Increasing public concern on insomnia during the COVID-19 outbreak in China: An info-demiology study

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ABSTRACT

Background: Since December 2019, an unexplained pneumonia has broken out in Wuhan, Hubei Province, China. In order to prevent the rapid spread of this disease, quarantine or lockdown measures were taken by the Chinese government. These measures turned out to be effective in containing the contagious disease. In spite of that, social distancing measures, together with disease itself, would potentially cause certain health risks among the affected population, such as sleep disorder. We herein conducted this web search analysis so as to examine the temporal and spatial changes of public search volume of the mental health topic of “insomnia” during COVID-19 pandemic in China.

Methods: The data sources included Baidu Index (BDI) to analyze related search terms and the official website of the National Health Commission of the People’s Republic of China to collect the daily number of newly confirmed COVID-19 cases. Following a descriptive analysis of the overall search situation, Spearman’s correlation analysis was used to analyze the relationship between the daily insomnia-related search values and the daily newly confirmed cases. The means of search volume for insomnia-related terms during the COVID-19 outbreak period (January 23rd, 2020 to April 8th, 2020) were compared with those during 2016–2019 using Student’s t test. Finally, by analyzing the overall daily mean of insomnia in various provinces, we further evaluated whether there existed regional differences in searching for insomnia during the COVID-19 outbreak period.

Results: During the COVID-19 outbreak period, the number of insomnia-related searches increased significantly, especially the average daily the BDI for the term “1 min to fall asleep immediately”. Spearman’s correlation analysis showed that 6 out of the 10 insomnia-related keywords were significantly positively related to the daily newly confirmed cases. Compared with the same period in the past four years, a significantly increased search volume was found in 60.0% (6/10) insomnia-related terms during the COVID-19 outbreak period. We also found that Guangdong province had the highest number of searches for insomnia-related during the pandemic.

Conclusions: The surge in the number of confirmed cases during the COVID-19 pandemic has led to an increase in concern and online searches on this topic of insomnia. Further studies are needed to determine whether the search behavior truly reflect the real-time prevalence profile of relevant mental disorders, and further to establish a risk prediction model to determine the prevalence risk of psychopathological disorders, including insomnia, using insomnia-related BDI and other well-established risk factors.

1. Introduction

In late 2019, an acute respiratory infection termed as coronavirus disease 2019 (COVID-19) emerged, giving rise to the initial outbreaks in China [1]. Thereafter, the World Health Organization (WHO) declared COVID-19 a pandemic in March 11, 2020 [2]. In order to contain this contagious disease from further spreading, Chinese central government decided to impose a lockdown in Wuhan from January 23rd, 2020 [3].
Starting from 10:00 on January 23rd, 2020, any non-essential transportation and travelling had been banned in this city [4, 5]. In other cities of China, similar “social distancing” measures were adopted thereafter within days, such as restriction of nonessential movement in and out of the place of residence, temporary closure of shops, restaurants, schools, and suspension of public transportation. In response to the centralized management, practically all the Chinese people were stuck at home. This restriction lasted for quite a long time, as not until April 8th, 2020, did Wuhan lift the transportation restriction, altogether lasting up to 76 days (January 23rd, 2020–April 8th, 2020). As of June 30th, 2020, COVID-19 has caused a huge social and economic burden in China, with 85,232 confirmed cases and 4,648 deaths [6]. Although COVID-19 is milder symptoms than severe acute respiratory syndrome coronavirus (SARSCoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), it is highly contagious [7]. As such, people are in threat of COVID-19 virus.

In addition to physical health burden, mental anxiety is another aspect associated with infectious disease pandemic and the corresponding restrictive lockdown and quarantine measures [8]. Mental symptoms like anxiety, depression, and insomnia have also been reported among the public during and after a disaster outbreak [9]. According to researches on severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), many medical staff experienced severe psychological trauma during the outbreak [10, 11]. During the COVID-19 pandemic, studies showed that not only medical staff was beset by insomnia and mental health [12, 13, 14, 15, 16], but ordinary people may suffer these problems [17, 18]. Take pregnant women in China as an example, a recent study revealed that during COVID-19, occurrence of psychological problems, including mild depression, mild generalized anxiety, sleeping disorders, and mild psychological stress was significantly increased when compared to before the outbreak [17]. Similar results were obtained from other countries, regions, and/or sub-population [19, 20, 21]. Based on a recent systematic review and meta-analysis, the corrected pooled estimated prevalence of sleep problems was 38% and 29% in female and male general population, respectively [22]. In another large-scale meta-analysis, it was also shown that the total prevalence of insomnia achieved up to 30.30% (95% CI: 24.60–36.60) [23]. In addition, a 25-minute online survey across 79 countries showed that over half adults aged 18–80 years reported significant insomnia symptoms during COVID-19 pandemic [18]. It is thus clear that sleep problem seems to have achieved a worrying level worldwide during COVID-19 pandemic. A better and timely surveillance of the prevalence of insomnia during the COVID-19 pandemic would provide important information on the occurrence and spread of related infectious diseases, such as AIDS [33], hand-foot-and-mouth disease [34], and dengue disease [35]. Based on the existing data demonstrating a potential association between sleep disorders and COVID-19 pandemic, we herein hypothesized that the surge in the number of confirmed cases due to COVID-19 spread would have an impact on sleep disorders, which would trigger an increase of search for insomnia-related terms. In addition, we hypothesized that there might exist a regional difference in web search for insomnia-related terms due to the regional heterogeneity of the impact and severity of this pandemic. To address these hypotheses, we conducted this web search analysis so as to examine the temporal and spatial changes of public search volume of the mental health topic of “insomnia” during COVID-19 pandemic in China.

2. Methods

2.1. Case data

This study collected the daily number of newly confirmed COVID-19 cases in China from January 20 to June 30, 2020. The data can be obtained from the official website of the National Health Commission of the People’s Republic of China [6].

2.2. Data from Baidu Index

BDI is an information platform for Baidu search engine users to share search behavior [36]. BDI is a weighted sum of search term frequency based on the daily search volume of each user’s search term (https://index.baidu.com/) and represent a relative value to reflect the ratio of the search volume of the keywords of interest in comparative period to that in baseline period [37]. Higher BDI value means higher search of specific terms [38]. In addition, the data can be collected in the form of country, province, city, daily, and weekly [35]. In BDI, different keywords would produce different search volume. Therefore, the choice of keywords becomes particularly important. Unfortunately, there are no clear rules or criteria for choosing search terms [39]. Previous studies have used disease names or clinical manifestations as search terms [29, 40, 41]. In this study, BDI can identify search terms and further analyze related search terms. This means that when Internet users enter search terms, other related search terms will be automatically provided. This, however, only helps obtain the search terms preliminarily. On the basis of this, relevant keywords can be further got access to through the Chinese website (http://stool.chinaz.com/baidu/words.aspx), in order to include as many relevant words as possible. We first input the search term “insomnia” to obtain other relevant terms. When it comes to keyword search, different words having the same meaning were adopted [39], whereas the recommended keywords but not related to insomnia were dropped [42, 43]. The obtained keywords having an extremely low search volume were also screened out. Finally these types of insomnia-related search terms included clinical symptoms, treatment, reason, and classifications (Table 1). BDI for these insomnia-related
terms was determined from January 20th, 2020 to June 30th, 2020 in the present study.

2.3. Statistical analysis

Normality of the data was assessed by Kolmogorov-Smirnov test and correspondingly parametric or non-parametric tests were used. As such, non-parametric Spearman’s correlation analysis was used to analyze the correlation between the daily insomnia-related BDI and daily newly confirmed cases. The insomnia-related BDI data for the last four years were summarized from January 23 to April 8, and the means of the BDI during the corresponding COVID-19 outbreak period in 2020 were calculated with every 7 days as a cycle. The two-period mean was compared using parametric independent t-test. The association between individual search trends of the insomnia-related terms and the daily new cases was graphed using Origin 2017 software. By analyzing the overall daily mean of insomnia in various provinces from January 23 to April 8, we further assessed whether there are regional differences among netizens searching for insomnia during the COVID-19 outbreak period. All the statistical analyses were conducted using Excel (Microsoft Corporation) and IBM SPSS (Version 20.0, IBM Corporation). And statistical significance was set as 0.05 (two-sided test).

3. Results

3.1. Descriptive analysis

Through BDI search, insomnia-related search statistics are summarized from January 20th, 2020 to June 30th, 2020 (Table 2). Among four categories comprising 10 keywords, it was found that the keyword “1 min to fall asleep” had prominently the highest daily average search index. Generally, the search volume for insomnia treatments was higher than that of other categories, suggesting an imperative public demand to obtain a solution to alleviate or eliminate sleep problems.

3.2. Year-on-year comparison

Kolmogorov-Smirnov test results showed that the search volumes of the insomnia-related terms during the COVID-19 outbreak period and those in the same period in the past four years were all normally distributed (all \( p > 0.05 \)), and thus student’s independent t-test was used for analysis. Compared with the same period in the past four years, a significant change in insomnia-related search volume was found during COVID-19 outbreak period (January 23rd, 2020 to April 8th, 2020) (Table 3). During the COVID-19 outbreak period, among others, 60.0% (6/10) search terms exhibited a statistically significant increase in BDI compared with the same period of the past four years, with the largest two percentage increases being “1 min to fall asleep” (439.9%; \( P < 0.001 \)) and “insomnia treatment” (212.38%; \( P = 0.004 \)). Overall, the insomnia-related search might be triggered by the COVID-19 and efforts to slow the spread of this disease.

### Table 1. Search terms related to insomnia in Baidu Index.

| Categories       | Search terms               |
|------------------|----------------------------|
| Clinical symptoms| Insomnia symptoms          |
|                  | Sleep disorders            |
|                  | Trouble falling asleep     |
| Treatment        | One minute to fall asleep  |
|                  | Insomnia remedies          |
|                  | Falling asleep quickly     |
|                  | A diet for insomnia        |
|                  | Insomnia treatment         |
| Reason           | How insomnia occurs        |
| Classifications  | Adolescent insomnia        |

### Table 2. The daily search statistics of Baidu search index for insomnia related keywords from January 20th to June 30th, 2020.

| Search term            | Mean (SD) | Minimum | Maximum |
|------------------------|-----------|---------|---------|
| Clinical symptoms      |           |         |         |
| Insomnia symptoms      | 161.02 (31.86) | 86      | 225     |
| Sleep disorders        | 764.93 (124.62) | 370     | 1025    |
| Trouble falling asleep | 405.67 (86.32) | 155     | 610     |
| Treatment              |           |         |         |
| One minute to fall asleep | 5028.37 (2358.20) | 2428 | 10930   |
| Insomnia remedies      | 210.83 (127.64) | 65      | 558     |
| Falling asleep quickly | 341.06 (63.01) | 199     | 593     |
| A diet for insomnia    | 53.79 (46.88) | 0       | 150     |
| Insomnia treatment     | 537.93 (491.81) | 67      | 1753    |
| Reason                 |           |         |         |
| How insomnia occurs    | 204.21 (44.46) | 100     | 311     |
| Classifications        |           |         |         |
| Adolescent insomnia    | 98.25 (33.47) | 0       | 155     |

### Table 3. The number of searches during the COVID-19 outbreak vs the same period of previous four years (from January 23rd to April 8th).

| Search terms         | BDI 2020 mean (SD) | BDI 2016-2019 mean (SD) | Percent change | \( P \) value |
|----------------------|--------------------|-------------------------|----------------|-------------|
| Clinical symptoms    |                    |                         |                |             |
| Insomnia symptoms    | 168.61 (24.706)    | 122.81 (11.419)         | 37.29          | <0.001      |
| Sleep disorders      | 803.99 (149.284)   | 491.26 (96.961)         | 63.48          | <0.001      |
| Trouble falling asleep | 435.00 (107.370)  | 392.03 (32.686)         | 10.96          | 0.229       |
| Treatment            |                    |                         |                |             |
| One minute to fall asleep | 6819.01 (2282.631) | 1263.01 (252.346)       | 439.9          | <0.001      |
| Insomnia remedies    | 298.18 (134.970)   | 269.96 (20.365)         | 10.45          | 0.508       |
| Falling asleep quickly | 367.21 (68.018)   | 365.97 (47.840)         | 0.34           | 0.961       |
| A diet for insomnia  | 69.03 (44.593)     | 63.08 (15.269)          | 9.43           | 0.683       |
| Insomnia treatment   | 881.21 (535.114)   | 282.10 (12.473)         | 212.38         | 0.004       |
| Reason               |                    |                         |                |             |
| How insomnia occurs  | 226.30 (35.751)    | 171.19 (11.955)         | 32.19          | <0.001      |
| Classifications      |                    |                         |                |             |
| Adolescent insomnia  | 105.42 (22.312)    | 83.00 (15.094)          | 27.01          | 0.012       |

3.3. Correlation analysis

Kolmogorov-Smirnov test results showed that most search volume of insomnia-related keywords and the number of daily newly confirmed cases were non-normally distributed (\( p \) ranging from <0.001 to 0.008), and thus Spearman’s correlation analysis was used to explore the correlation between insomnia-related search and the number of daily newly confirmed cases. The results showed that six out of the ten insomnia-related keywords were significantly positively related to the number of daily newly confirmed cases (Table 4). We also described the individual searches for the six terms related to insomnia, as well as the trends between them and the daily newly confirmed cases. It can be seen from Figure 1 that although their search frequencies are different, their trends are the same: all rise or fall as the daily number of newly diagnosed cases of COVID-19 rises or falls (Figure 1a–f). Since January 24th, the search volume had gradually increased and reached a peak. As the number of cases decreased, the search volume had gradually decreased and
Table 4. Spearman’s rank correlation analysis of insomnia-related search index and newly confirmed cases.

| Searched terms                        | r (P value) |
|---------------------------------------|-------------|
| Clinical symptoms                     |             |
| Insomnia symptom                      | 0.135 (P = 0.086) |
| Sleep disorders                       | 0.210 (P = 0.007) |
| Trouble falling asleep                | 0.102 (P = 0.196) |
| Treatment                             |             |
| One minute to fall asleep             | 0.639 (P < 0.001) |
| Insomnia remedies                     | 0.325 (P < 0.001) |
| Falling asleep quickly                | 0.499 (P < 0.001) |
| A diet for insomnia                   | 0.068 (P < 0.387) |
| Insomnia treatment                    | 0.185 (P = 0.018) |
| Reason                                |             |
| How insomnia occurs                   | 0.371 (P < 0.001) |
| Classification                        |             |
| Adolescent insomnia                   | 0.069 (P = 0.384) |

The search indexes of insomnia in various provinces during the COVID-19 outbreak period and cities from January 23rd to April 8th, 2020 were shown in Figure 2. Guangdong Province had the highest search index, while Taiwan had the lowest. In general, the highest volume of search for insomnia was seen in Eastern China, followed in turn by Northern, Central, Southwestern, Southern and Northeast China, and lowest search volume occurred in Northwestern China, including the Ningxia Hui Autonomous Region, the Xinjiang Uygur Autonomous Region, Qinghai, Shaanxi, and Gansu.

4. Discussion

During the COVID-19 pandemic, the daily lives and health status of the Chinese public would be hampered. In the present study, we provided evidence showing that search volume for many insomnia-related terms had changed significantly. This is compatible with a previous report showing that globally half reported significant insomnia symptoms [18], and another meta-analysis showing the surge of insomnia during this pandemic [23]. Among the four categories of ten insomnia-related terms, the search volume for the category of “treatment” ranked the top, with the terms “1 min to fall asleep” had the highest search volume. Further comparison between insomnia-related search volume during the COVID-19 outbreak period (January 23rd, 2020 to April 8th, 2020) and that during the same period of the previous four years (2016–2019) also revealed a significant increase of insomnia-related search in 2020, suggesting that the insomnia problem caused by COVID-19 and efforts to slow its spread, e.g., public health restrictions, is substantial, extensive and long-standing [8]. Long-term perceived stress from pandemic and corresponding lockdown or precautionary measures would severely affect the physical and mind health and result in a range of mental health problems such as anxiety, depression, and sleep disturbance. It is worth noting that these negative mental conditions are often closely related to each other with a high level of comorbidity rate, including during the period of COVID-19 pandemic [44, 45, 46]. Among the six dramatically increased search terms in BDI, “1 min to fall asleep” and “insomnia treatment” had the largest increase, indicating that netizens searching for insomnia should be given more appropriate psychological support [47]. Increased search volume of these terms may be due to insufficient medical resources in some areas at the beginning of the outbreak [48]. In addition, more than one-third patients live far away from their nearest hospital [49], which makes it difficult for patients to seek medical attention, and correspondingly triggers an increased online search queries for insomnia treatment through the internet. This indicated, to a certain extent, that most searchers in China have already suffered from insomnia and hope to learn about related diseases through online resources.

In order to further corroborate the influence of the pandemic on the quality of sleep, we further analyzed the correlation between the search volume of insomnia-related terms and that of daily newly confirmed cases. Our data showed that as the daily newly confirmed cases increased during the pandemic, the BDI of Chinese public searches for insomnia-related terms also increased. The frequency of Internet use by the Chinese public changes with the change of an event [50]. In terms of insomnia, the search volume has gradually increased since January 24th, which may be related to the gradual implementation of the large-scale quarantine of Wuhan and several cities by the Chinese government from January 23rd, 2020 [51]. This speculation was corroborated by a more recent study which showed that during the lockdown period in China, up to 38.1% patients undergoing ophthalmic consultation had insomnia symptoms [47]. Psychological hotline services set up in the early stage of the COVID-19 pandemic in Wuhan and Guangdong revealed that a substantial proportion of calls were related to insomnia and emotional problems [52]. The increase of search on sleep disorders under distancing measures was also frequently reported in other countries and regions [53, 54, 55]. Quarantine measures and a large number of negative news, especially the increase of newly confirmed and dead cases, may increase the incidence of mental health problems and mental illness among different groups of people [56]. In line with this, the significant temporal correlations between the daily number of newly confirmed cases and the daily visit rates for mental health disorders were also observed previously [57].

We found that although most areas were affected by insomnia during the pandemic period, the search volume still exhibited regional differences. For example, Eastern China has the largest search volume, while underdeveloped areas such as Northwestern China rank the last. People living in cities with large populations and developed economies in Eastern China searched for insomnia more frequently than those in cities with small populations and underdeveloped economies, indicating that developed areas were more subjected to social and economic impacts during the pandemic, and correspondingly people living within presented more distress and insomnia. Guangdong province was once affected by SARS [58], which might account for its higher search volume for insomnia than other regions. In spite of that, we are unable to exclude the potential difference of other confounders that influence the volume of insomnia-related search. These at least include the accessibility to internet and internet usage behaviors.

Collectively, this study suggests that there emerges a surge of insomnia related search among the public during the COVID-19 pandemic. The government and related institutions should focus on the insomnia-related info-demiology data, and take appropriate measures (e.g., online psychological services [59]) to alleviate this concern among the public during the COVID-19 pandemic. Given that the number COVID-19 related global deaths produces worse sleep quality and other mental disorders [57, 60], it is reckoned that the rapid increase of insomnia related search might truly reflect the real-time prevalence profile of these body-mind problems well. Further studies are needed to verify this assumption. And, if it is the case, future studies are also warranted to establish a risk prediction model to determine the prevalence risk of psychopathological disorders, including insomnia, using insomnia-related BDI and other well-established risk factors.

This study has several major limitations. Firstly, Since BDI data are limited to people using Baidu search engine, the sole use of BDI to collect data would bring about bias. Secondly, we cannot identify the detailed information of internet users. Other information searching sources, such as posts on Weibo, the largest social networking platform in China, should be applied in the future to complement the detail information of this topic. Thirdly, temporal sequence of the association analysis between
new cases of COVID-19 and web search on insomnia is warranted in the future study. Fourthly, since data provided by BDI does not represent a random sample of the population of interest, the selection bias seems inevitable, as the elderly constituting the age group having the highest COVID-19 risk are least likely to use the internet. Finally, year-on-year comparison and difference of regional distribution regarding insomnia-related search volume might be confounded by multiple factors, such as accessibility of the internet, and different characteristics of internet
users in different ages. Despite these limitations, our findings would potentially provide the government and healthcare department valuable information to facilitate their mental health intervention towards the public during the COVID-19 pandemic.

5. Conclusions

The surge in the number of confirmed cases during the COVID-19 pandemic has led to an increase in concern and online searches of insomnia problems. Further studies are needed to determine whether the search behavior truly reflect the real-time prevalence profile of relevant mental disorders, and further to establish a risk prediction model to determine the prevalence risk of psychopathological disorders, including insomnia, using insomnia-related BDI and other well-established risk factors.

Declarations

Author contribution statement

Yuying Chu; Wenhui Li: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.
Hongliang Dai: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.
Suyan Wang; Guizhi Jia; Yuqiang Zhang: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Additional information

No additional information is available for this paper.

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