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The impact of social isolation on sleep disturbances – evidence from geospatial big data during COVID-19

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Abstract:

Social isolation and loneliness are among the foremost public health issues of our time, particularly during the COVID-19 pandemic. Social psychology studies have suggested that compromised quality of sleep mediates the association between persistent loneliness and adverse health conditions. Animal experiments have shown that the mechanisms underlying social isolation-induced sleep loss are social isolation duration dependent and are under circadian and seasonal influences. Although animal studies have started to reveal the genetic and neural basis of chronic social isolation-induced sleep loss, investigating the true relationship between sleep disorders and the environment under isolation in animals remains challenging. Comparative studies using human data are crucially needed to ensure that the research findings in animal experiments can be validated and applied to human beings. However, traditional psychology research on sleep using individual human subjects is survey-based, limited in sample sizes, and time-consuming.

The emergence of social media has enabled billions of Internet users to share their feelings and discuss "what's happening" anytime at any place. Consequently, user-generated data from popular social media platforms, e.g., Twitter, offer a unique lens at an unprecedented size and speed to observe human behaviors under various influences and environments. These data are naturally time-stamped and geo-tagged, making them suitable for time series and geographical analyses. For example, recent studies demonstrated that Twitter data could be used to determine the phase, period, and amplitude of circadian rhythmic oscillations and daily activity patterns, which are critical factors for defining sleep by neurobehavioral approaches. Geographically resolved Twitter data can also be matched to the historical information of the local seasons and policies, which allow us to construct social isolation conditions (lockdown policy) of different seasons and durations (lengths of lockdown).

This study proposes to use the geospatial big data from Twitter to investigate the effect of social isolation triggered by the COVID-19 lockdown on sleep disturbances at human population levels. The objectives of this project are: (1) to develop a framework for mining location-based sleep disturbances (e.g., sleeping late behaviors) from social media data; (2) to investigate the social, geographical, seasonal, and political disparities of isolation and sleep disorders detected from social media. We hypothesized that: (a) as observed in animal research, social isolation during the pandemic lockdown impacts sleep on human population levels; (b) the degree of the impacts is potentially correlated with the local season/climate conditions and the strength/duration of lockdown policies.

This research consists of three steps (Figure 1a). The first step is Twitter data collection and cleaning. Complete geo-tagged Twitter data from 2019 to 2021 were obtained using the Twitter Academic API v2. The initially collected data were preprocessed to exclude tweets outside of the United States or posted by non-public users. Second, we spatially joined each tweet with cities and used the city as the spatial unit for the subsequent analysis. The top ten cities with the largest number of tweets were selected as the study area (Figure 1b), including Los Angeles, Houston, Chicago, Manhattan, Brooklyn, Philadelphia, Atlanta, Dallas, Washington D.C., and San Antonio, with annual tweets ranging from 2.3 million to 8 million. Third, the temporal variations of proportions of daytime and nighttime tweets, which reflect the circadian sleep rhythms of Twitter users, were computed. Tweets posted between 6 am to 6 pm are considered daytime tweets, while Twitter messages published through the night from 6 pm to the morning before 6 am are categorized as nighttime tweets. The daytime/nighttime tweeting behaviors in 2019 were used as baseline information to normalize the tweeting circadian rhythms during 2000-2021. We computed the monthly proportions of daytime and nighttime tweets in each city to infer the temporal dynamics of the circadian activities of Twitter users. Finally, the associations of disturbances of the circadian activities of Twitter users with the strictness of lockdown policies and the environmental conditions during each pandemic phase were examined.

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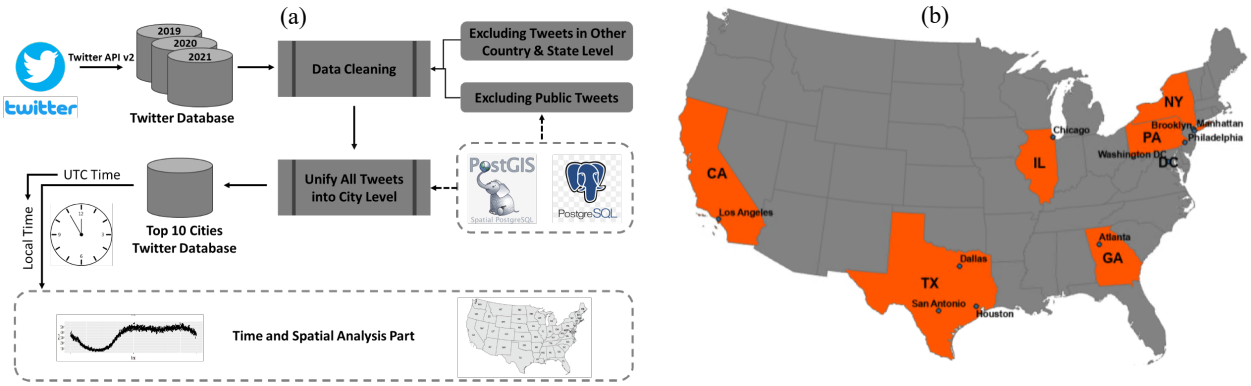

Figure 1. (a) The framework of Twitter data mining for analyzing city-level sleep circadian rhythms; (b) the selected ten cities with the largest amounts of tweets from 2020-2021.

The temporal variations of the proportions of daytime and nighttime tweets from 2020 to 2021 in the selected ten U.S. cities are summarized in Figure 2. During the first wave of the COVID-19 outbreak in the U.S. from March to May 2020 (shaded areas in Figure 2a), the proportions of nighttime tweets significantly increased by an average of 5% compared with the proportions in January (the pre-pandemic period) in all ten cities. The ratios of nighttime tweets decreased to the pre-pandemic levels since June 2020. The results confirm that more Twitter users remained active during nighttime due to the isolation caused by the lockdown policies during COVID-19. This phenomenon was most significant when the lockdown policy was the strictest.

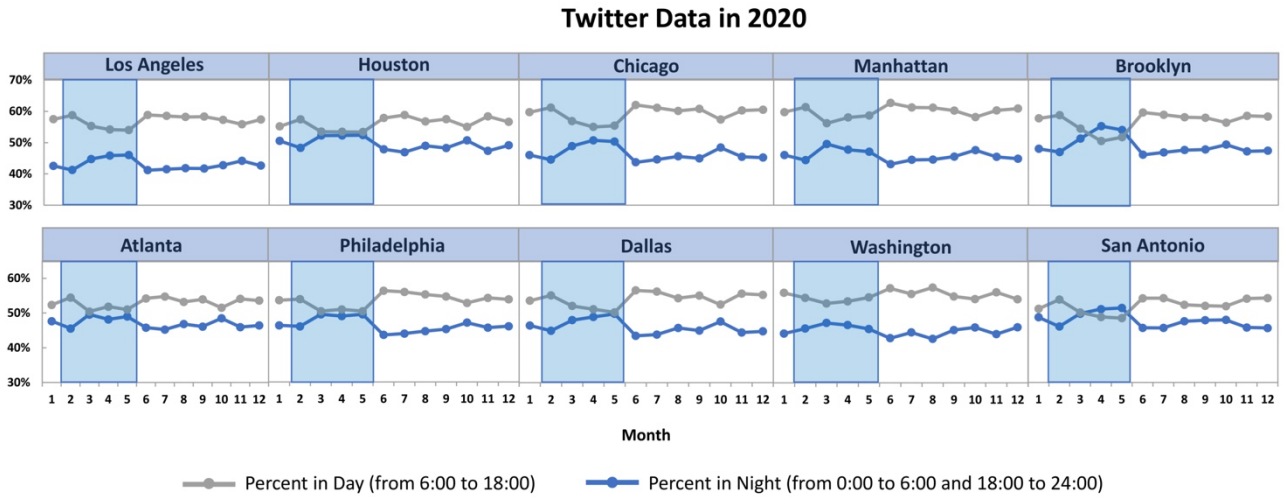

Figure 2. The temporal dynamics of the proportions of daytime/nighttime tweets in the top ten U.S. cities in 2020.

This research yields significant results and offers broad impacts. First, it raises awareness for social isolation-associated mental health issues that have been exacerbated during the pandemic. Second, knowledge learned from human-derived big data will guide future animal research, the results of which will be ultimately used for designing interventions to alleviate the suffering caused by social isolation and loneliness.

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