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SCIENTIFIC INVESTIGATIONS

# Outpatient health care utilization for sleep disorders in the Cerner Health Facts database

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**Study Objectives:** Sleep disorders are common in the general population. This study aimed to identify direct health care utilization for sleep disorders using big data through the Cerner Health Facts database.

**Methods:** The Cerner Health Facts database has 68.7 million patients in the data warehouse, documenting approximately 506.9 million encounters from 100 nonaffiliated health care systems. To identify sleep-related health care utilization, we examined the frequency of outpatient encounters related to sleep disorders between the years 2000 and 2017. Sleep disorders were grouped-based on the *International Classification of Sleep Disorders-Third Edition*.

**Results:** Approximately 20.5 million patients were identified with a total of 127.4 million outpatient encounters. In pediatric patients (ages 0–18 years), health care utilization for major sleep diagnoses was measured per 100,000 encounters. Sleep-related breathing disorders ranked first among common sleep disorders for pediatric patients followed by parasomnia, insomnia, sleep movement disorders, hypersomnolence, then circadian rhythm disorders (820.1, 258.1, 181.6, 68.3, 48.1, and 16.2 per 100,000 encounters, respectively). However, in adult patients, the ranking was slightly different, with sleep-related breathing disorders ranked first, followed by insomnia, sleep-related movement disorders, hypersomnolence, parasomnia, then circadian rhythm disorders (1352.6, 511.6, 166.3, 79.1, 25.7, and 4.2 per 100,000 encounters, respectively). In general, there was a bimodal pattern with a clear dip in sleep-related health care utilization in young adults age (age 19–29 years), with the exception of insomnia.

**Conclusions:** Patients with sleep disorders show relatively low health care utilization despite a known high prevalence of sleep disorders in the general population. This finding may highlight under-recognition of sleep problems or decreased access to health care for sleep disorders. In addition, this study highlights the effect of age-based variation on different sleep disorders, which may have an impact on allocating resources.

**Keywords:** Cerner, health facts, sleep disorders, prevalence, health care, utilization, big data

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**BRIEF SUMMARY**

**Current Knowledge/Study Rationale:** Sleep disorders are very common in the general population. However, the data on health care utilization and burden of sleep disorders is limited.

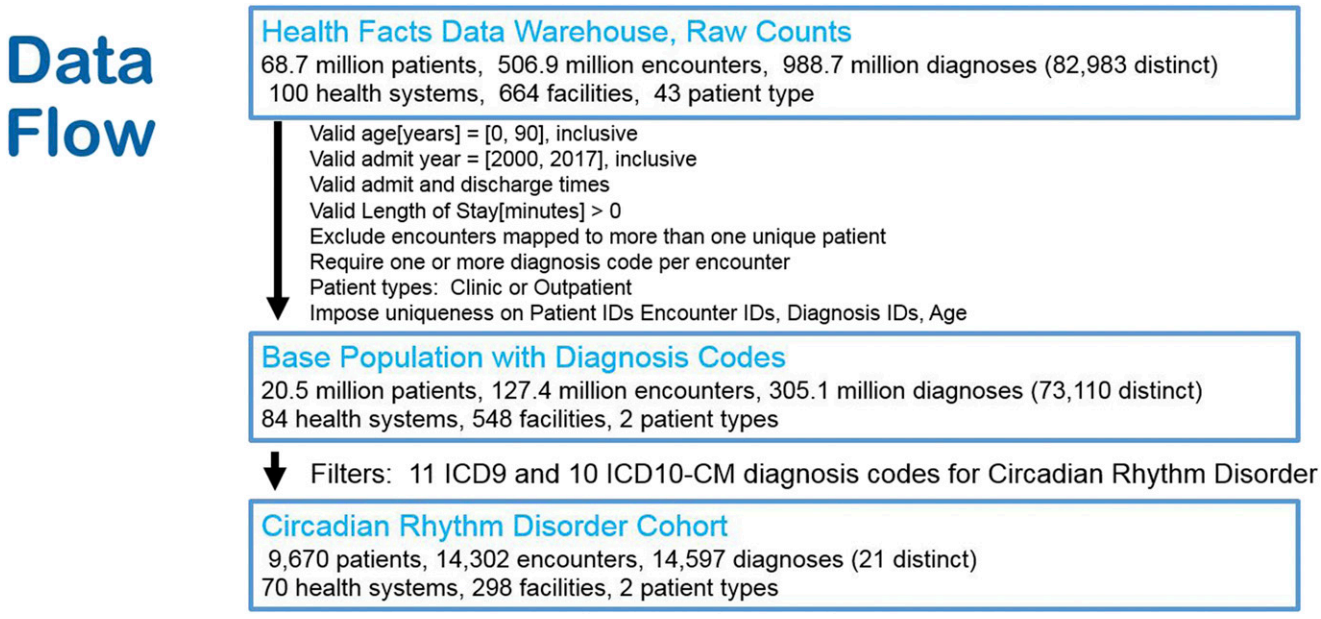
**Study Impact:** Using big data, this study may highlight under-recognition of sleep disorders or decreased access to health care for patients with sleep disorders.

## INTRODUCTION

Sleep disorders are highly prevalent in the general population worldwide. Estimates of prevalence range from 20% to 40% and appear to be rising with time.[1–6] Data from the National Health and Nutrition Examination Survey (NHANES) suggest that 20% of Americans have symptoms of insomnia, 18% have hypersomnia or nonrestorative sleep, and up to 31% report snoring.[7] Similarly, up to 25% of children may experience a sleep problem.[8] Multiple studies have shown that these sleep disorders have significant implications for overall well-being, quality of life, daytime functioning, and other health morbidities such as cardiovascular, psychiatric, and neurological diseases.[9–11] Furthermore, the indirect morbidities related to sleep disorders are substantial, such as motor vehicle accidents, work-related accidents, injury risk in young children, workday loss, and decreased productivity.[11–13] Many of these studies showed that the increased health care utilization and cost related to sleep disorders are due primarily to indirect morbidities.[14] These findings highlight the importance of early treatment for sleep disorders to curtail associated morbidity and mortality. However, evidence exists that patients may not seek medical attention for their sleep disorders and that parents may underreport their children's sleep complaints.[15–17]

With the development of electronic health records and availability of big data sets over the past 20 years, interest has increased in using such data for accelerating medical discoveries, directing health care resources, and guiding patient care.[18] Such big data would help in estimating the direct burden of sleep disorders on health care, which would help in filling gaps in the current knowledge of health care utilization for sleep disorders in both adult and pediatric patients. To examine this hypothesis,

**Figure 1**—Health Facts database query method.




This is an example for circadian rhythm disorder cohort and the same was applied for each sleep disorder category. ICD = *International Classification of Diseases*.

we looked into the frequency of outpatient health care visits for the main sleep disorder categories based on the latest version of the *International Classification of Sleep Disorders*: insomnia, hypersomnia, parasomnia, circadian rhythm disorders, sleep movement disorders, and sleep-related breathing disorders in a large de-identified database of electronic health records data, Cerner Health Facts (HF).

## METHODS

### Design

This study was a retrospective data analysis conducted using de-identified patient data from the HF database (Cerner Corporation, Kansas City, MO). HF is a large Health Insurance Portability and Accountability Act–compliant database that stores and organizes de-identified electronic health record data from more than 600 US sites associated with 100 nonaffiliated health systems.[19] Data available in HF include information on patient demographics, diagnoses, medication orders, procedures, and laboratory tests, as well as details about the type of treatment setting. The use of HF was determined to be non-human subjects research by the institutional review board governing the hospital at which the study was conducted.

### Patient selection

A base population was extracted from HF through several filters, including selection of all ages from birth to over 90 years old between the years 2000 and 2017. Only "clinic" or "outpatient" patient types were included. Several technical exclusions were applied to exclude problem data, such as values that were out of range, inconsistent, or duplicated. **Figure 1** shows the procedure to identify patient encounters for circadian rhythm disorders, and a similar process was used for the other sleep disorders. Based on *International Classification of Disease*, 9th and 10th Revisions codes, several "sleep diagnosis categories" were defined according to the *International Classification of Sleep Disorders*, third edition (**Table 1**). We considered all sleep diagnoses in each encounter regardless of the priority. However, to prevent double counting, special database queries were used to record only the number of unique encounters and number of unique patients for the given sleep disorder diagnosis and age interval. This base population contained 20.5 million patients having 127.4 million encounters with 305.1 million diagnosis records (73,110 distinct codes) from 84 health systems with 548 facilities. A database query was used to compute the number of encounters for specific age intervals for each of the 73,110 diagnosis codes. The frequency of encounters for diagnosis category within the base population could not be computed directly with the initial summary by diagnosis code because patient encounters in HF often have multiple diagnosis codes per encounter. To compute frequency of a category, we calculated the number of encounters for a diagnosis category for each age interval via a separate database query, treating each category as a separate cohort and counting only the unique encounter identifiers.

## RESULTS

Frequency of outpatient visits for patients with sleep disorders was computed according to the following age brackets: 0–12 months, 1–2 years, 2–5 years, 6–11 years, 12–18 years, 19–21 years, 22–29 years, 30–39 years, 40–49 years, 50–59 years,

**Table 1**—Sleep diagnosis categories and corresponding ICD-9 and ICD-10 codes.

| Sleep Diagnosis Categories | ICD-10 and ICD-9 |
|---|---|
| Circadian rhythm disorders | G47.2, G47.20, G47.21, G47.22, G47.23, G47.24, G47.25, G47.26, G47.27, G47.29, 307.45, 327.3, 327.30, 327.31, 327.32, 327.33, 327.34, 327.35, 327.36, 327.37, 327.39 |
| Hypersomnolence | F51.1, F51.11, F51.12, F51.13, F51.19, G47.1, G47.10, G47.11, G47.12, G47.13, G47.14, G47.19, G47.4, G47.41, G47.411, G47.419, G47.421, G47.429, 307.43, 307.44, 327.1, 327.10, 327.11, 327.12, 327.13, 327.14, 327.15, 327.19, 347, 347.0, 347.00, 347.01, 347.1, 347.10, 347.11, 780.53, 780.54 |
| Insomnia | A81.83, F51.01, F51.02, F51.03, F51.04, F51.05, F51.09, G47.0, G47.00, G47.01, G47.09, Z73.81, Z73.810, Z73.811, Z73.812, Z73.819, 046.72, 307.41, 307.42, 327.0, 327.00, 327.01, 327.02, 327.09, 780.51, 780.52, V69.5 |
| Parasomnia | F51.3, F51.4, F51.5, F98.0, G47.5, G47.50, G47.51, G47.52, G47.53, G47.54, G47.59, N39.44, 307.46, 307.47, 307.6, 327.4, 327.40, 327.42, 327.43, 327.44, 327.49, 780.56, 780.36 |
| Sleep-related movement disorders | G25.81, G47.6, G47.61, G47.62, G47.63, G47.69, 327.5, 327.51, 327.52, 327.53, 327.59, 333.94, 780.58 |
| Sleep-related breathing disorders | E66.2, G47.3, G47.30, G47.31, G47.33, G47.34, G47.35, G47.36, G47.37, G47.39, P28.3, R06.83, 278.03, 327.2, 327.20, 327.21, 327.23, 327.24, 327.25, 327.26, 327.27, 327.29, 780.57 |
| Other sleep disorders | F51, F51.8, F51.9, G47, G47.8, G47.9, Y93.84, Z72.82, Z72.820, Z72.821, 307.4, 307.40, 307.48, 307.49, 327, 327.8, 780.5, 780.50, 780.55, 780.59, V69.4 |

ICD = *International Classification of Diseases*.

**Table 2**—Pediatric and adult total encounters numbers in Health Facts data in each sleep diagnoses category.

| | Pediatric Encounters (n = 346,303) | Adult Encounters (n = 2,398,895) |
|---|---|---|
| Circadian rhythm disorders | 3,403 | 10,899 |
| Hypersomnolence | 10,133 | 84,137 |
| Insomnia | 38,216 | 544,292 |
| Parasomnia | 54,319 | 27,369 |
| SRMD | 14,374 | 176,967 |
| SRBD | 172,622 | 1,439,043 |
| Other sleep disorders | 53,236 | 116,188 |

SRBD = sleep-related breathing disorders, SRMD = sleep-related movement disorders.

60–69 years, 70–79 years, 80–89 years, and 90 years and above. A total of 127,435,108 encounters are included from HF, which includes 21,047,813 encounters in pediatric population (age 0–18 years) and 106,387,454 encounters in adult population (age 19–90+ years). There were 2,433,525 encounters with different sleep diagnoses, leading to around 1,910 encounters per 100,000 HF encounters with sleep disorder diagnoses. **Table 2** shows the absolute encounter numbers for each group of sleep diagnoses category. **Figure 2** presents the absolute number of encounters for each group of sleep diagnoses and for the base population by age bracket. There is a clear picture that patients between the ages of 40s and 60s have more frequent outpatient health care encounters, which appears to be the case in the base population sample and for most sleep disorders except parasomnia, where children and adolescents are more predominant. To normalize the number of visit encounter, sleep diagnoses frequency per 100,000 encounters of base population in HF by age bracket is shown in **Figure 3**. In general, there was a bimodal pattern, with a first peak around ages 2–11 years and a second peak around 40–60 years. Note that this bimodal distribution was not due simply to differences in visits for any reason, because the data are normalized per 100,000 encounters. Young adults, aged 19–29 years, had a clear dip in the frequency of sleep disorders clinic visits, with the exception of insomnia. There was also a clear spike in clinic visits for parasomnia diagnoses in the ages 6 to 11 year olds; on further analysis, this was largely related to an increase in enuresis diagnoses. As demonstrated in **Figure 4**, sleep diagnoses were further analyzed by grouping encounters by pediatric (aged 0–18 years) vs. adult (older than 18 years). Both adult and pediatric patients had sleep-related breathing disorders as the most frequent sleep diagnosis for which health care was sought. This was followed in adults by insomnia, then sleep-related movement disorders. However, in children, parasomnias ranked second for sleep disorder burden, again largely related to enuresis. Children had more outpatient clinic visits related to circadian rhythm

**Figure 2**—Absolute number of encounters for the base population and the different sleep disorders groups in Health Facts database by age bracket.

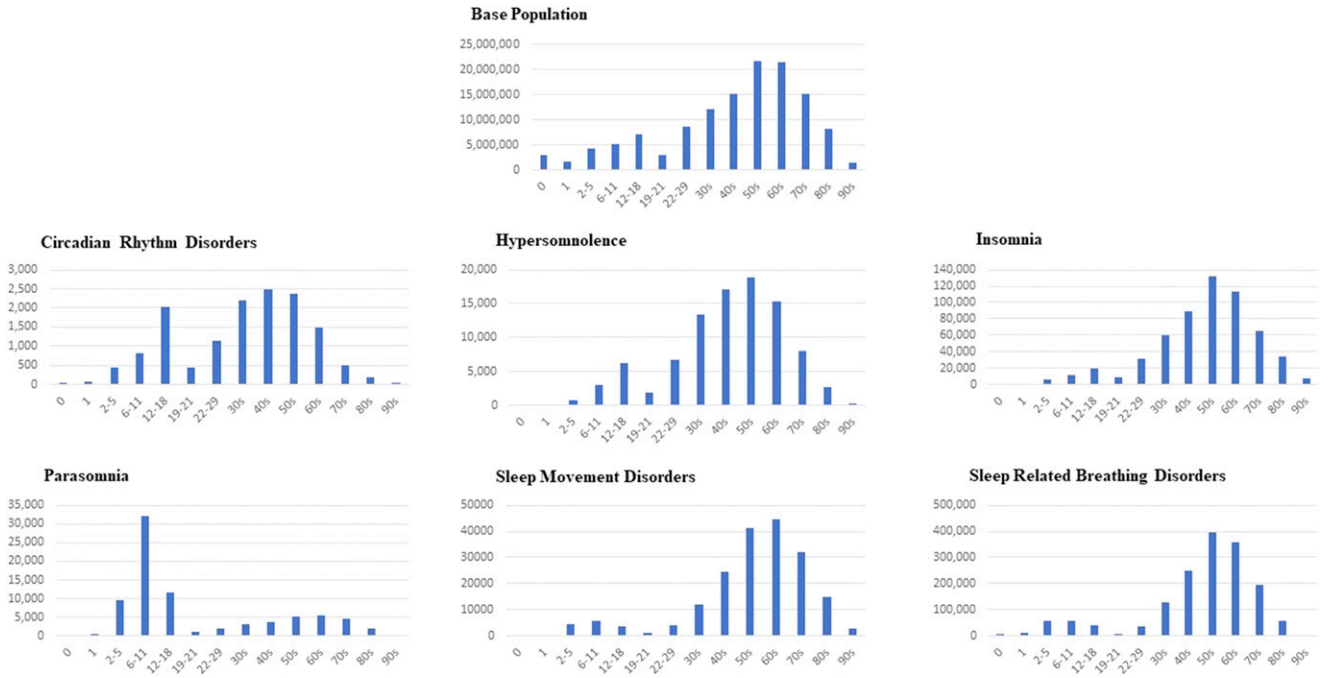
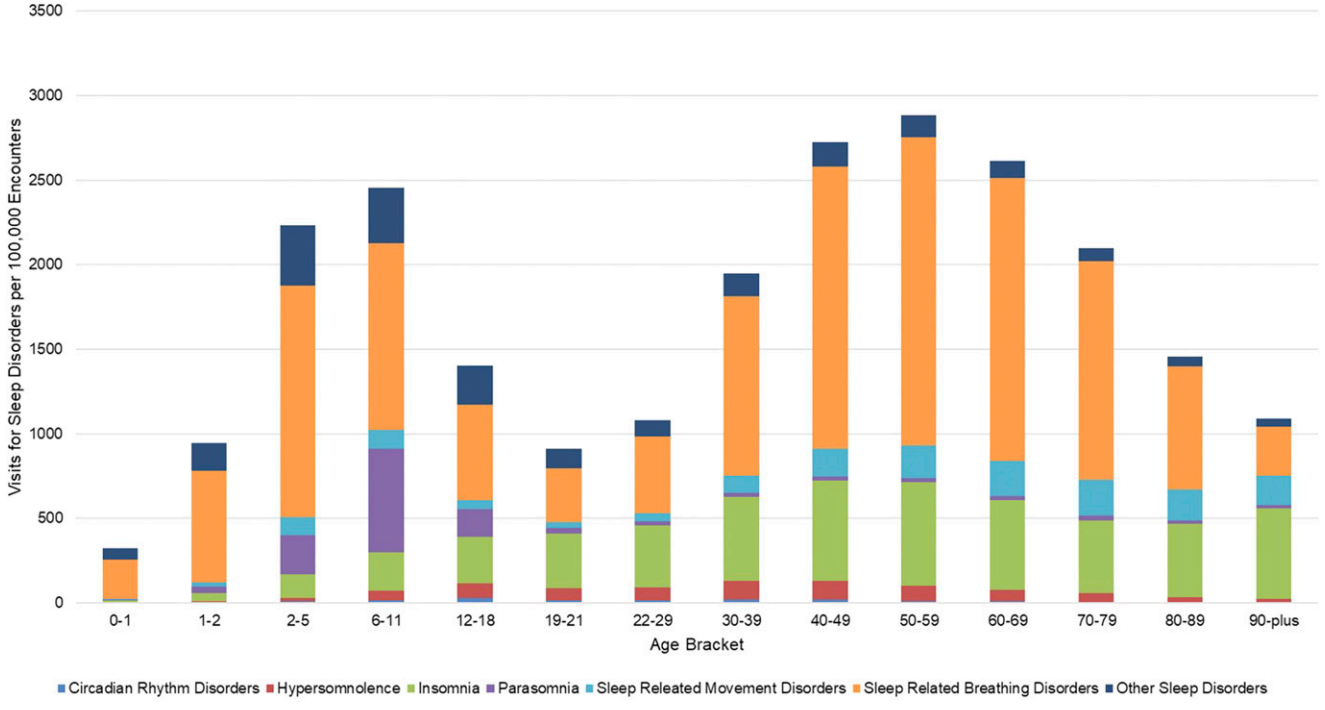
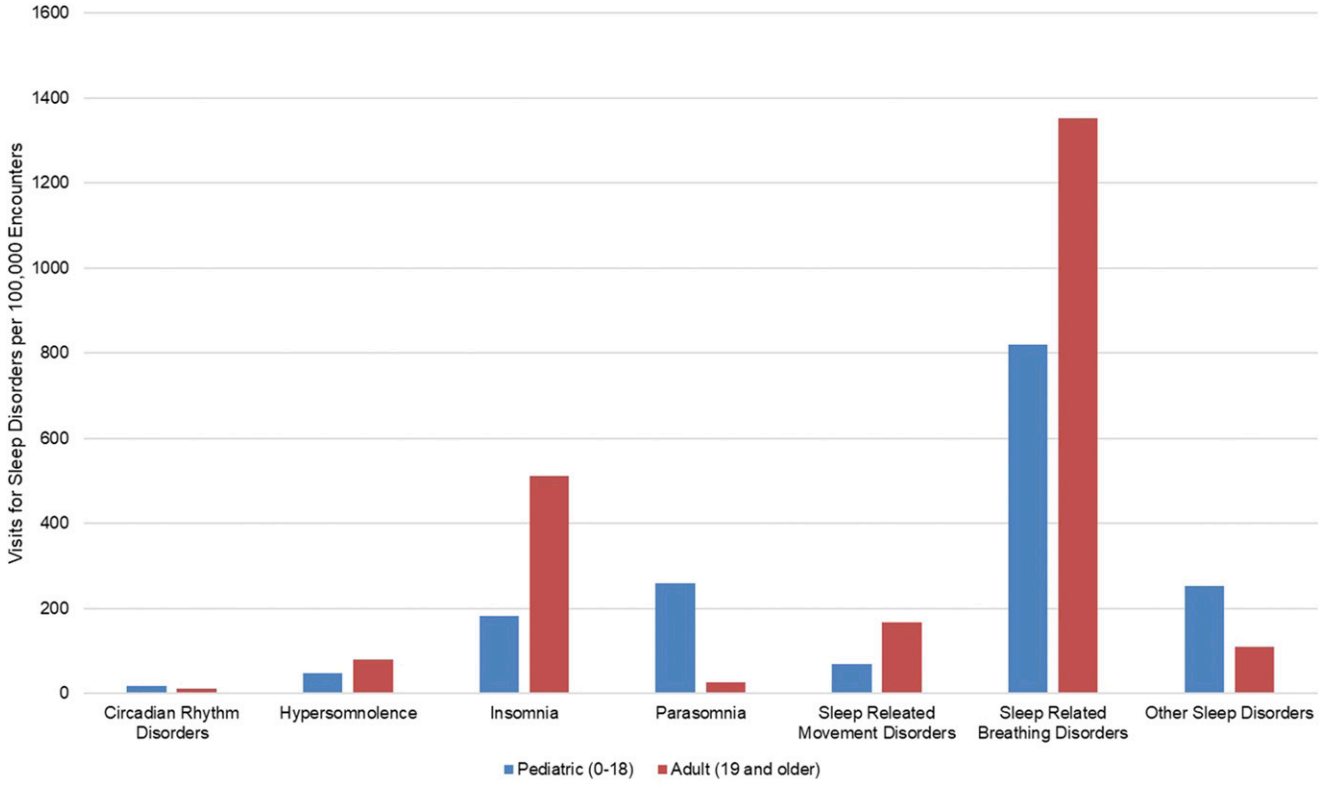



**Figure 3**—Sleep disorders visit frequency per 100,000 encounters by age bracket.




disorders compared to adults, with a peak around age 12–18 years. On the other hand, encounters with hypersomnolence diagnoses were more common in adults than children. There were more nonspecific sleep disorders diagnoses encounters in pediatric patients compared to adults. Direct statistical comparison between pediatric and adult encounters was performed via chi-square testing, yielding statistically significant differences for in every diagnostic category (circadian rhythm [$\chi^2$= 549, $P$ < .00001], hypersomnolence [$\chi^2$= 2,275, $P$ < .00001], insomnia [$\chi^2$= 42,066, $P$ < .00001], parasomnia [$\chi^2$= 148,080, $P$ < .00001], movement disorders [$\chi^2$= 11,267, $P$ < .00001], breathing disorders [$\chi^2$= 39,901, $P$ < .00001], other sleep

**Figure 4**—Pediatric vs. adult sleep disorders rate per 100,000 encounters.




disorders [$\chi^2 = 27{,}334$, $P < .00001$]); this is not surprising given the large number of encounters included in analysis. Finally, we included a data supplement that demonstrates our sample overall characteristics as well as sleep disorder encounters by sex (**Figure S1**), race (**Figure S2**), US Census region (**Figure S3**), and payor type (**Figure S4**) in the supplemental material.

## DISCUSSION

Drawing on big data from over 127 million encounters, this study shows that sleep-related outpatient encounters of sleep disorders are lower than what would be expected based on general population prevalence. In addition, it shows that sleep-related breathing disorders are the leading sleep disorder category for both adult and pediatric patients seeking medical care. Many of these sleep categories show bimodal distribution with increases in the ages of 2–11 years and 40–60 years.

The low number of outpatient clinic visits for all sleep disorders is of a great concern. This finding has been reported previously in smaller studies.[15–17] The reasons behind such low numbers of outpatient clinic visits for sleep disorders, despite high population prevalence, are unclear. We speculate that several contributing factors could explain the low frequency of outpatient health care visits for sleep disorders: lack of training about sleep disorders for primary care providers (medical education), lack of sleep care providers (health care access), and lack of general public awareness of sleep disorders (public awareness). While the general frequency of diagnoses in HF correlates with other national data sets, it is possible that patients requiring evaluation for sleep disorders may be seen at facilities that are underrepresented in the HF data set.[20] Despite the advances in sleep medicine, sleep education in medical school is still scarce when compared to other areas in medical education. A survey in 2011 showed medical schools in United States and Canada spend around 3 hours of total sleep education, out of which only 27 minutes is devoted to pediatric sleep.[21] Another survey done in 1993 showed US medical schools include less than 2 hours of sleep disorder education.[22] While time allocated to sleep education in medical schools appears to have improved slightly, it is clearly lagging the advances in sleep medicine and the importance of these disorders in overall well-being. The near absence of sleep education in medical school means that many doctors are uncomfortable dealing with sleep disorders and unlikely to discuss sleep health with their patients.[23] A related access challenge is that there is currently a shortage of board-certified sleep medicine physicians who could meet the demand for patients with sleep disorders.[24]

Public awareness of the importance of sleep health is another factor that is likely contributing to patients not seeking medical care. One of the areas of interest for "Healthy People 2020" is to improve sleep health by improving public awareness. Only about 25% of adults with symptoms of obstructive sleep apnea seek medical care. One of the goals for "Healthy People 2020" is to raise this percentage to 27.8%. Another goal for "Healthy People 2020" is to improve the percentage of high

school students (grades 9–12) who obtain sufficient sleep (defined as 8 or more hours of sleep on an average school night). Currently only 30.9% of high school students sleep 8 or more hours.[25]

This study also demonstrated that patients with sleep-disordered breathing (SDB) seek medical care more frequently than patients with other sleep disorders. While SDB is a relatively common problem, it lags insomnia in general population prevalence. Therefore, it is unclear why adult, and even pediatric, patients with SDB would seek more outpatient health care visits. This finding could be due to heightened public awareness about the disorder or due to the perception by patients and health care providers that SDB is a serious medical problem that needs to be followed more closely. Over the past 2 decades, there has been ample literature about SDB and its associated comorbidities such as daytime sleepiness and cardiovascular and neurological morbidities and mortalities.[26–28] This literature may have an impact of increasing public awareness about SDB and associated comorbidities.

This study highlights the role that age plays in health care utilization for sleep disorders. For example, children ages 2–5 years are expected to have increased risk for SDB, as they are at risk for adenotonsillar hypertrophy. Also, middle-aged adults are known to be at increased risk for SDB. At the same time, it is known that adolescents are at increased risk for many sleep disorders, especially circadian rhythm disorders and hypersomnia/narcolepsy, while parasomnias are more common in toddler and school-aged children (preteen). This study shows that most of the sleep disorders follow a bimodal pattern with a dip in health care visits between the ages of 19 and 29 years. One could speculate that health care visits decline in this age group because college-aged and young adults generally consider themselves to be healthy, or it may be that their access to health care is jeopardized once they are no longer covered by their parents' insurance. However, because sleep visits were normalized per total visits for any reason within age bracket, it is sleep disorders specifically that they were less likely seek care for, rather than a general decreased utilization of health care. Insomnia, on the other hand, is the only sleep disorder in this study that showed a steady increase of health care visits with age until the fifth decade of life. The reason only insomnia failed to show a dip in health care visits between the ages of 19 and 29 years is unclear and warrants further research.

While this study has many strengths, we would like to highlight some of the limitations. Using electronic health records allows mining data in large numbers, which is a major strength. However, using electronic health records is based on the quality of the diagnoses coding and documentation. Therefore, a shortfall in the providers' coding or documentation may affect the frequency of specific diagnosis.

In conclusion, the growth in use of electronic health records and ability to use big data represents a very promising venue in which to conduct data science research for sleep disorders. We have shown that the high prevalence of sleep disorders in the general population does not seem commensurate in outpatient health care visits. Further studies are needed to elucidate the underlying reasons for the observed trend and ascertain whether limited access to specialized and trained medical providers is one of the reasons for low health care utilization in sleep disorders. These data may have significant implications for allocating health resources to improve care for such prevalent diseases

## ABBREVIATIONS

HF, Cerner Health Facts
SDB, sleep-disordered breathing
SRBD, sleep-related breathing disorders
SRMD, sleep-related movement disorders

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## DISCLOSURE STATEMENT

All authors have seen and approved this manuscript. Dr. Ingram has served on a medical advisory board for Jazz Pharmaceuticals and has received research support from Wake Up Narcolepsy. Otherwise, the authors have no financial interests relevant to this manuscript to disclose.