)	
College graduate	5,149	22.5 (21.6–23.4)	13,774	29.6 (28.9–30.3)	392	12.4 (10.5–14.6)	

^bDomain does not sum to 49,365 due to non-response

^cSurvey question referred to the prior 30 days

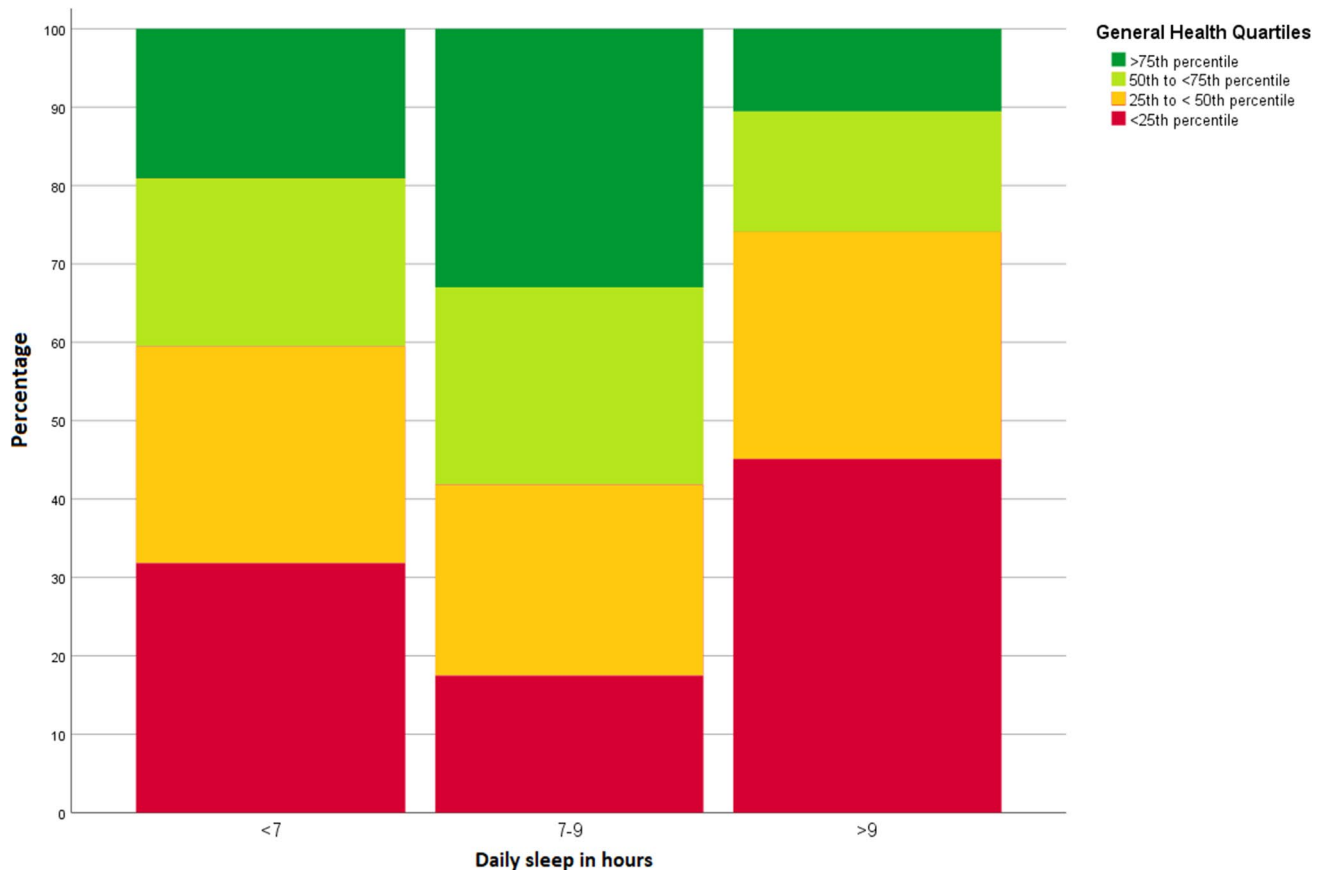


Fig. 1 General health by sleep category

than 7 h of sleep per day were only 1.5 times more likely than the recommended sleep group to earn less than \$20,000 per year.

An examination of participants' educational achievements revealed similar patterns as health and income. Individuals who reported sleeping 7–9 h per day had the highest proportion of four-year college graduates (29.6%). In contrast, those who reported sleeping fewer than 7 h or more than 9 h per day had significantly higher rates of having no more than a high school education or a GED (both $p < 0.05$). Moreover, the group sleeping more than 9 h per day had the highest rates of both less than a high school level of education and claiming only a high school education or GED (both $p < 0.05$).

4 Discussion

To the best of our knowledge, this study represents the first attempt to specifically assess the relationship between the optimal sleep duration of 7–9 h and indicators of "health, wealth, and wisdom" in a population of average-aged adults. Our findings indicate that adults who adhered to the recommended 7–9 h of sleep exhibited significantly better health and life satisfaction, higher incomes, and higher educational achievements compared to those who slept more or less. Conversely, individuals reporting more than 9 h of sleep expressed significant dissatisfaction with life, experienced poorer overall health, lower income levels, lower educational attainment, and reported a higher number of sick days in the previous 30 days. Therefore, a U-shaped association between reported sleep duration and markers of poor "health, wealth, and wisdom" was evident. These findings may also shed light on the possible existence of a U-shaped association between sleep duration and all-cause mortality [34].

The American Heart Association has extensively documented the health benefits of optimal sleep, particularly in relation to cardiometabolic risk factors such as obesity, hypertension, type 2 diabetes, and cardiovascular disease [19]. They recommend 7–9 h of sleep as a preventive measure against these risks. Furthermore, they advocate for routine screening of sleep duration and sleep disorders in both clinical and public health settings [19]. Optimal sleep has also been linked to

improved mental health [11]. Sleep plays a critical role in brain homeostasis, affecting emotional and social functioning, which aligns well with the data presented here, as individuals outside the optimal sleep range reported higher levels of dissatisfaction with their health. Individuals with depression often report comorbid insomnia, which likely contributes to insufficient sleep, placing them in the category of those sleeping less than 7 h per day [35]. Future studies on this topic could consider evaluating both sleep opportunity and total sleep obtained to determine the presence of insomnia or other sleep disorders. Assessing medical comorbidities and current medications would also be beneficial, as they may influence total sleep.

The relationship between optimal sleep duration and its impact on wealth and wisdom (educational achievement) is not as extensively described. One study found that it was not sleep duration but rather the practice of "early to bed, early to rise" that correlated with improved academic performance in college students [36]. Conversely, while overall improvements in academic achievement have not been consistently demonstrated, the American Academy of Pediatrics and the American Academy of Sleep Medicine advocate for delayed school start times for middle and high school students to increase sleep duration and optimize educational achievement, as well as physical and emotional health and safety of adolescents [8, 37–39]. This recommendation considers the natural "sleep phase delay" that occurs during adolescence and emphasizes the importance of sleep duration rather than early rising in this age group.

Although we did not find gender differences, our study revealed variations among racial groups, with non-Hispanic Blacks being significantly more likely to report insufficient sleep compared to the recommended duration. Several population-based studies support this finding [40–42]. The Alameda County Health and Ways of Living Study, which collected data at five different time points over 35 years, evaluated short sleep duration in adults, excluding those who reported more than 9 h of sleep [13]. The study demonstrated that low socioeconomic status strongly predicted inadequate sleep (< 7 h per night), with suboptimal sleep duration being most prevalent among individuals with lower incomes and lower educational levels [13].

Sleep duration has decreased by 1.5–2 h over the past five decades among adults and adolescents in the United States [43–46]. Consistent with previous findings, our study revealed that over one-third of adults do not achieve the recommended minimum of 7 h of sleep per night. This trend of sleep deprivation is believed to be influenced by factors such as increased work responsibilities, excessive reliance on electronic devices, long commutes, and other modern lifestyle changes [47]. It remains unclear whether adequate sleep leads to better health, income, and education, or if individuals with better health, income, and education tend to obtain sufficient sleep. Nevertheless, there appears to be a relationship between sleep and overall well-being.

4.1 Limitations

This study has several noteworthy limitations. The data collection method of the BRFSS relies on self-reported responses that may be subject to biases in recall and reporting, and only one question was used to assess sleep duration. Furthermore, households without telephones were not included in the survey, potentially leading to sampling bias. As a cross-sectional study, it is important to note that causality cannot be determined. It is possible that individuals who chose to participate in the study differ from those who did not. Additionally, respondents with higher education levels may exhibit more awareness of the "correct" responses, potentially biasing their answers. Lastly, this data was collected prior to the COVID-19 pandemic, during and after which sleep problems have become more prevalent during the pandemic, affecting approximately 40% of the general population and healthcare workers. Patients with active COVID-19 have shown higher rates of sleep problems as well [48]. This topic requires further investigation.

5 Conclusion

In this nationally representative sample of adults aged 18–60 years, we observed a statistically significant association between self-reported sleep duration and individuals' perceived assessments of their health, income, and educational achievements. Specifically, those who reported consistently sleeping 7–9 h per night demonstrated better overall health, higher income levels, and higher educational attainment compared to those who slept fewer or more hours. This study supports the idea that adequate sleep contributes to a person's health, wealth, and wisdom. Given the substantial number of adults in the US reporting insufficient sleep, we hope these findings help advocate for healthier sleep practices.

Disclaimer The opinions or assertions contained herein are the private views of the authors and are not to be construed as the official policy of the Department of the Army, Defense Health Agency, Department of Defense, or the US Government.

Author contributions CSBC: Methodology, Formal analysis, Writing, Review & Editing. TB: Methodology, Formal analysis, Writing, Review & Editing. RHH, SPM: Writing, Review & Editing. YSC: Formal analysis, Review & Editing.

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Data availability Publicly available datasets were analyzed in this study. All data used in this study are derived from the public BRFSS data portal—https://www.cdc.gov/brfss/annual_data/annual_data.htm.

Declarations

Competing interests The authors report no conflict of interest.

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