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Sleep duration and quality among U.S. adults with epilepsy: National Health Interview Survey 2013, 2015, and 2017

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Abstract

Background: Epilepsy is associated with a high prevalence of sleep disturbance. However, population-based studies on the burden of sleep disturbance in people with epilepsy are limited. This study assessed sleep duration and sleep quality by epilepsy status in the general U.S. adult population aged ≥18 years.

Methods: We pooled data of cross-sectional National Health Interview Surveys in 2013, 2015, and 2017 to compare the prevalence of sleep duration and quality among those without epilepsy (N=93,126) with those with any epilepsy (a history of physician-diagnosed epilepsy) (N=1,774), those with active epilepsy (those with a history of physician-diagnosed epilepsy who were currently taking medication to control it, had one or more seizures in the past year, or both) (N=1,101), and those with inactive epilepsy (those with a history of physician-diagnosed epilepsy who were neither taking medication for epilepsy nor had had a seizure in the past year) (N=673). We also compared these measures between those with active and those with inactive epilepsy. The prevalences were adjusted for sociodemographics, behaviors, and health covariates, with multivariable logistic regression. We used Z-tests to compare prevalences of sleep duration and quality at the statistical significance level of 0.05.

Results: Adults with any epilepsy reported significantly higher adjusted prevalences of short sleep duration (<7 hours) (36.0% vs. 31.8%) and long sleep duration (>9 hours per day) (6.7% vs. 3.7%) but a lower prevalence of healthy sleep duration (7–9 hours per day) (57.4% vs.64.6%) than those without epilepsy. In the past week, adults with any epilepsy reported significantly higher adjusted prevalences than adults without epilepsy of having trouble falling asleep (25.0% vs. 20.3%), staying asleep (34.4% vs. 26.3%), nonrestorative sleep (adults did not wake up feeling well rested) (≥3 days) (50.3% vs. 44.3%), and taking medication to help themselves fall asleep or stay asleep (≥1 times) (20.9% vs. 13.5%). However, adults with active epilepsy did not differ from adults with inactive epilepsy with respect to these sleep duration and quality measures.

Conclusions: Adults with epilepsy reported more short or long sleep duration and worse sleep quality than those without epilepsy. Neither seizure occurrence nor anti-epileptic drug

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use accounted for these differences in sleep duration and quality. Careful screening for sleep complaints as well as identifying and intervening on the modifiable risk factors associated with sleep disturbances among people with epilepsy could improve epilepsy outcomes and quality of life.

Keywords

epilepsy; seizure; adults; sleep duration; insomnia

1 INTRODUCTION

Sleep is vital to health. Complete sleep deprivation in animals leads to death over a few weeks [1]. Inadequate sleep (i.e., short sleep duration [2]) and sleep disorders such as insomnia [3] are associated with individuals' poor health and quality of life. About one-third of the U.S. adult population report an average sleep duration <7 hours per day [2, 4] or complain of insomnia symptoms [5]. Therefore, these common sleep problems continue to be major public health concerns [6, 7].

Over 4 million U.S. adults have reported a history of epilepsy [8], and sleep disturbances in epilepsy are common [9, 10, 11]. The relationship between sleep disturbances and epilepsy is a particularly vicious cycle. Nocturnal seizures can interrupt physiological sleep stages leading to sleep fragmentation, while anything that causes sleep disturbance or fragmentation can worsen [9] or even trigger seizures [12]. The primary sleep disturbances in patients with epilepsy include insomnia, excessive day time sleepiness, and other nocturnal events [10,13]. As in the general population [5], these sleep disturbances, occasionally accompanied by symptoms of anxiety, depression, and suicidal ideation [14–17], can significantly impair patients' quality of life [16–18] and contribute to the intractability of epilepsy in some patients [17].

Although some studies found that adults with epilepsy reported subjective sleep complaints more often than adults without epilepsy [10, 18], results are not consistent. In one study, mean scores for epilepsy patients on each of six common sleep disturbance scales (insomnia, sleep apnea, periodic leg movements, daytime sleepiness, psychiatric sleep disorder, and narcolepsy) using the Sleep Diagnosis Questionnaire statistically significantly exceeded these scores in controls [18]. In another study, however, the most common sleep disorders and sleep-related symptoms occurred only as often in epilepsy patients as in controls. [19]. These inconsistent findings may have occurred because most studies were small, cross-sectional, hospital-based convenience samples (e.g., specialized epilepsy outpatient clinics) that represented highly selected populations [20] and because the studies used different case definitions (e.g., various insomnia inventories were used) [5], data collection procedures, and analyses (e.g., some used controls, but others did not) [20].

To further understand sleep disturbances and to get reliable estimates among people with epilepsy, we analyzed pooled data of National Health Interview Surveys in 2013, 2015, and 2017 to assess the prevalence of sleep duration and quality by epilepsy status.

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2 Methods

2.1 Data source

The U.S. National Health Interview Survey (NHIS) is a large, annual, population-based, household interview survey with standard data collection procedures and quality assurance and control conducted by the Centers for Disease Control and Prevention (CDC)'s National Center for Health Statistics (NCHS) [21]. Its sampling method follows an area-based probability design that permits representative sampling of households and noninstitutional groups. Trained personnel from the U.S. Census Bureau conduct face-to-face household, family, and personal interviews to collect data. Before 2019, the consistent year-to-year basic or core data module consists of four main components: the Household Composition section, the Family Core, the Sample Adult Core, and the Sample Child Core. From each family in NHIS, one sample adult aged 18 years or older is randomly selected. This study used person-level data from the Sample Adult Core, and imputed income files of the Family Core to estimate family income levels. Data from the 2013, 2015, and 2017 NHIS were aggregated to provide more reliable estimates [21]. The number and final response rates of adult respondents were 34,557 (61.2%) in 2013, 33,672 (55.2%) in 2015, and 26,742 (53.0%) in 2017. After excluding 71 respondents with missing information on epilepsy history (respondents who refused to respond, or responded "don't know" or not ascertained to questions), we included 94,900 (99.9%) respondents in the analysis. The Ethics Review Board of the CDC and the NCHS approved the NHIS. The data are publicly available.

2.2 Variable definitions

A respondent with any epilepsy (a history of physician-diagnosed epilepsy) was defined as a respondent who responded "yes" to a question, "Have you ever been told by a doctor or other health professional that you have a seizure disorder or epilepsy?" [22]. Active epilepsy was defined for adults with any epilepsy who responded "yes" to "Are you currently taking any medicine to control your seizure disorder or epilepsy?" or respondent confirmed having had one or more seizures to the question of "Think back to last year about the same time. About how many seizures of any type have you had in the past year?, or both. Correspondently, inactive epilepsy was defined as those adults with any epilepsy who responded as neither taking medication for epilepsy nor as having had a seizure in the past year.

Based on information about recommended sleep hours for a healthy adult from the American Academy of Sleep Medicine and Sleep Research Society [23], we defined short sleep duration as reporting <7 hours sleep per 24 hours, a healthy sleep duration as 7–9 hours sleep per 24 hours, and long sleep duration as >9 hours sleep per 24 hours for adults who responded to the question, "On average, how many hours of sleep do you get in a 24-hour period?" We classified responses to two insomnia symptom-related questions, "In the past week, how many times did you have trouble falling asleep" and "In the past week, how many times did you have trouble staying asleep?" as 0–2 times or ≥3 times [24]. We also classified responses to one question about sleep medication use, "In the past week, how many times did you take medication to help you fall asleep or stay asleep?" as 0 times or ≥1 times (any sleep medication use). Finally, we created a variable for nonrestorative

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sleep by subtracting from 7 the response to “In the past week, on how many days did you wake up feeling well rested?”. Responses were classified as 0–2 days or ≥3 days/week of nonrestorative sleep.

We also selected the following available sociodemographic, behavioral, or health risk factors as potential confounders for associations between epilepsy and sleep duration and sleep quality or difficulties: age group (18–24, 25–44, 45–64, and ≥65 years old); sex; race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic/Latino, and other race and ethnic groups including non-Hispanic American Indians/Alaska Natives, Asians, multiple races, and race group not released); poverty status (<200% or ≥200% of the ratio of family income to the annual Federal Poverty Level) derived from NHIS imputed income file [25]; education level (less than high school graduate, high school graduate or equivalent, or at least some college); currently employed (“yes” response to the questions about “working for pay at a job or business”, “with a job or business but not at work”, or “working, but not for pay, at a family-owned job or business”); body mass index based on self-reported height and weight (underweight [<18.5 kg/m^2], normal weight [18.5–24.9 kg/m^2], overweight [25.0–29.9 kg/m^2], or obese [≥30 kg/m^2]); marital status (married/living with a partner, widowed/divorced/separated, or never married); region (Northeast, Midwest, South, or West); having usual health care providers (response of “yes” or “there is more than one place” to the question, “Is there a place that you usually go to when you are sick or need advice about your health?”); smoking status (lifetime nonsmokers, former smokers, or current smokers); alcohol drinking status (lifetime abstainers, former drinkers, or current drinkers); physical activity status (meeting aerobic physical activity guidelines by participating in moderate-intensity leisure-time physical activities ≥150 minutes per week or in vigorous-intensity activities ≥75 minutes per week or an equivalent combination of the two); and having serious psychological distress defined as having a score greater than or equal to 13 on the Kessler 6 nonspecific distress scale [26] based on how often each of the following six symptoms of mental illness or nonspecific psychological distress the respondent reported [i.e., “during the past 30 days, how often did you feel: 1) so sad that nothing could cheer you up; 2) nervous; 3) restless or fidgety; 4) hopeless; 5) that everything was an effort; and 6) worthless.”].

2.3 Statistical Analysis

We used SAS ® (version 9.4)-callable SUDAAN (version 11.0.1) (Research Triangle Institute, Research Triangle Park, NC) statistical software to account for NHIS’s complex sampling design. Data were weighted to produce estimates that were nationally representative of the civilian noninstitutionalized U.S. population. We used Proc CROSSTAB to tabulate distributions (prevalence) of selected characteristics among adults and crude estimates of prevalence of sleep duration and indicators of sleep quality by epilepsy status. We used Proc MULTILOG to perform multivariable logistic regression analysis to produce prevalence of sleep duration and indicators of sleep quality among adults by epilepsy status, after adjusting for the previously listed potential confounders. We conducted Z-tests to compare the prevalence estimates between adults with any epilepsy and without epilepsy, between adults with active epilepsy and with inactive epilepsy, and between active or inactive epilepsy and those without epilepsy at the statistical significance

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level of 0.05. We mentioned only the statistically significant findings among these pairs of groups in the results.

3 RESULTS

In the combined 2013, 2015, and 2017 NHIS, 1,774 (1.8%) reported a history of epilepsy (any epilepsy), which included 1,101 (1.1%) reporting active epilepsy and 673 (0.7%) reporting inactive epilepsy, and 93,126 (98.2%) reported no history of epilepsy.

Compared to adults without epilepsy, adults with any epilepsy were more likely to be non-Hispanic White, be underweight or obese, be widowed, divorced, separated or never married, live in the South, have usual health care providers, be a current smoker, be former drinkers and report serious psychological distress (Table 1). On the other hand, adults with any epilepsy were less likely to be older than 65 years, be Hispanic/Latino, have a higher family income, have a college education, be employed, be lifetime nonsmokers, be current drinkers, and meet current aerobic physical activity guidelines.

Compared to adults without epilepsy, adults with active epilepsy shared the same characteristic distribution patterns as adults with any epilepsy did. Also, when compared to adults without epilepsy, adults with inactive epilepsy were more likely to be women, be non-Hispanic White, be underweight, to be never married, be current smokers, be former drinkers, and to have serious psychological distress but less likely to be Hispanic/Latino, have a higher family income, have a college education, be employment, be Married/Living with partner, and live in the Northeast.

Compared to adults with inactive epilepsy, adults with active epilepsy were more likely to be men, have a lower family income, have less education, be unemployed, be unmarried, be a lifetime abstainer from alcohol and less likely to be a current drinker, and not meet current aerobic physical activity guidelines.

Compared to adults without epilepsy, adults with any epilepsy, active epilepsy, or inactive epilepsy had higher unadjusted prevalences of short sleep duration (37.2%, 35.7%, 39.3%, vs. 31.7%) (Table 2). Adults with any epilepsy, active epilepsy, and inactive epilepsy also had higher unadjusted prevalences of long sleep duration than adults without epilepsy (10.6%, 11.6%, 9.0%, vs. 3.8%), but lower unadjusted prevalences of healthy sleep duration (52.3%, 52.7%, 51.7% vs. 64.5%) than adults without epilepsy. Compared with adults without epilepsy, adults with any epilepsy, active epilepsy, or inactive epilepsy had higher prevalences of trouble falling asleep (≥3 times in past week) (34.8%, 34.7%, 35.1%, vs. 22.7%), trouble staying asleep (≥3 times in past week) (42.7%, 42.2%, 43.5%, vs. 28.4%), taking medication to help themselves fall asleep or stay asleep (≥1 times in past week) (29.2%, 32.0%, 24.7%, vs. 16.1%), and nonrestorative sleep (≥3 days in past week) (54.5%, 54.1%, 55.0%, vs. 44.2%).

After multivariable adjustment (Table 3), adults with any epilepsy (36.0%) and inactive epilepsy (37.5%) but not those with active epilepsy (34.8%) reported significantly higher prevalences of short sleep duration than those without epilepsy (31.8%). Adults with any epilepsy (6.7%), active epilepsy (6.5%), and inactive epilepsy (7.0%) reported higher

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prevalences of long sleep duration than those without epilepsy (3.7%); these adults with epilepsy also reported lower prevalences of healthy sleep duration than those without epilepsy (57.4%, 58.7%, 55.4%, vs 64.6%, respectively). In the past week, adults with any epilepsy, active epilepsy, and inactive epilepsy reported significantly higher prevalences than adults without epilepsy of having trouble falling asleep (25.0%, 24.4%, 25.8%, vs. 20.3%, respectively); having trouble staying asleep (34.4%, 33.3%, 36.2%, vs. 26.3%, respectively), and taking sleep medications (20.9%, 22.7%, 18.0%, vs. 13.5%, respectively). Adults with any epilepsy (50.3%) or active epilepsy (51.0%) but not those with inactive epilepsy (49.1%) had significantly higher prevalences of nonrestorative sleep than adults without epilepsy (44.3%). Adults with active epilepsy did not differ from adults with inactive epilepsy on all sleep duration or quality measures.

The adjusted prevalence of sleep duration and indicators of sleep quality in adults with epilepsy did not differ between those with and without seizures in those who used or did not use antiseizure medication (ASM), and between those who used or did not use ASM whether or not they had seizures (Table 4).

4 DISCUSSION

While sleep duration has been extensively studied in the general population of U.S. adults [2, 4, 27], only a few reports on sleep duration exist among people with epilepsy [19, 28, 29]. Although hospital outpatient-based, cross-sectional surveys in adults with epilepsy suggested a similar average total sleep time (7.5 hours per night) to that in controls [19, 30], more adults with epilepsy than controls reported extreme total sleep times of >10 hours per night (3% vs. 1%) and of <6 hours per night (7% vs. 1%) [19]. In the U.S. adult population, one study with a smaller sample size reported significantly fewer adults with a history of epilepsy (i.e., any epilepsy) (53%) or active epilepsy (50%) reported usually sleeping 7–8 hours in 24 hours than without epilepsy (62%) [28]. Significantly more adults with active epilepsy (16%) than without epilepsy (10%) usually slept ≥9 hours in 24 hours, and significantly more adults with a history of epilepsy (34%) than without a history of epilepsy (29%) usually slept ≤6 hours in 24 hours.

The current study is the first to study sleep duration among adults with epilepsy using the most recent and largest U.S. nationally-representative data. In this study, adults with any epilepsy or inactive epilepsy more likely than those without epilepsy reported a short sleep duration. Inadequate sleep (i.e., short sleep duration) is common (about 30% in the general U.S. population [2,4]) and can considerably impair daytime functioning and quality of life. In patients with epilepsy, the consequences are potentially even worse because inadequate sleep or sleep deprivation can trigger seizures [12], starting repeated cycles of seizure-sleep disruption. In a hospital outpatient-based, cross-sectional survey, 24% of epilepsy patients were suspected to have chronic sleep insufficiency [19]. In our study, more adults with any epilepsy (36.0%) and inactive epilepsy (37.5%) reported short sleep duration than adults without epilepsy (31.8%). Besides other common risk factors such as unhealthy sleep habits or behavioral problems, higher prevalences of short sleep duration among people with any or inactive epilepsy could be due to higher prevalences of insomnia symptoms found in those two groups. A higher prevalence of insomnia symptoms was also observed in adults

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with active epilepsy when compared to adults without epilepsy. However, we did not find a higher prevalence of short sleep duration in those with active epilepsy compared to adults without epilepsy. Perhaps people with active epilepsy, who used ASM with sleep medication that have synthetic sedative effects, may have improved their insomnia symptoms and reduced their short sleep duration, or different pathophysiological conditions in the brain between those with active epilepsy and those with inactive epilepsy may have accounted for the different responses to sleep medications since there was no difference of taking sleep medication between those with active epilepsy and those with inactive epilepsy. In addition, people with active epilepsy may have overreported the number of hours they slept [29]. Our findings suggest that improving inadequate sleep in adults with epilepsy may be necessary among people with epilepsy. More importantly, no matter how well-controlled seizures are, people with epilepsy should always be aware of the risks of sleep deficiency, an established trigger of seizure occurrence. Further research is needed to investigate the effects of sleep medication and ASM use on short sleep duration.

Our study also found that more adults with epilepsy reported long sleep duration (>9 hours per day) than adults without epilepsy. In a clinical study, patients with refractory epilepsy reported spending more time sleeping (10.5 hours per day) than they really had, as documented on polysomnography [29]. Since excessive daytime sleepiness is among the most common complaints of people with epilepsy [9, 10, 13, 17], adults with epilepsy in our study could have overreported sleeping long hours. Even though it is uncertain whether long sleep duration by itself contributes to health risks in the general population [23], identifying excessive daytime sleepiness among adults with epilepsy who report long sleep duration could also identify those with obstructive sleep apnea [10], which occurs in over 30% of adults with epilepsy [31]. Obstructive sleep apnea itself may also exacerbate epilepsy or seizure occurrence through changes in normal sleep stages or hypoxia and sleep deprivation [9, 10]. Most importantly, this sleep condition can be treated with continuous positive airway pressure (CPAP), and treatment might reduce seizure frequency and improve sleep outcomes such as excessive daytime sleepiness [32, 33]. Excessive daytime sleepiness is also related to depression [34], which occurs in 30%-50% of patients with epilepsy [35]. Depression may change normal sleep stages [36] and is related to insomnia [37, 38].

The most common complaint in patients with epilepsy is insomnia [13]. However, its prevalence in previous hospital-based, cross-sectional surveys varies because of differences in study populations, sample sizes, or study methodology. In our study, U.S. adults with a history of epilepsy reported more insomnia-related symptoms (trouble falling asleep and trouble staying asleep), sleep medication use, and non-restorative sleep than adults without epilepsy after adjusting for multiple demographic, behavioral or clinical covariates. Good sleep hygiene (i.e., habits that promote good sleep including a consistent sleep schedule) and psychological and behavioral interventions by health care providers for insomnia disorder in adults have proven effective for insomnia disorders in adults [39, 40] and may help to reduce insomnia in patients with epilepsy. Patients with epilepsy and insomnia who are treated for affective disorders through medication or behavioral interventions (e.g., epilepsy-self management) may have improved sleep quality and reduced seizure frequency or severity [41, 42].

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In our study, distributions of potential confounders were similar between persons with and persons without any epilepsy and between persons with active epilepsy and persons with inactive epilepsy. However, even after adjustment for confounders, sleep duration and sleep quality indicators differed between persons with and without any epilepsy but did not differ between persons with active epilepsy and persons with inactive epilepsy. These findings imply that a history of epilepsy itself rather than the presence of seizures or ASM use (which were absent in those with inactive epilepsy) affected sleep duration and sleep quality. The lack of associations between both sleep duration and sleep quality by seizure status and ASM use further confirmed this conclusion (Table 4). This conclusion supports a long-standing hypothesis that the presence of epilepsy itself, not just the occurrence of seizure or the effects of ASMs, predisposes persons to sleep disruption [43–45] and further implies a shared underlying pathophysiological mechanism between epilepsy and sleep disturbances and/or disorders [46]. In a recent cross-sectional clinical study, ASM burden and seizure frequency did not explain highly prevalent subjective and objective daytime sleepiness in adults with epilepsy [47]. Further evidence from basic science, clinical practice, and epidemiologic studies are warranted on this issue.

Our study has several limitations. First, because NHIS is cross-sectional, we cannot make causal inferences between sleep duration or quality and epilepsy. Second, the self-reported responses to its survey questions may be subject to recall bias so that persons with epilepsy might be more likely to recall sleep problems than persons without epilepsy. Third, because NHIS data does not include information about daytime sleepiness, we could not study the relationship between daytime sleepiness and reported long sleep duration. Finally, even though two major insomnia symptoms were measured, we do not know if persons reporting these symptoms had acute insomnia (< 3 months of symptoms) or chronic insomnia (≥3 months) [48] because NHIS does not collect information about the duration of these symptoms.

5 CONCLUSIONS

In this study, adults with history of epilepsy were more likely to report shorter sleep duration, longer sleep duration, and worse sleep quality than adults without epilepsy, even after adjustment for multiple demographic, behavioral, or other health covariates. Because adults with active epilepsy resembled those with inactive epilepsy with respect to sleep duration and sleep quality, these sleep disturbances appear related to a history of epilepsy itself (shared underlying pathophysiological mechanisms) rather than to ASM use or seizure occurrence, which do not occur in those with inactive epilepsy.

Careful screening for sleep-related complaints and identifying and intervening on modifiable risk factors related to sleep disturbances may improve patients’ sleep, as well as associated outcomes and their quality of life.

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Abbreviations:

NHIS	National Health Interview Survey
NCHS	National Center for Health Statistics
CDC	Centers for Disease Control and Prevention
ASM	antiseizure medication

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Table 1.

Distribution of selected characteristics among adults aged ≥ 18 years, by epilepsy status-National Health Interview Survey, United States, 2013, 2015, and 2017.

	Any epilepsy[a]		Active epilepsy[b]		Inactive epilepsy[c]		No epilepsy	
Characteristics	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**
Age (years)								
18–24	144	13.5 (11.1–16.5)	83	13.3 (10.2–17.1)	61	14.1 (10.2–18.9)	8,360	12.3 (11.9–12.7)
25–44	553	35.1 (32.1–38.2)	333	34.2 (30.5–38.2)	220	36.5 (31.7–41.6)	30,557	34.2 (33.7–34.7)
45–64	714	37.7 (34.7–40.7)	449	37.5 (33.8–41.3)	265	38.0 (33.5–42.7)	31,156	34.2(33.8–34.7)
65 over	363	13.7 (12.1–15.5)[j]	236	15.0 (12.8–17.6)[j]	127	11.5 (9.3–14.1)	23,053	19.3 (18.9–19.7)
Sex								
Men	759	46.2 (43.1–49.3)	509	50.4 (46.3–54.5)[k]	250	39.1 (34.3–44.1)	41,814	48.2 (47.8–48.7)
Women	1,015	53.8 (50.7–56.9)	592	49.6 (45.5–53.7)	423	60.9 (55.9–65.7)[j]	51,312	51.8 (51.3–52.2)
Race/ethnicity								
White, non-Hispanic	1,219	71.6 (68.6–74.5)[j]	740	70.5 (66.6–74.0)[j]	479	73.6 (69.2–77.6)[j]	58,774	64.8 (64.0–65.6)
Black, non-Hispanic	263	13.6 (11.5–16.1)	172	14.7 (11.9–18.0)	91	11.8 (9.1–15.3)	12,194	11.7 (11.2–12.1)
Hispanic/Latino	179	9.0 (7.4–10.9)[j]	114	9.3 (7.2–11.8)[j]	65	8.5 (6.4–11.2)[j]	14,597	15.7 (15.4–16.3)
Other[f]	113	5.8 (4.5–7.3)	75	5.6 (4.1–7.5)	38	6.1 (4.0–9.2)	7,561	7.9 (7.5–8.3)
Poverty status[g]								
<200% of FPL	991	47.4 (44.2–50.7)	668	52.1 (47.8–56.3)[k]	322	39.8 (35.0–44.7)	33,460	30.6 (30.0–31.2)
≥200% of FPL	783	52.6 (49.3–55.8)[j]	433	47.9 (43.7–52.2)[j]	351	60.2 (55.3–65.0)[j]	59,666	69.4 (68.8–70.0)
Education level								
Less than high school graduate, general education degree or equivalent, or high school graduate	854	49.5 (46.3–52.8)	573	53.2 (49.1–57.2)[k]	281	43.6 (38.7–48.5)	35,834	37.5 (36.9–38.1)
At least some college	898	50.5 (47.2–53.7)[j]	513	46.8 (42.8–50.9)[j]	385	56.4 (51.5–61.3)[j]	56,915	62.5(61.9–63.1)
Current employment								
Yes	594	35.9 (32.9–39.0)[j]	291	28.4 (25.0–32.2)[j]	303	48.3 (43.3–53.3)[j]	54,429	62.1 (61.6–62.6)
No	1,180	64.1 (61.0–67.1)	810	71.6 (67.8–75.0)[k]	370	51.7 (46.7–56.7)	38,654	37.9 (37.4–38.4)

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	Any epilepsy[a]		Active epilepsy[b]		Inactive epilepsy[c]		No epilepsy	
Characteristics	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**
Body mass index (kg/m ^{2})								
Underweight (<18.5)	64	2.9 (2.1–3.9)[j]	38	2.3 (1.6–3.4)	26	3.8 (2.3–6.2)[j]	1,611	1.8 (1.7–1.9)
Normal (18.5-<25)	527	31.1 (28.3–34.0)	323	31.9 (28.2–35.9)	198	29.1 (24.7–33.8)	30,485	33.2 (32.8–33.7)
Overweight (25.0-<29.9)	525	29.7 (26.9–32.6)	319	29.3 (25.7–33.1)	204	30.5 (26.0–35.4)	30,204	32.6 (32.2–33.0)
Obese (≥30)	658	36.4 (33.2–39.6)[j]	415	36.5 (32.4–40.7)[j]	242	36.6 (32.0–41.4)	30,258	32.4 (31.9–32.8)
Marital status								
Married or Living with partner	659	44.8 (41.9–47.8)	380	40.7 (36.8–44.6)[k]	279	51.7 (46.9–56.4)	46,415	60.5 (60.0–61.0)
Widowed, divorced, or separated	584	22.1 (20.0–24.3)[j]	379	23.7 (20.8–26.8)[j]	205	19.3 (16.3–22.8)	24,924	17.4 (17.1–17.7)
Never married	529	33.1 (30.1–36.3)[j]	340	35.6 (31.6–39.8)[j]	189	29.0 (24.4–34.0)[j]	21,580	22.1 (21.6–22.6)
Region								
Northeast	249	14.4 (12.4–16.7)	166	15.1 (12.5–18.1)	83	13.3 (10.5–16.8)[j]	15,312	17.8 (17.1–18.5)
Midwest	406	23.2 (21.7–22.9)	237	21.3 (18.3–24.7)	169	26.4 (22.1–31.2)	20,101	22.3 (21.7–22.9)
South	672	40.9 (37.7–44.3)[j]	429	42.9 (38.7–47.2)[j]	243	37.7 (32.9–42.8)	33,620	36.7 (35.8–37.6)
West	447	21.4 (18.9–24.2)	269	20.7 (17.2–24.6)	178	22.6 (18.7–27.1)	24,093	23.2 (22.5–24.0)
Have usual health care providers								
Yes	1,617	90.4 (88.2–92.2)[j]	1,023	92.5 (89.8–94.5)[j]	594	87.0 (83.2–90.0)	79,657	85.9 (85.6–86.3)
No	145	9.6 (7.8–11.8)	69	7.5 (5.5–10.2)	76	13.0 (10.0–16.8)	12,831	14.1 (13.7–14.4)
Smoking status								
Lifetime nonsmokers	847	53.1 (50.0–56.2)	533	54.0 (50.0–57.9)	314	51.6 (46.8–56.4)	56,044	62.5 (62.0–63.0)
Former smokers	424	22.0 (19.8–24.4)	258	21.0 (18.3–24.1)	166	23.7 (19.9–28.0)	21,579	22.1 (21.7–22.5)
Current smokers	498	24.9 (22.4–27.5)[j]	307	24.9 (21.8–28.3) [j]	191	24.7 (20.9–29.0) [j]	15,153	15.4 (15.1–15.8)
Alcohol drinking status								
Lifetime abstainers	431	28.5 (25.3–31.8)	308	32.7 (28.5–37.2)[k]	123	21.4 (17.0–26.5)	18,577	20.3 (19.8–20.8)
Former drinkers	425	21.4 (19.1–23.9)[j]	285	23.3 (20.1–26.7)[j]	140	18.3 (14.9–22.3)[j]	14,068	13.8 (13.5–14.1)
Current drinkers	887	50.1 (47.0–53.3)[j]	488	44.0 (40.1–48.0)[j,k]	399	60.3 (55.0–65.4)	59,203	65.9 (65.3–66.4)
Met aerobic guidelines[h]								

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	Any epilepsy[a]		Active epilepsy[b]		Inactive epilepsy[c]		No epilepsy	
Characteristics	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**	**No[d]**	**% (95% CI)[e]**
Yes	605	35.7 (32.7–39.0)[j]	322	32.2 (28.3–36.2)[j]	283	41.8 (36.9–46.8)	44,904	50.8 (50.2–51.4)
No	1,142	64.3 (61.0–67.3)	764	67.8 (63.8–71.7)[k]	378	58.2 (53.2–63.1)	46,619	49.2 (48.6–49.8)
Having serious psychological distress[i]								
Yes	220	11.8 (9.8–14.2)[j]	161	13.6 (11.0–16.7)[j]	59	9.0 (6.4–12.6)[j]	3,352	3.5 (3.3–3.6)
No	1,476	88.2 (85.8–90.2)	877	86.4 (83.3–89.0)	599	91.0 (87.4–93.6)	86.203	96.5 (96.4–96.7)

Abbreviations: FPL= Federal Poverty Level; CI=confidence interval.

[a] Any epilepsy was defined as adults who responded “yes” to ever having been told by doctor or other health professional that they had a seizure disorder or epilepsy (or having a history of epilepsy).

[b] Active epilepsy was defined as adults who reported a history of epilepsy and either were currently taking medication to control it, or had one or more seizures in the past year, or both.

[c] Inactive epilepsy was defined as adults who reported a history of epilepsy but were not taking medication for epilepsy and had not had a seizure in the past year.

[d] Unweighted numbers. Categories might not sum to the sample total because of missing responses for some categories.

[e] Weighted percent and 95% confidence interval (CI). A Z-test was conducted to compare the prevalence between groups (see methods) at the statistical significance level of 0.05.

[f] Other race/ethnicity category includes other non-Hispanic groups (American Indians, Alaskan Natives, Asian, multiple races, and race group not released).

[g] Poverty status was defined as the ratio of family income to Federal Poverty Level.

[h] Responders were considered as meeting the aerobic activity guidelines if they participated in moderate-intensity leisure-time physical activities 150 minutes or more per week or in vigorous-intensity activities 75 minutes or more per week or an equivalent combination of the two.

[i] Serious psychological distress was defined as adults who have a score greater than or equal to 13 on the Kessler 6 nonspecific distress scale.

[j] $p<0.05$ when compared with no epilepsy group in the same category of selected characteristics.

[k] $p<0.05$ when compared with inactive epilepsy group in the same category of selected characteristics.

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Table 2.

Crude prevalence of sleep duration and indicators of sleep quality among adults aged ≥18 years, by epilepsy status---National Health Interview Survey, United States, 2013, 2015, and 2017.

	Any epilepsy[a]		Active epilepsy[b]		Inactive epilepsy[c]		No epilepsy	
	No[d]	% (95% CI)[e]	No[d]	% (95% CI)[e]	No[d]	% (95% CI)[e]	No[d]	% (95% CI)[e]
Sleep duration (hours/24-hours)								
<7	660	37.2 (34.2–40.2)[g]	391	35.7 (31.9–39.8)[g]	264	39.3 (34.7–44.2)[g]	28,758	31.7 (31.2–32.1)
7–9	888	52.3 (49.2–55.3)[g]	539	52.7 (48.6–56.5)[g]	346	51.7 (46.9–56.5)[g]	57,713	64.5 (64.1–65.0)
>9	184	10.6 (8.8–12.8)[g]	132	11.6 (9.3–14.4)[g]	52	9.0 (6.3–12.7)[g]	3,572	3.8 (3.7–4.0)
Trouble falling asleep (times in past week)								
0–2	1,120	65.2 (62.3–67.9)	673	65.3 (61.6–68.9)	445	64.9 (60.2–69.4)	71,106	77.3 (76.9–77.7)
≥3	663	34.8 (32.1–37.7)[g]	430	34.7 (31.1–38.4)[g]	228	35.1 (30.6–39.8)[g]	22,020	22.7 (22.3–23.1)
Trouble staying asleep (times in past week)								
0–2	994	57.3 (54.1–60.5)	605	57.8 (53.6–61.9)	386	56.5 (51.6–61.3)	65,304	71.6 (71.2–72.1)
≥3	789	42.7 (39.5–45.9)[g]	498	42.2 (38.1–46.4)[g]	287	43.5 (38.7–48.4)[g]	27,822	28.4 (27.9–28.8)
Sleep medication use (times in past week)								
0	1,240	70.8 (67.9–73.5)	728	68.0 (64.1–71.7)	507	76.9 (72.7–80.6)	77,210	83.9 (83.6–84.3)
≥1	543	29.2 (26.5–32.1)[g]	375	32.0 (28.3–35.9)[g]	166	24.7 (20.9–29.0)[g]	15,916	16.1 (15.7–16.4)
Nonrestorative sleep (days in past week)[f]								
0–2	783	45.5 (42.5–48.6)	472	45.9 (41.9–49.8)	309	45.0 (40.0–50.1)	50,295	55.8 (55.3–56.4)
≥3	928	54.5 (51.4–57.5)[g]	573	54.1 (50.2–58.1)[g]	350	55.0 (49.9–60.0)[g]	39,512	44.2 (43.6–44.7)

Abbreviations: CI=confidence interval.

[a] Any epilepsy was defined as adults who responded “yes” to ever having been told by doctor or other health professional that they had a seizure disorder or epilepsy (or having a history of epilepsy).

[b] Active epilepsy was defined as adults who reported a history of epilepsy and either were currently taking medication to control it, or had one or more seizures in the past year, or both.

[c] Inactive epilepsy was defined as adults who reported a history of epilepsy but were not taking medication for epilepsy and had not had a seizure in the past year.

[d] Unweighted numbers. Categories might not sum to the sample total because of missing responses for some categories.

[e] Weighted percent and 95% confidence interval (CI). A Z-test was conducted to compare the prevalence between groups (see methods) at the statistical significance level of 0.05.

[f] Nonrestorative sleep was defined by subtracting 7 from the responses to the question of “In the past week, on how many days did you wake up feeling well rested?”.

[g] $p<0.05$ when compared with no epilepsy group in the same category of sleep duration or indicators of sleep quality.

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Table 3.

Adjusted[a] prevalence of sleep duration and indicators of sleep quality among adults aged ≥18 years, by epilepsy status---National Health Interview Survey, United States, 2013, 2015, and 2017.

	Any epilepsy[b] % (95% CI)[e]	Active epilepsy[c] % (95% CI)[e]	Inactive epilepsy[d] % (95% CI)[e]	No epilepsy % (95% CI)[e]
Sleep duration (hours/24-hours)				
<7	36.0 (33.0–39.1)[g]	34.8 (30.9–39.0)	37.5 (33.1–42.2)[g]	31.8 (31.3–32.2)
7–9	57.4 (54.2–60.5)[g]	58.7 (54.4–62.9)[g]	55.4 (50.6–60.1)[g]	64.6 (64.1–65.0)
>9	6.7 (5.4–8.1)[g]	6.5 (5.1–8.3)[g]	7.0 (5.0–10.0)[g]	3.7 (3.5–3.9)
Trouble falling asleep (times in past week)				
0–2	75.0 (72.4–77.5)	75.6 (72.2–78.8)	74.2 (69.9–78.1)	79.7 (79.3–80.1)
≥3	25.0 (22.5–27.6)[g]	24.4 (21.2–27.8)[g]	25.8 (21.9–30.1)[g]	20.3 (19.9–20.7)
Trouble staying asleep (times in past week)				
0–2	65.6 (62.4–68.7)	66.7 (62.4–70.8)	63.8 (59.1–68.3)	73.7 (73.3–74.2)
≥3	34.4 (31.3–37.6)[g]	33.3 (29.2–37.6)[g]	36.2 (31.7–40.9)[g]	26.3 (25.8–26.7)
Sleep medication use (times in past week)				
0	79.1 (76.8–81.2)	77.3 (74.1–80.3)	82.0 (78.3–85.1)	86.5 (86.1–86.8)
≥1	20.9 (18.8–23.2)[g]	22.7 (19.7–25.9)[g]	18.0 (14.9–21.7)[g]	13.5 (13.2–13.9)
Nonrestorative sleep (days in past week)[f]				
0–2	49.7 (46.6–52.7)	49.0 (44.9–53.0)	50.9 (46.0–55.8)	55.7 (55.2–56.3)
≥3	50.3 (47.3–53.4)[g]	51.0 (47.0–55.1)[g]	49.1 (44.2–54.0)	44.3 (43.7–44.8)

Abbreviations: CI=confidence Interval.

[a]Model adjusted for age, sex, race/ethnicity, poverty status, education, having usual health care providers, current employment, body mass index, smoking and alcohol drinking status, physical activity, marital status, region, and serious psychological distress.

[b]Any epilepsy was defined as adults who responded “yes” to ever having been told by doctor or other health professional that they had a seizure disorder or epilepsy (or having a history of epilepsy).

[c]Active epilepsy was defined as adults who reported a history of epilepsy and either were currently taking medication to control it, or had one or more seizures in the past year, or both.

[d]Inactive epilepsy was defined as adults who reported a history of epilepsy but were not taking medication for epilepsy and had not had a seizure in the past year.

[e]Weighted percent and 95% confidence interval (CI). A Z-test was conducted to compare the prevalence between groups (see methods) at the statistical significance level of 0.05.

[f]Nonrestorative sleep was defined by subtracting 7 from the responses to the question of “In the past week, on how many days did you wake up feeling well rested?”.

[g]p<0.05 when compared with no epilepsy group in the same category of sleep duration or indicators of sleep quality.

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Table 4.

Adjusted[a] prevalence of sleep duration and indicators of sleep quality among adults aged ≥ 18 years who reported a history of epilepsy, by anti-epileptic drug use, and seizure status---National Health Interview Survey, United States, 2013,2015 and 2017.

	With ASM[b]				Without ASM			
	With seizures[c]		Without seizures		With seizures[c]		Without seizure	
	No[d]	% (95% CI)[e]	No[d]	% (95% CI)[e]	No[d]	% (95% CI)[e]	No[d]	% (95% CI)[e]
Sleep duration (hours/24-hours)								
<7	173	32.1 (26.9–37.8)	139	37.9 (31.2–45.1)	76	38.4 (30.1–47.5)	264	41.0 (36.2–46.0)
7–9	240	54.8 (48.6–60.8)	225	52.4 (45.5–59.3)	70	55.1 (45.8–64.1)	346	49.8 (44.9–54.7)
>9	66	13.1 (9.4–18.0)	51	9.6 (6.6–13.9)	13	6.5 (3.1–13.0)[f]	52	9.2 (6.5–12.9)
Trouble falling asleep (times in past week)								
0–2	298	69.5 (63.8–74.7)	293	66.8 (60.4–72.7)	75	59.4 (49.7–68.5)	445	65.6 (60.9–70.1)
≥ 3	203	30.5 (25.3–36.2)	130	33.2 (27.3–39.6)	91	40.6 (31.5–50.3)	228	34.4 (29.9–39.1)
Trouble staying asleep (times in past week)								
0–2	267	62.6 (56.6–68.2)	263	61.4 (54.6–67.8)	71	48.6 (38.0–59.3)	386	56.1 (51.2–60.8)
≥ 3	234	37.4 (31.8–43.4)	160	38.6 (32.2–45.4)	95	51.4 (40.7–62.0)	287	43.9 (39.2–48.8)
Sleep medication use (times in past week)								
0	315	69.3 (63.4–74.6)	306	71.7 (65.2–77.4)	99	66.9 (56.4–76.0)	507	76.8 (72.5–80.6)
≥1	186	30.7 (25.4–36.6)	117	28.3 (22.6–34.8)	67	33.1 (24.0–43.6)	116	23.2 (19.4–27.5)
Nonrestorative sleep (days in past week)[g]								
0–2	207	49.1 (43.3–54.8)	214	45.4 (39.2–51.7)	48	33.4 (24.6–43.4)	309	44.9 (40.0–49.9)
≥3	264	50.9 (45.2–56.7)	191	54.6 (48.3–60.8)	109	66.6 (56.6–75.4)	350	55.1 (50.1–60.0)

Abbreviations: ASM, antiseizure medication; CI=confidence Interval.

[a]Model adjusted for age, sex, race/ethnicity, poverty status, education, having usual health care providers, current employment, body mass index, smoking and alcohol drinking status, physical activity, marital status, region, and serious psychological distress.

[b]With ASM was defined for adults with any epilepsy who responded “yes” to the question of: “Are you currently taking any medicine to control your seizure disorder or epilepsy?”.

[c]With Seizure was defined for adults with any epilepsy who responded having had one or more seizures in the past year.

[d]Unweighted numbers. Categories might not sum to the sample total because of missing responses for some categories.

[e]Weighted percent and 95% confidence interval (CI). A Z-test was conducted to compare the prevalence between those with and without seizures in those with or without ASM, and between those with seizures or without seizures across with and without ASM groups at the statistical significance level of 0.05.

[f]Relative standard error >30%. Interpret these data cautiously.

[g]Nonrestorative sleep was defined by subtracting 7 from the responses to the question of “In the past week, on how many days did you wake up feeling well rested?”.