RESEARCH ARTICLE
Seasonality of Obstructive Sleep Apnea in Asia: Insights from Google Trends
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ABSTRACT
Background and objectives: Obstructive sleep apnea (OSA) is the most common type of sleep-disordered breathing encountered in clinical practice and has considerable medical and psychosocial consequences. Snoring is the most common sign of OSA, yet it is most often ignored. Seasonal changes may lead to changes in body weight, pharyngeal flow, and frequency of allergies, which in turn leads to changes in the severity of OSA. The seasonal pattern of worsening of OSA can be demonstrated by the analysis of information-seeking behavior on the internet from a specific region. Google, the most popular search engine, indexes the queries with every search performed and makes this information available to the public through Google trends.

Materials and methods: In the current study, we used Google trends data to investigate the seasonal variation in sleep-disordered breathing in eight countries in the Asia-Pacific region (India, Hong Kong, Thailand, Singapore, Malaysia, Taiwan, Japan, and South Korea) from 2015 to 2020. The seasonality of queries for the term “snoring” was analyzed using the cosinor model.

Results: Peaks and troughs in trends of search volume index (SVI) or normalized search volume during the specific period for the term “snoring” were evident. There were significant differences in mean SVI values across the seasons. Cosinor models confirmed the seasonality for “snoring” in all countries in the study. The peak season for queries corresponded to the cold climate in the respective countries, with maximum amplitude seen in India.

Conclusion: Obstructive sleep apnea exhibits seasonality with increased severity in winter. The results of this study can guide targeted implementation of sleep awareness programs in winters to increase the awareness and the management of OSA across the Asian countries.

Keywords: Obstructive sleep apnea, Sleep apnea, Sleep-related breathing disorders.

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INTRODUCTION
Sleep-disordered breathing is an umbrella term for sleep-related breathing disorders, which include obstructive sleep apnea (OSA), central sleep apnea, and sleep-related hyperventilation. An OSA is the most common type of sleep-disordered breathing encountered in clinical practice and has considerable medical and psychosocial consequences.1 It not only impairs daytime function but is also associated with cardiovascular morbidity and mortality. Snoring is the most common sign of OSA, yet it is most often ignored.

It is now known that OSA can also be influenced by environmental factors.2 Seasonal changes may lead to changes in body weight, pharyngeal flow, and frequency of allergies, which in turn leads to changes in severity of OSA.3–5 Seasonal variability has also been demonstrated in diseases such as cardiovascular diseases, which show increased mortality in winters.6 Seasonal variability in OSA has mostly been shown in studies conducted in the pediatric population.7,8 Cassol et al. conducted a retrospective study in 7,523 adults who underwent laboratory polysomnography and found that the severity of OSA has a seasonal pattern, with peak severity noticed in winter.9

An alternative method to demonstrate the seasonal pattern includes analysis of information-seeking behavior on web in a specific region. It has been shown that internet search queries show seasonal and geographic variations that resemble the variations observed in the real-world population.10 These “big data” can provide a real-time insight into population behavior and thus guide the implementation of awareness strategies. Google, the most popular search engine, indexes the queries with every search performed and makes this information available to public through Google trends. Google trends have been used to study patterns and variations in health conditions such as influenza, depression, smoking, and restless leg syndrome.11–14 Ingram et al. used Google search engine data to demonstrate seasonal variations in internet search engine queries pertaining to snoring and sleep apnea in USA and Australia.15 However, no such studies have been conducted for countries in Asia-Pacific till date. In the current study, we intended to use Google trends data to investigate the seasonal variation in sleep-disordered breathing in 8 countries in the Asia-Pacific region (India, Hong Kong, Thailand, Singapore, Malaysia, Taiwan, Japan, and South Korea). The results from this study can guide the implementation of OSA awareness campaigns in the resource-constrained Asian countries.

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Materials and Methods

Data Selection

Google maintains historical logs (2004–present) of the search queries performed by the user and categorizes this information according to the term, time, and region. Google trends is a freely available web tool that makes this recorded information available to all. The system eliminates repetitive search queries from the same user performed in a short span of time. The volume of search queries for a pertinent term is expressed relative to the total number of search queries in the chosen time frame and region. The relative data are normalized and presented as search volume index (SVI) on a scale from 0 to 100, with individual values over time calculated by dividing each point on the graph by the highest value and multiplying by 100. In short, SVI is the normalized search volume of any specific query. Search queries can be filtered by topic to incorporate related searches as well.

We did a preliminary analysis of search volumes generated by the terms “snoring” and “sleep apnea.” “Snoring” generated larger volumes vs “sleep apnea” probably due to the simplicity of the term “snoring” and lack of awareness of the term “sleep apnea” in the non-English-speaking Asian population. We analyzed the search volumes of the word “snoring” in 8 countries in Asia, i.e., India, Hong Kong, Thailand, Singapore, Malaysia, Taiwan, Japan, and South Korea. We queried the Google trends for monthly results of the search volume for the term “snoring” from January 1, 2015 to July 22, 2020 for each country separately. Data were downloaded in xls format for the respective countries, and the data consisted of monthly SVI average for the term “snoring” from January 1, 2015 to July 22, 2020.

Seasons in the chosen 8 regions were defined according to the guidance issued by the meteorological department and/or government in the respective countries16–23 (Table 1).

Statistical Analysis

The downloaded Google trends data were analyzed using IBM SPSS v26. Initial analysis included the calculation of mean SVI for the specified term as per the seasons in the respective country. Entire data from January 1, 2015 to July 22, 2020 were included, and the mean values were calculated separately for each region. Graphs showing the trends of SVI for the term “snoring” from January 1, 2015 to July 22, 2020 were plotted separately for each country. Box plots were plotted with month number on x-axis (no years included) and SVI on y-axis. This was done to observe the trends before subjecting the data to cosinor analysis.

To analyze the seasonal variations, we fitted the data to sinusoidal function (cosinor model), using the R version 3.6.3. The cosinor model consists of fitting a linear regression where SVI of “snoring” for a specific country was regressed onto sine and cosine transformation of time. In this case, time refers to the monthwise data of SVI for “snoring” from January 1, 2015 to July 22, 2020 (each year consisted of 12 data points for SVI corresponding to twelve months in a year). The month corresponded to the month number of the year. For example, month 1 represented January, month 2 represented February, and so on. The resulting sinusoid consists of an amplitude (A) which refers to the magnitude of seasonal change, phase month (IP) timing of the peak, and length of seasonal cycle (12 for monthly data). As sinusoid is a part of the generalized linear model, it allows for the calculation of statistical significance. The significance level was set at \( p < 0.025 \) for controlling the type I error due to multiple testing in the cosinor analysis. The primary outcome was timing of the peak of SVI for the term “snoring” in the selected eight countries.

Results

Means of SVI for “snoring” of each country according to seasons in the specific country are presented in Table 2. Means of two different countries cannot be compared as the search volume is expressed relative to the search queries for the specified country. Graphical trends are presented in Figure 1. On visual inspection, peaks and troughs in the trends of SVI in the specific period for the term “snoring” are evident. For assessing the monthly SVI pattern throughout the study duration, we plotted SVI on y-axis vs month number on x-axis (Fig. 2). On the x-axis, 1 represented SVI in January, 2 represented SVI in February, and so on.

Table 1: Seasons and seasonal duration in the selected eight countries in the Asia-Pacific region

| Country    | Number of seasons | Seasonal distribution across the year as defined by the respective meteorological department/Government agencies/reliable sources |
|------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------|
| India      | 4                 | Winter: January–February, Premonsoon: March–May, Monsoon: June–September, Postmonsoon: October–December |
| Hong Kong  | 4                 | Winter: December–February, Spring: March–May, Summer: June–August, Autumn: September–November |
| Japan      | 4                 | Winter: December–February, Spring: March–May, Summer: June–August, Autumn: September–November |
| South Korea| 4                 | Winter: December–February, Spring: March–May, Summer: June–August, Autumn: September–November |
| Malaysia   | 2                 | Southwest monsoon: May–September, Northeast monsoon: November–March |
| Singapore  | 2                 | Southwest monsoon: May–September, Northeast monsoon: November–March |
| Taiwan     | 4                 | Winter: December–February, Spring: March–May, Summer: June–August, Autumn: September–November |
| Thailand   | 3                 | Winter: mid-October to mid-February, Summer: mid-February to mid-May, Rainy season: mid-May to mid-October |

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Cosinor models confirmed the monthly trends for “snoring” in all countries in the study (Fig. 3). Seasonality was confirmed by values of cosinor models (amplitude, phase, and \( p \) value < 0.025). (Table 3)

**Discussion**

To the best of our knowledge, our study is the first study to look at the trends of search queries for sleep-disordered breathing in the Asian countries. Similar to a study conducted in the USA and Australia, our study showed a significant seasonal pattern for the search queries pertaining to “snoring” in the selected Asian countries.19 This study adds to the scarce evidence on sleep-disordered breathing in Asia.

It is also important to look at the amplitude and phase month in addition to seasonality. The phase month (or the peak month) for all countries except Malaysia lies in the range from 12.4 to 1.7, corresponding to the month of December and January. These two months correspond to winters in the selected countries. The phase month of Malaysia might be explained by the proximity of the country to the Equator and the monsoon-predominant climate. It is indeed interesting to notice that the phase months of two neighboring countries, Malaysia and Singapore, are different: responsible factors may include population size and area of Singapore, which are relatively smaller as compared to Malaysia. For India, the phase month for queries was 12.8, which refers to the period near the end of December and the beginning of January. This period corresponds to winter in India, with many regions experiencing record low temperatures. The low point month, i.e., 6.8 in India, corresponds to the advent of monsoon and is characterized by warm humid weather. The phase months in Japan, Hong Kong, Taiwan, Thailand, and South Korea can be explained by a similar logic.

Of the countries selected, the SVI of “snoring” in India showed the highest amplitude, implying the extent of increase in search queries for the specified term. The three countries, i.e., Thailand, Singapore, and Malaysia have the lowest amplitude of seasonal change in queries as compared to other selected countries, probably due to their location near the equator (that leads to relatively warm climate), and the distinct seasonal patterns.

There are several plausible explanations of OSA and snoring in winter season. Risk factors of OSA such as obesity, alcohol consumption and tobacco consumption are influenced by seasons.24-26 With regard to obesity, it has been observed that body mass index and neck circumference increase in winters, probably due to decreased physical activity and increased caloric intake.5,27 Alcohol consumption, which leads to relaxation of upper airway muscles, has been found to peak in winters.28,29 Tobacco consumption and smoking, on other hand, decreases in cold climate, and this can be expected to alleviate the severity of OSA.30 Increased air pollution in winters is an important risk factor and can lead to increased upper airway inflammation, thereby worsening OSA.31,32 Hence, majority of patients with severe OSA presented to a sleep clinic in a cold season.9

There is a potential strategic implication of our study, which will be useful for governments, sleep societies, and medical device manufacturers. Google trends gives us an estimate of the population interest for a term, and identification of these population interests might be useful in generating awareness in the specified population through awareness campaigns, blogs, and videos. The potential to change the health-seeking behavior and generating awareness is highest when the population is interested in it. A consumer-marketing strategy, search engine optimization, can be used during the phase month (which falls mostly in winter) to deliver the right information at the “right” time. The results from our study can be used to select appropriate time for such public OSA awareness campaigns in Asian countries. Physicians play a key role in the diagnosis of sleep-related disorders, and hence, international sleep societies can drive targeted physician education programs during this season. The synergy of public interest in “snoring” and physician skills will possibly lead to better management of OSA across the Asian countries. The trends can help sleep physicians to identify the appropriate time for interventions in patients with OSA, thereby possibly improving the lifestyle factors and compliance with CPAP therapy.

There are several limitations to our study. First, Google trends does not capture the demographic details, and hence, it is not possible to do an additional analysis depending on the age, sex, residence, and income level. Second, it is assumed that the trends in Google trends are representative of the actual disease activity. This assumption cannot be verified or proved. However, a study has shown the correlation between Google queries and epidemiologic data in 2005–2006 for the flu season, and this was the basis for assumption in the current study as well.33 Third, we only used the term “snoring” in the selected Asian countries, where search engines

**Table 2: Means of search volume index of the selected eight countries according to the seasons**

| Country   | Winter       | Premonsoon/Spring | Monsoon/Summer | Postmonsoon/Autumn |
|-----------|--------------|-------------------|----------------|-------------------|
| India     | 81.83 ± 11.915 | 41.94 ± 7.635   | 35.50 ± 3.143 | 59.93 ± 17.906   |
| Hong Kong | 63.29 ± 18.821 | 46.72 ± 12.722   | 37.59 ± 8.860 | 39.20 ± 8.695    |
| Japan     | 81.94 ± 10.238 | 78.39 ± 7.366    | 61.06 ± 6.240 | 71.67 ± 9.271    |
| South Korea | 67.35 ± 12.614 | 63.83 ± 14.952  | 40.24 ± 10.152 | 53.40 ± 17.852  |
| Malaysia | 66.18 ± 12.679 (South west monsoon) | 70.11 ± 13.242 (Northeast monsoon) | 7.366 ± 7.635 | 61.06 ± 15.702       |
| Singapore | 66.14 ± 11.280 (South west monsoon) | 77.71 ± 13.131 (Northeast monsoon) | 12.555 ± 7.366 | 39.20 ± 8.695       |
| Taiwan    | 79.29 ± 12.368 | 58.50 ± 15.443  | 44.12 ± 8.717 | 51.20 ± 10.557   |
| Thailand  | 74.96 ± 14.284 (Winter) | 62.11 ± 12.555 (Summer) | 8.12 ± 7.635 | 71.67 ± 9.271       |
Despite its limitations, this study points towards the seasonality of severity of OSA in the population, as indicated by the search queries. The results of this study can guide targeted implementation of sleep awareness program in winters to increase the awareness and management of OSA across the Asian countries.
Figs 2A to H: Monthwise trends in search volume index (SVI) patterns from January 1, 2015 to July 22, 2020 for the term “snoring” from eight countries in Asia-Pacific.
Figs 3A to H: Cosinor analysis showing seasonality in search volume index (SVI) for “snoring” in eight countries in Asia-Pacific.
Table 3: Amplitude, phase, and p values for the seasonal variation in search volume index for the term “snoring”

| Country    | Amplitude | Phase month | Low point month | p value |
|------------|-----------|-------------|-----------------|---------|
| India      | 24.44     | 12.8        | 6.8             | < 0.0001|
| Hong Kong  | 12.89     | 1.4         | 7.4             | < 0.0001|
| Japan      | 11.97     | 1.7         | 7.7             | < 0.0001|
| Malaysia   | 6.21      | 10.7        | 4.7             | < 0.025 |
| Singapore  | 8.27      | 12.8        | 6.8             | < 0.0001|
| South Korea| 14.35     | 1.7         | 7.7             | < 0.0001|
| Taiwan     | 19.97     | 1.4         | 7.4             | < 0.0001|
| Thailand   | 8.68      | 12.4        | 6.4             | < 0.025 |

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