Hospitalization Spending for Inpatients Affected by Sleep Disorders: Results from Hunan, China

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Abstract

Background

Sleep disorders are conditions that result in alterations in normal sleeping. There are many sleep disorders and the most frequently discussed major sleep disorders include insomnia, in which the patients have difficulty falling asleep or staying asleep throughout the night; sleep apnea, in which the patients experience abnormal patterns in breathing while sleeping; and narcolepsy, a condition characterized by extreme sleepiness during the day and falling asleep suddenly during the day.

Methods

Population health data were extracted from Chinese National Health Statistics Network Reporting System (CNHSNRS) for the province of Hunan in China. Patients affected by sleep disorders (ICD-10 codes F51.0 and G47.0) as the principal diagnosis and hospitalized between 1 January 2017 and 31 December 2019 were included. Information on age, gender, number of comorbidities, type of sleep disorders, level of hospital, location of hospital, hospital costs, length of stay, admission year, and method of payment were retrieved from CNHSNRS. Median with interquartile range (IQR) was used to describe the hospital costs and Kruskal-Wallis test was conducted to examine significant differences among different groups. Quantile regression was applied to investigate how the hospital costs at low and high quantile of the distribution vary across groups.

Results

Hospital costs for patients suffering from sleep disorders were substantial: $1229.31 per patient, nearly a quarter and almost all per capita disposable yearly household income of urban ($5,024.30) and rural ($1,914.53) residents in Hunan in 2017, respectively. The study also identified several significant independent variables associated with hospital costs, including age, gender, type of sleep disorder, and hospital characteristics. In-hospital care for sleep apnea accounted for almost 80% of the total spending, and about half of the spending was from the patient’s pocket money.

Conclusion

Hospital costs for patients suffering from sleep disorders were substantial: nearly a quarter and almost all per capita disposable yearly household income of urban and rural residents in Hunan in 2017, respectively. Age, gender, type of sleep disorder, and hospital characteristics were significant independent variables associated with hospital costs.

BACKGROUND

Sleep disorders are conditions that result in alterations in normal sleeping. There are many sleep disorders and the most frequently discussed major sleep disorders include insomnia, in which the patients have difficulty falling asleep or staying asleep throughout the night; sleep apnea, in which the patients
experience abnormal patterns in breathing while sleeping; and narcolepsy, a condition characterized by extreme sleepiness during the day and falling asleep suddenly during the day (1). While covering a wide range of conditions and symptoms, sleep disorders can be broken down into two main types according to underlying causes: primary sleep disorders that are not caused by another medical or psychological condition, and secondary sleep disorders that are the result of another medical problem, such as depression, thyroid problems, stroke, arthritis, or asthma (1). Sleep disorders affect many aspects of well-being and quality of life for people of all ages. Nearly one-third of adults in the United States do not meet the recommended at least 7 hours of sleep daily (2–4) and the quality of sleep has been deteriorating during the COVID-19 pandemic (5). Factors related to deficient or poor-quality sleep include physical health problems (6, 7), mental health issues such as depression (8), accidents (9, 10), and socio-demographic factors such as family structure, marital status, and young children living in the household (11–15).

Sleep disorders have major economic impact on the society and the health care system. A study in the United States found that short duration sleepers reported an additional $1,278 in total health care expenditures over average duration sleepers after adjusting for demographics, socioeconomic factors, and health behavior factors (16). Although medical treatment in out-patient settings is the most frequently used form of care for patients suffering from sleep disorders, for patients with severe conditions, in-hospital care may be needed (17, 18). For sleep apnea, a potentially serious sleep disorder in which breathing repeatedly stops and starts, surgical intervention with in-hospital care is often needed (19).

The severe and complicated sleep disorders that require in-hospital treatment will have implication for resources to the health care system, the patients, and the society. Reports on economic impact of in-hospital treatment for sleep disorders are scarce in the literature. We therefore conducted the comprehensive analysis of the hospitalization costs associated with in-hospital treatment for sleep disorders, overall and for specific sleep disorders in Hunan province of the People's Republic of China. This study is characterized by data collected in recent years from a large representative sample, covering a population of approximately 68.99 million in 2018 (20). We sought to provide comprehensive information about hospital costs for inpatients with sleep disorders, to determine the significant factors associated with hospital costs, and to provide scientific basis for resource allocation and cost controlling for inpatients with sleep disorders.

**METHODS**

**Data source and study population**

Population health data were extracted from Chinese National Health Statistics Network Reporting System (CNHSNRS) for the province of Hunan in China. The patients affected by sleep disorders and hospitalized between 1 January 2017 and 31 December 2019 were identified. All data were proofread using the criteria developed by the National Health Commission of the People's Republic of China. The diagnoses in this
database were coded according to the International Classification of Disease Tenth Revision (ICD-10), resulting in one principal and a maximum of fifteen secondary diagnoses. In this study, only when the principal diagnoses were sleep disorder (codes F51.0 and G47.0) would cases be identified and enrolled. Patients who only had a diagnosis code without hospitalization were excluded.

We adjusted the hospitalization costs by the Consumer Price Index (CPI) in Hunan in 2017 (the base year) according to the National Bureau of Statistics of China. Each 1 RMB was converted to 0.148 US Dollars according to the average exchange rate in 2017 for all hospital costs. We reviewed the database in CNHSNRS and retrieved information on age, gender, number of comorbidities, type of sleep disorders (primary: F51.0, secondary-obstructive sleep apnea hypopnea syndrome: G470-3; secondary-others: G47.0 excluding G470-3), level of hospital, location of hospital, hospital costs, length of stay (LOS), admission year, and method of payment. Hospital costs included lab costs, medicine costs, costs related to surgeries and other procedures, service costs, and material costs. LOS was defined as the interval between the date of admission and the date of discharge. Comorbidity was identified according to the secondary diagnoses in the database. Hospitals in China are grouped into three levels (primary, secondary, and tertiary) in accordance with the numbers of beds and diagnosis and treatment equipment possessions. In China, tertiary, secondary and primary hospitals are required to have a capacity of at least 500, 100–499, and 20–99 beds, respectively. In this study, hospitals were divided into tertiary and non-tertiary hospitals, because few patients were hospitalized in primary hospitals. Location of hospital was divided into two categories: provincial capital (Changsha city) and non-capital.

**Statistical methods**

At population level, the hospitalization spending was visualized using the Sankey diagram and Pyramid diagram. At individual level, a series of nonparametric tests and regression models were applied to investigate the factors for cost.

The results of Kolmogorov-Smirnov test showed that hospitalization costs were in skewed distribution ($p < 0.05$). Accordingly, median with interquartile range (IQR) was used to summarize the sample population. Kruskal-Wallis H test was conducted to examine significant differences among different groups. Kernel density estimations were performed to display the distribution of hospitalization costs among different groups. Quantile regression (QR) was applied to investigate how the hospitalization costs at low and high quantile of the distribution vary across groups.

QR has been widely used in analyzing cost in various areas, for it does not require distributional assumptions for the outcome of interest [24]. Moreover, QR can explore the associations between the explanatory variables and costs across the entire distribution by enabling the modeling of any conditional quantile of the hospitalization costs [25]. Thus, compared to ordinary least squared (OLS) regression, QR is more suitable for analyzing hospitalization costs.

All data management and analyses were performed with R version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria). QR parameters were estimated at the 0.10, 0.25, 0.50, 0.75, and 0.90
percentiles, respectively, using the R package ‘quantreg’. OLS regression was also performed for the purpose of comparison.

RESULTS

Descriptive statistics

A total of 24,713 patients with a principal diagnosis of sleep disorders who admitted to a hospital in Hunan province for treatment between 2017–2020 were identified and were included in the final analysis. Among them, 1,288 were primary sleep disorder, 16,460 were secondary-sleep apnea, and 6,965 were secondary sleep disorder by other causes (Table 1). The mean (SD) age was 31.9 (24.4) years and median (IQR) age was 33 (7–53) years. Men and women accounted for 61.3% and 38.7% of the cases, respectively. Of these patients, 85.6% (n = 21,145) admitted to a tertiary hospital and 54.7% (n = 13,529) admitted to a provincial capital hospital.

<table>
<thead>
<tr>
<th>Primary sleep disorders (ICD-10 code)</th>
<th>Number (%)</th>
<th>Secondary sleep disorders (ICD-10 code)</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary insomnia (F51.0)</td>
<td>1132 (4.52)</td>
<td>Secondary insomnia (G47.0)</td>
<td>1626 (6.50)</td>
</tr>
<tr>
<td>Nonorganic hypersomnia (F51.1)</td>
<td>20 (0.08)</td>
<td>Hypersomnia (G47.1)</td>
<td>38 (0.15)</td>
</tr>
<tr>
<td>Nonorganic circadian rhythm sleep-wake disorder (F51.2)</td>
<td>3 (0.01)</td>
<td>Circadian rhythm sleep-wake disorder (G47.2)</td>
<td>9 (0.04)</td>
</tr>
<tr>
<td>Sleep walking (F51.3)</td>
<td>16 (0.06)</td>
<td>Sleep apnoea (G47.3)</td>
<td>16558 (66.18)</td>
</tr>
<tr>
<td>Night terrors, or pavor nocturnus(F51.4)</td>
<td>12 (0.05)</td>
<td>Narcolepsy-cataplexy (G47.4)</td>
<td>145 (0.58)</td>
</tr>
<tr>
<td>Nightmares (F51.5)</td>
<td>23 (0.09)</td>
<td>Other sleep disorders (G47.8)</td>
<td>38 (0.15)</td>
</tr>
<tr>
<td>Unspecified (F51.9)</td>
<td>106 (0.42)</td>
<td>Unspecified (G47.9)</td>
<td>5293 (21.16)</td>
</tr>
</tbody>
</table>

Overall hospital spending on sleep disorders in the province of Hunan during the study period was 30.38 million US dollars. The Sankey diagram displayed the mobilization of spending across age groups, type of payers, and aggregated categories of sleep disorder (Fig. 1). Sleep apnea accounted for 78.8% of the total spending. The proportion of out-of-pocket (OOP) payments was 46.6% for sleep disorders, and the population aged under 20 accounted for 49.0% of the total spending. When stratifying the spending by sex and age, distinct patterns were observed between the types of sleep disorder: while the spending on
sleep apnea was predominated by children and adolescents (Fig. 2B), the highest spending among middle-aged women was on primary or other secondary sleep disorders (Fig. 2A/C).

At individual level, the median hospital spending was $1,227.40 (IQR: $642.3 to 1625.8). Table 2 shows that significantly statistical differences of hospital costs existed across year of hospitalization, age, sex, type of sleep disorder, number of comorbidities, LOS, level of hospital, and location of hospital ($P<0.05) Significant differences existed among all variables ($P<0.05).
Table 2
Hospitalization spending in patients with sleep disorders in Hunan during Jan 2017 and Sept 2020

<table>
<thead>
<tr>
<th>Variables</th>
<th>N (%)</th>
<th>Median (IQR)</th>
<th>H statistics</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>24713 (100)</td>
<td>1227.4 (642.3, 1625.8)</td>
<td>66.7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Year of hospitalization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017 (12 months)</td>
<td>4434 (17.9)</td>
<td>1077.3 (581.7, 1624.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 (12 months)</td>
<td>6191 (25.1)</td>
<td>1260.4 (631.3, 1645.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019 (12 months)</td>
<td>7944 (32.1)</td>
<td>1295.0 (659.8, 1649.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020 (9 months)</td>
<td>6144 (24.9)</td>
<td>1235.7 (670.4, 1561.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td>459.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Men</td>
<td>15141 (61.3)</td>
<td>1350.7 (679.0, 2189.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>9572 (38.7)</td>
<td>1067.4 (602.5, 1517.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td>3084.6</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>&lt; 20</td>
<td>10754 (43.5)</td>
<td>1498.8 (1216.8, 1652.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–44</td>
<td>4614 (18.7)</td>
<td>1014.5 (475.2, 2031.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45–64</td>
<td>6684 (27.0)</td>
<td>777.6 (469.5, 1249.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 65</td>
<td>2659 (10.8)</td>
<td>803.2 (526.3, 1183.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of sleep disorder</td>
<td></td>
<td></td>
<td>5871.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Primary</td>
<td>1288 (5.2)</td>
<td>750.4 (494.8, 1030.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary-sleep apnea</td>
<td>16460 (66.6)</td>
<td>1492.2 (1082.2, 1711.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary-other</td>
<td>6965 (28.2)</td>
<td>672.8 (419.3, 996.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td></td>
<td></td>
<td>921.3</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>0</td>
<td>3345 (13.5)</td>
<td>829.3 (369.5, 1490.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–2</td>
<td>12766 (51.7)</td>
<td>1423.6 (851.5, 1650.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 3</td>
<td>8602 (34.8)</td>
<td>1019.5 (622.4, 1560.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of hospital</td>
<td></td>
<td></td>
<td>2819.6</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Tertiary</td>
<td>21145 (85.6)</td>
<td>1355.6 (797.2, 1658.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IQR, interquartile range.
### Results of quantile regression for hospitalization costs

Multivariable QR was employed to estimate the effect sizes of variables on different cost segments (Fig. 3 & Table S1). The LOS was unsurprisingly associated with the hospital cost, and the effect size increased from $39.0 at the 10th percentile to $96.0 at the 90th percentile. An older age was associated with less cost at lower quantiles, but its effect was reversed at higher quantiles. The cost of sleep apnea was significantly higher than that of primary sleep disorder by $267.0 at the 10th percentile of cost ($P < 0.01) and $1,017.6 at the 90th percentile, primarily attributable to the surgery cost for adenoidal hypertrophy. The cost of other secondary sleep disorder was also higher than that of primary sleep disorder (up to $209.0), partially due to the treatment of comorbidities. However, the effect of comorbidities decreased across the quantiles of spending from −243.6 at the 10th percentile to −42.9 at the 90th percentile (none vs. ≥3 comorbidities). The level and location of hospital were also significant factors for spending with increasing effect sizes in higher quantiles.

### DISCUSSION

#### Chief findings

The results of present study demonstrated that median direct hospital costs for patients suffering from sleep disorders were substantial: $1229.31 per patient, nearly a quarter and almost all per capita disposable yearly household income of urban ($5,024.30) and rural ($1,914.53) residents in Hunan in 2017, respectively. The study also identified several significant independent variables associated with hospital costs, including age, gender, type of sleep disorder, and hospital characteristics. In-hospital care for sleep apnea accounted for almost 80% of the total spending, and about half of the spending was from the patient’s pocket money.

#### Strengths and weaknesses

To the best of our knowledge, this is the first population based comprehensive assessment of in-hospital spending for sleep disorders. Sample size is large in our study so that the estimates were stable. We have employed various advanced statistical analyses including QR to assess the magnitude and determinants of spending on in-hospital care for sleep disorders. Because it does not need to make distributional assumptions for the outcome of interest, QR has been widely used in analyzing cost in various areas.
Moreover, QR can explore the associations between independent variables with hospital costs across the entire distribution (22). Thus, compared to Ordinary Least Squared (OLS) regression, QR is more suitable to analyze hospital costs.

Several limitations of this study should be acknowledged. Most of the costs for the care of sleep disorders occur in out-patient settings (14–16) so our study may have reflected only a small amount of the economic impact of sleep disorders on the affected and the health care system. Total economic costs of sleep disorders would include indirect costs such as reduced productivity and personal income. Actually, the losses from reduced productivity and personal income could be substantially higher than medical cost during hospitalization. Our data contain only in-hospital medical costs, and could not reflect the overall economic burden of sleep disorders on patients and the society. Most of the patients admitted to a hospital with a diagnosis of sleep disorder may have other primary diseases. As a result, they were not included in our analysis according to our inclusion criteria. Sample size of our study although large overall, became small to assess specific sleep disorders that seldom require a hospitalization.

**Interpretation/implications**

Hospital costs for sleep disorders displayed a unique age distribution, with population aged under 20 accounted for 49.0% of the total spending. This is very different from most chronic diseases that affect predominately adults/seniors. The hospital costs for children and youth were largely driven by the costs for sleep apnea, which accounted for 78.8% of the total spending. Although the risk of sleep apnea increases with age, surgical treatment for obstructive sleep apnea (OSA), is often done at young age (23–25). This is because most sleep apnea in children and youth is caused by enlarged tonsils or adenoids, or both, and about 75% of these cases, surgical removal of the tissues cures sleep breathing problems (24). On the other hand, OSA in adults is not likely to be cured by surgery (24). As surgery often requires hospitalization, hospital costs for sleep disorders in children and youth were high in our study. Reasons for high hospital spending among middle-aged women on primary or other secondary sleep disorders were not fully understood. Women have better sleep quality compared with men but more sleep-related complaints than men (26). Insomnia and restless legs syndrome have a female predominance (26). The combined higher incidence of certain sleep disorders and increased sleep-related complaints among women may explain higher hospital costs for female patients observed in our study.

Our study found that almost half of the hospital costs for sleep disorders was paid by the patients’ pocket money. This will impose substantial burden to the affected patients and their families, especially for patients from rural areas: almost all per capita disposable yearly household income for them will be spent on hospital care for sleep disorders. Measures have been proposed to curb the costs for care of patients affected by sleep disorders, including the use of continuous positive airway pressure (27) and telemedicine (28). Rigorous evaluation to demonstrate the cost-effectiveness of these measures could help in developing programs in the future. Hospital costs for sleep disorders increased with increased number of comorbidities. This makes sense as part of the costs would be related to the treatment of comorbidities. Moreover, hospital-related characteristics are also associated with the hospital costs. A Japanese study demonstrated that the increasing hospital volume was significantly associated with
lower costs for pancreaticoduodenectomy (29). On the other hand, in our study, patients admitted to high-volume capital and tertiary hospitals incurred higher costs. This is to a great extent attributed to the fact that sleep disorders are highly heterogenous entities and more complicated cases tended to be treated in high-volume capital and tertiary hospitals. Also in China, advanced treatment techniques and equipment with high costs, which can improve efficiency and effectiveness, are more available in high-volume capital tertiary hospitals.

In the QR for cost, we found that an older age was associated with less cost at lower quantiles, but its effect was reversed at higher quantiles. We speculate that this may be attributable to the diagnosis and treatment for different types of sleep disorders. Sleep apnea is among the highest cost with a median of $1492, primarily because of the surgery for adenoidal hypertrophy. Compared with children and adolescents, older patients may have more complications after the surgery and need a longer stay for recovery. As a result, the spending in older age groups was higher than that in younger age group (< 20 yrs) at higher quantiles. In contrast, a younger older age was associated with higher cost at lower quantiles. In this age group, sleep disorder (except sleep apnea) is less prevalent, while its cause may be more complicated, resulting in a higher cost for diagnosis and ascertainment for cause of disease.

CONCLUSIONS

Our large-scale study based on the whole province of Hunan in China found that direct hospital costs for patients suffering from sleep disorders were substantial: nearly a quarter and almost all per capita disposable yearly household income of urban and rural residents in Hunan in 2017, respectively. Our study also identified several significant independent variables associated with hospital costs, including age, gender, type of sleep disorder, and hospital characteristics.

Abbreviations

CNHSNR: Chinese National Health Statistics Network Reporting System; IQR: Interquartile Range; ICD-10: Disease Tenth Revision; CPI: Consumer Price Index; LOS: Length of Stay; QR: Quantile Regression; OLS: Ordinary least Squared; OOP: Out-of-pocket; OSA: Obstructive Sleep Apnea

Declarations

Ethics approval and consent to participate

Approval was granted by Science and Technology Ethics Administration Commission of Hunan Province. The need for informed consent for the project was waived by Science and Technology Ethics Administration Commission of Hunan Province.

Consent for publication

Not applicable.
Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests. The funders played no role in study design, data analysis, or result interpretation. This work has not been published previously, is not under consideration for publication elsewhere, its publication has been approved by all authors, and if accepted, it will not be published elsewhere (either in whole or in part, in print or electronic form, in English or in any other language, etc) without the written consent of the copyright holder.

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Authors' contributions

YX - Conception of the study, study design, implementation, interpretation of data, literature review and initial drafting, overall oversight. MS, ZZ, JH - study design, implementation and interpretation of data; literature review and manuscript revision. CT, PX, XZ - Study design, interpretation of the data. SWW - drafting and revising the paper, approval of the final draft. ZL, YD-providing financial support.

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Author information

Affiliations
References


Supplementary Table S1

Supplementary Table S1 is not available with this version

Figures
Figure 1

Hospitalization spending in Hunan province during Jan 2017 and Sept 2020, by age group, type of payer, and aggregated category of sleep disorders.

Figure 2

Hospitalization spending on sleep disorders by age group and sex. (A) Primary sleep disorder; (B) Secondary sleep disorder-Sleep apnea; (C) Secondary sleep disorder-Other (excluding G47.3).
Figure 3

Estimated parameters for spending by quantile regression versus linear regression. Black lines signify point estimates by quantile regression at 0.1, 0.25, 0.5, 0.75, and 0.9 quantiles (gray bands signify 95% confidence interval); red lines signify point estimates by linear regression (red dash lines signify 95% confidence interval).