

## MINI-REVIEW

# Do face masks prevent yawning? A key factor to consider in sleep research

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## Abstract

The COVID-19 pandemic has resulted in widespread face mask usage to curb disease spread. However, an unintended effect is that masks may contribute to sleep disturbances. Since sleep and excessive sleepiness are closely connected to yawning, the typical design of face masks might restrict jaw movement, thereby altering normal yawning behavior. Moreover, masks can interfere with contagious yawning by making it harder to recognize yawns in social and community environments. Yawning influences alertness and facilitates transitions between wakefulness and sleep—particularly through thermoregulation—wearing face masks, theoretically restricts jaw movement. Factually, face masks also impede the occurrence of contagious yawning by obstructing the visual detection of yawns. While altering airflow dynamics, face masks may disrupt the counter-current heat exchange with the external environment, a process integral to yawning. Face masks can potentially introduce clinical uncertainties and subtle statistical biases in epidemiological studies and clinical trials. In this review, these theoretic and factual points are used to support the hypothetical mechanism proposed. This paper explores the possible sources and hypothetical mechanisms of such bias. The proposed hypothesis carries potential implications for ongoing clinical trials, the interpretation of retrospective and prospective data across different contexts, the reassessment of sleep disorder diagnostic criteria, standards for systematic reviews, meta-analyses comparing data from before and after COVID-19, and, crucially, the reevaluation of previous findings and comparative research. This paper provides a conceptual discussion identifying possible sources of bias, rather than a systematic or quantitative analysis.

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## 1. Introduction

Yawning is strongly linked to the shifts between sleep and wakefulness, as well as excessive sleepiness.<sup>1,2</sup> It is a physiological reflex marked by a sudden cycle that follows a typical pattern of movements lasting about six s.<sup>3</sup> This involuntary behavior involves widely opening the jaw with a deep breath-in, reaching a peak in muscle contraction, and then passively closing the jaw during exhalation. Comparative evolutionary studies indicate that yawning has several roles, such as aiding transitions between physiological states, regulating alertness levels, and improving brain temperature control through processes

like intracranial blood flow and counter-current heat exchange.<sup>4</sup> Moreover, yawning exhibits social contagion in humans and some animals, which helps coordinate group behaviors and alertness.<sup>5,6</sup>

Consistent with the functional role of yawning, recent research shows that drowsiness—an indicator of lowered alertness and vigilance—is the main trigger for yawning. Furthermore, self-reported feelings of sleepiness have been found to predict yawning behavior.<sup>7</sup> Yawning frequently occurs during transitions between sleep and wakefulness, and an increased yawning rate may indicate sleep deprivation.<sup>8</sup> Boredom, known to precede yawning,<sup>9</sup> happens when environmental stimuli fail to maintain a person's attention. This state also promotes drowsiness by activating sleep-inducing mechanisms.<sup>10</sup> Additionally, recent studies suggest that the chance of contagious yawning is strongly affected by individuals' self-reported sleepiness levels.<sup>11</sup>

A potential relationship between yawning and rapid eye movement (REM) sleep has been proposed from both phylogenetic and ontogenetic perspectives.<sup>12–15</sup> Empirical evidence has demonstrated a parallel trajectory linking the frequency of yawning with the duration of REM sleep.<sup>16–18</sup> Furthermore, the rhythmic pattern of yawning has been shown to induce predictable alterations in brain wave activity, as measured by electroencephalography (EEG).<sup>19,20</sup> Specifically, yawning has been found to modulate slow-wave activity within sleep EEG recordings.<sup>20</sup> In one investigation, individuals experiencing excessive sleepiness exhibited spontaneous yawning while attempting to maintain alertness in a dimly lit and quiet environment.<sup>19</sup> These yawning episodes were correlated with increased delta activity in the EEG relative to other movements, both preceding and following the yawning event. Additionally, post-yawning EEG recordings revealed a significant reduction in alpha rhythms, characterized by a deceleration and a spatial shift toward central brain regions.<sup>19</sup>

Beyond the well-documented and consistent correlations between yawning and factors such as sleep propensity, sleep disorders, and various sleep stages, the physiological mechanisms underlying yawning are also implicated in thermoregulatory processes.<sup>21</sup> Moreover, atypical or excessive yawning patterns have been associated with a range of medical conditions, including epilepsy, multiple sclerosis, stroke, and systemic lupus erythematosus.<sup>10,22</sup> From a neuropharmacological standpoint, multiple neurotransmitters and neurohormones are integral to the initiation and modulation of yawning. These substances encompass dopamine, acetylcholine, serotonin, glutamate, opioids, oxytocin, gamma-aminobutyric acid (GABA), nitric oxide, adrenergic agents, as well

as proopiomelanocortin-derived peptides such as adrenocorticotropic hormone (ACTH) and alpha-melanocyte-stimulating hormone ( $\alpha$ -MSH). Importantly, despite the involvement of this diverse neurochemical repertoire, yawning is predominantly regulated by at least three distinct pathways, which appear to converge on cholinergic neurons within the hippocampus.<sup>23</sup> Additionally, the phenomenology of yawning demonstrates marked differences between physiological and pathological states.<sup>14</sup> For a more exhaustive examination of these interrelations, readers are recommended to refer to recent comprehensive review articles that address these topics in greater detail.<sup>22–26</sup>

In this paper, a search strategy applied. A set of keywords was employed, using only one combination for each search. The algorithm used to create the search combinations was structured as follows: (“face mask” AND (“temporomandibular joint”) OR (“jaw movement”) OR (“jaw mobility”) OR (“jaw motion”) AND (“yawning” OR “yawn” OR “yawning behavior”)).

Due to the specialized nature of our subject, we chose to conduct a wide-ranging search across five databases, namely PubMed, Embase, EBSCO, Web of Science, and Google Scholar.

## 1.1. Hypothesis

The inhibition of conventional yawning behavior resulting from face mask usage may serve as a confounding factor in sleep studies.

Yawning, characterized by its morphological and neurological complexity, plays a vital role in regulating key daily functions and mental states, particularly those involving transitions in arousal and shifts between sleep and wakefulness. Within this framework, we propose that the widespread use of face masks during the COVID-19 pandemic may impede or modify this adaptive mechanism in many ways (Figure 1), thereby representing a potential factor to consider in sleep research conducted during or after the pandemic period.

The majority of masks designed to reduce COVID-19 transmission are fabricated from materials that closely cover the mouth, a configuration suspected of restricting mandibular movement.<sup>27,28</sup>

Two works conducted during the COVID-19 pandemic—including one involving radiological and questionnaire assessment<sup>28</sup> and a review paper<sup>29</sup>—conclude that long-term face mask wearing during this period has significantly restricted temporomandibular joint movement, the primary joint responsible for yawning. Another prospective experimental study concluded that

face masks use during the COVID-19 pandemic was significantly correlated with restricted temporomandibular joint (TMJ) movements and discomfort, and an increase in its use was associated with restricted TMJ movements, discomfort, and increased masseter muscle activity,<sup>30</sup> which in turn significantly changes the yawning pattern.<sup>31,32</sup>

In some cases, such as early class III protraction face mask treatment, it has been shown that conventional yawning patterns may be affected by the limited jaw mobility.<sup>33</sup> Specifically, the application of a tightly fitted mask may entirely inhibit the initiation of yawns and diminish their intensity or duration once initiated.<sup>33,34</sup> Furthermore, because face masks alter airflow dynamics, they may disrupt the counter-current heat exchange with the external environment, a process integral to yawning.<sup>35</sup> Consequently, the prevalent use of face masks may potentially alter fundamental spontaneous yawning behaviors at the individual level, potentially leading to reductions in both the frequency and intensity of yawning. Such modifications could subsequently impact sleep onset, sleep duration, and subjective fatigue levels.

Furthermore, face masks impede the occurrence of contagious yawning by obstructing the visual detection of yawns.<sup>36</sup> Empirical studies suggest that spontaneous yawning primarily functions to regulate normal sleep-wake cycles,<sup>9,37</sup> whereas contagious yawning may facilitate increased alertness and the synchronization of sleep transitions among group members.<sup>4</sup> It is noteworthy that during the pandemic, various types of face masks, such as N95, cloth, and FFP2/FFP3 masks,<sup>38</sup> were used, each affecting the TMJ, hypoxemia, and hypercapnia differently.<sup>39,40</sup> It is interesting to know that all these variables are significantly associated with yawning behavior and sleep.<sup>41,42</sup>

Therefore, the widespread use of face masks may carry important social consequences for the initiation of sleep and the experience of fatigue. Based on these observations, we propose that mask wearing constitutes a significant factor that could introduce clinical complexities and should be considered a potential variable in epidemiological research related to sleep.

## 2. Assessment of the hypothesis: Key considerations regarding face mask usage and yawning

Given the notable similarities and differences observed in the contexts of face mask usage, yawning behavior, and sleep quality across various environments, this paper provides a concise summary of critical factors to be taken into account during the COVID-19 pandemic that may

influence the outcomes of sleep research. It should be noted that this overview does not address biases directly attributable to the COVID-19 pandemic itself.

- (i) Gender and affiliation: Recent research indicates that women tend to exhibit a more responsible attitude toward COVID-19 compared to men.<sup>40,43</sup> The majority of studies suggest that men are generally less compliant with face mask usage, although exceptions exist.<sup>44</sup> This generally more casual approach among men regarding mask wearing may contribute to an increased COVID-19 risk profile.<sup>45</sup> Regarding spontaneous yawning, no significant differences have been observed between men and women,<sup>46</sup> and most evidence on contagious yawning in humans similarly indicates no gender disparity.<sup>3</sup> However, a contentious study reported that women might be more susceptible to contagious yawning,<sup>47</sup> which, if substantiated, could imply that women are more affected by the presence of face masks. In a related context, a recent study examining gender differences in the relationship between smartphone use and sleep quality revealed a range of heterogeneous socioeconomic factors; notably, the negative correlation between smartphone use and sleep quality was predominantly driven by women.<sup>24</sup> Observational research has demonstrated that the strength of social bonds serves as a significant predictor of yawn contagion, with the highest incidence of contagious yawning observed among friends and family members.<sup>48</sup> Although this phenomenon may be influenced by variations in social attention—where individuals are more likely to perceive the yawns of those in close social proximity,<sup>6</sup> the implementation of face masks is anticipated to modify the frequency of yawn contagion, particularly in social contexts characterized by close interpersonal affiliations.
- (ii) Age: The sociodemographic patterns of mask usage during the COVID-19 pandemic vary between younger and older adults.<sup>49–51</sup> Specifically, older individuals tend to wear masks more consistently, often most or all of the time. For instance, individuals aged 55 years and above have been reported to exhibit significantly higher likelihoods of mask-wearing adherence,<sup>52</sup> indicating greater compliance with recommended preventive measures among the elderly population relative to their younger counterparts.<sup>53</sup> In this context, older adults tend to yawn less frequently than younger individuals,<sup>7</sup> particularly during the morning and mid-afternoon periods. Similar to younger subjects, older individuals predominantly yawn upon awakening and prior to sleep; however, they exhibit an earlier peak in the morning and an increase in yawning during the evening.<sup>7</sup> Similar to younger subjects, older

individuals predominantly yawn upon awakening and prior to sleep; however, they exhibit an earlier peak in the morning and an increase in yawning during the evening.<sup>54,55</sup> Additionally, a comparable negative correlation between yawn contagion and age has been reported in previous studies. These age-related behavioral differences, specifically regarding face mask-wearing habits and the frequency and timing of yawning, indicate that among regular mask users, younger individuals may be more susceptible to the adverse effects associated with mask usage.<sup>56</sup>

- (iii) Occupation settings: Although merely 2.3% of the Chinese workforce reported experiencing insomnia, 58% of frontline medical personnel indicated suffering from severe insomnia.<sup>57</sup> Comparable variability has been documented in other nations; for instance, in Italy, the prevalence of insomnia has been reported to range between 37.6% and 57%.<sup>58</sup> During the COVID-19 pandemic, many individuals working night shifts were mandated to wear face masks. Yawning occurs with greater frequency during the early morning and late evening hours, corresponding to periods near sleep onset and immediately following awakening. This pattern supports the hypothesis that yawning serves as a behavioral indicator of sleep propensity, with its temporal distribution differing according to chronotype.<sup>2</sup> Variability in contagious yawning among individuals is believed to be influenced by multiple factors, including an individual's inherent tendency to yawn spontaneously and elevated levels of sleepiness.<sup>4</sup> Consequently, the contagious nature of yawning fluctuates throughout the day. Both spontaneous and contagious yawning reach their peak during early morning and late evening, aligning with the circadian rhythm of sleepiness.<sup>7</sup> Therefore, disruptions in yawning behavior attributable to face mask usage may disproportionately affect workers in specific occupational groups, potentially interacting with variations in sleep-wake cycles. Supporting this perspective, night shift workers, particularly healthcare professionals, face an increased risk of both COVID-19 infection and sleep-related disorders.<sup>59-63</sup>

Individuals use different types of face masks (e.g., N95, cloth, and FFP2/FFP3), and the duration of mask wearing varies among individuals. This heterogeneous pattern of face mask use can potentially affect yawning behavior, its visibility, and contagiousness, which may consequently introduce a confounding effect in sleep studies. Various interactions between different variables of levels A and B can potentially create bias, especially in non-randomized studies.

### 3. Discussion

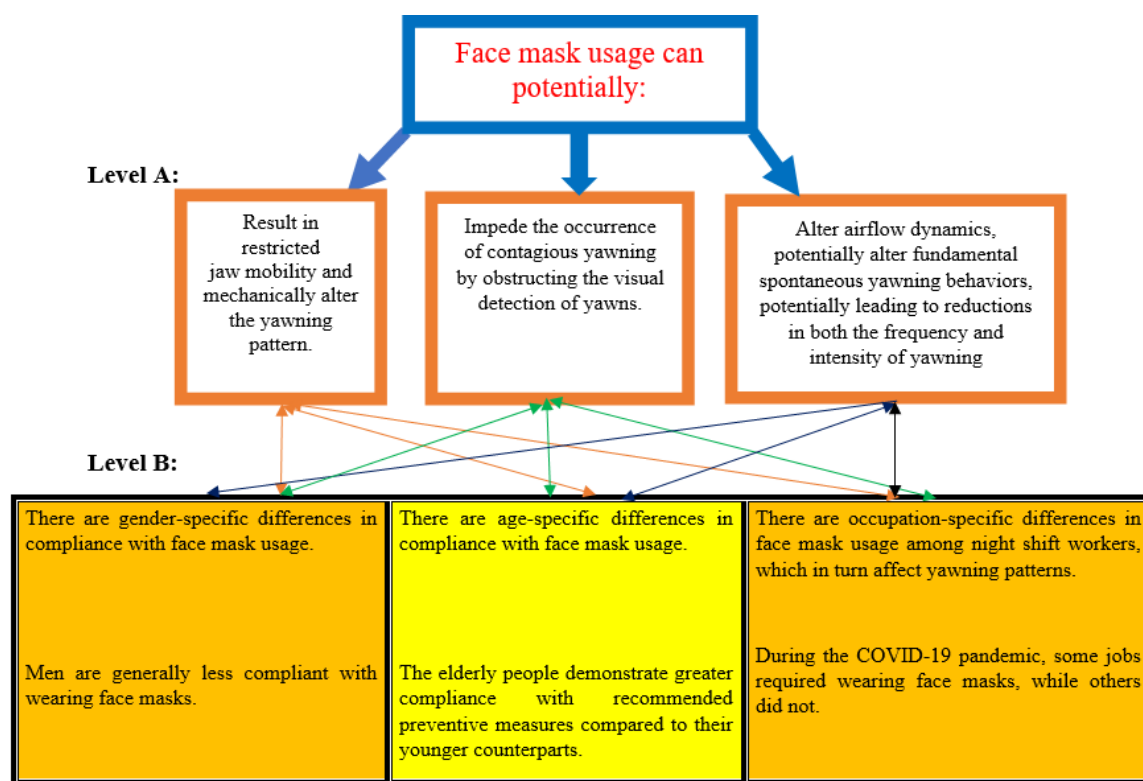
There is a lack of direct empirical evidence to sufficiently support this hypothesis. Currently, there is a gap in the literature supporting the following claims:

- (i) That yawning frequency or intensity is objectively reduced when people wear masks;
- (ii) That such changes, if present, are substantial enough to influence sleep propensity, EEG measures, or clinical endpoints;
- (iii) That mask-related change in the perception of others' yawns meaningfully alters group-level sleep-wake patterns.

Future studies may focus on exploring the aforementioned points. Also, re-analysis of data from past studies may be insightful for future preparedness.

In summary, we propose that the use of face masks may potentially influence the outcomes of sleep-related clinical and epidemiological research, primarily by affecting the occurrence or perception of yawning, both self-experienced and observed in others. These outcomes include, but are not limited to, self-reported and objective total sleep time, sleep latency, sleep efficiency, sleep fragmentation, apnea-hypopnea index, sleep microarchitecture, breathing disturbances and disorders, airflow dynamics, and absenteeism. This potential bias could interact with or modify results across diverse individuals and contexts, necessitating careful consideration during data analysis to distinguish authentic sleep disorders from those confounded by mask usage. Given the considerable international variability in COVID-19 prevention and mitigation policies,<sup>64</sup> the impact of face masks on sleep studies should be assessed in relation to the specific populations sampled. Furthermore, variations in mask-wearing practices and techniques across different community settings warrant attention.<sup>65-68</sup> Future research should aim to quantify the extent of mask use within existing datasets, and appropriate statistical adjustments and methodological strategies should be implemented to prevent misinterpretation of clinical and epidemiological findings.

The potential influence of face mask usage on yawning behavior, and consequently on sleep patterns, is likely associated with factors including the duration of mask wearing, frequency of mask replacement, as well as the mask's thickness, material composition, sealing quality, and fit tightness.<sup>69</sup> Although the potential implications of this bias have been briefly addressed herein, further empirical investigation is warranted. Beyond influencing thermoregulation and modulating arousal or vigilance through changes in the frequency, timing, intensity, and/or



**Figure 1.** A brief summary of hypothetical mechanisms by which face mask usage may alter yawning patterns and, consequently, affect sleep studies. Image created by the author.

counter-current heat exchange associated with yawning—mechanisms that are well established—additional hypothetical ways in which face mask usage may subtly affect sleep studies include the induction of dyspnea, hypercapnia, hypoxia, and/or headaches following mask wearing.<sup>69</sup> Moreover, it is established that in systemic conditions such as Sjögren's syndrome, face mask-induced ocular dryness may compound pre-existing dry eye symptoms, thereby exacerbating sleep disturbances.<sup>70</sup>

If it is proven that face mask use meaningfully impedes yawning, this potential interaction may obscure the underlying pathophysiological mechanisms associated with other etiologies and consequently delay appropriate therapeutic interventions.

#### 4. Conclusion

This paper explores the hypothesis that widespread face mask usage during and after the COVID-19 pandemic may theoretically inhibit yawning—both spontaneous and contagious—and thereby bias the assessment of sleepiness, sleep-wake transitions, and sleep-related outcomes in epidemiological studies and clinical trials. The hypothesis is original and potentially significant because yawning is closely linked to arousal regulation, REM

sleep, thermoregulation, and excessive daytime sleepiness. Additionally, much of the recent sleep research has been conducted under mandatory masking policies.

This mini-review offers a general overview of the physiology of yawning and presents several plausible, though largely untested, hypotheses regarding how masks might influence yawning and, consequently, sleep research outcomes. It does not include original data or a defined methodology for literature search or selection to date.

Should it be established that face masks can potentially influence sleep propensity, duration, and/or quality through the modulation of yawning, it is plausible that the effectiveness of interventions designed to ameliorate sleep disorders may be underestimated or attenuated. Conversely, the severity, incidence, or prevalence of certain medical conditions could be artificially inflated. The widespread use of face masks carries potential implications for contemporary clinical trials, the extrapolation of retrospective and prospective data across diverse contexts, the reevaluation of diagnostic criteria for sleep disorders, and the standards applied in systematic reviews and meta-analyses comparing pre-COVID-19 and post-COVID-19 data. Most critically, these factors necessitate a reconsideration and reinterpretation of prior findings and

comparative studies within the field.

Finally, as preparation for the future, it is necessary to design experimental or epidemiological studies to test this hypothesis. Examples include laboratory protocols measuring yawning frequency with and without masks under controlled sleepiness levels; reanalysis of existing cohort data where mask-wearing duration is recorded; or observational studies involving night shift workers.

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## Author contributions

This is a single-authored article.

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Not applicable.

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Not applicable.

## Availability of data

Not applicable.

## Further disclosure

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