



# Obstructive Sleep Apnea and Risk of COVID-19 Infection, Hospitalization and Respiratory Failure

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## Abstract

**Purpose** To study the relationship between OSA and risk of COVID-19 infection and disease severity, identified by the need for hospitalization and progression to respiratory failure.

**Methods** We queried the electronic medical record system for an integrated health system of 10 hospitals in the Chicago metropolitan area to identify cases of COVID-19. Comorbidities and outcomes were ascertained by ICD-10-CM coding and medical record data. We evaluated the risk for COVID-19 diagnosis, hospitalization, and respiratory failure associated with OSA by univariate tests and logistic regression, adjusting for diabetes, hypertension, and BMI to account for potential confounding in the association between OSA, COVID-19 hospitalization, and progression to respiratory failure.

**Results** We identified 9405 COVID-19 infections, among which 3185 (34%) were hospitalized and 1779 (19%) were diagnosed with respiratory failure. OSA was more prevalent among patients requiring hospitalization than those who did not (15.3% versus 3.4%,  $p < 0.0001$ ; OR 5.20, 95% CI (4.43, 6.12)), and among those who progressed to respiratory failure (19.4% versus 4.5%,  $p < 0.0001$ ; OR 5.16, 95% CI (4.41, 6.03)). After adjustment for diabetes, hypertension, and BMI, OSA was associated with increased risk for hospitalization (OR 1.65; 95% CI (1.36, 2.02)) and respiratory failure (OR 1.98; 95% CI (1.65, 2.37)).

**Conclusions** Patients with OSA experienced approximately 8-fold greater risk for COVID-19 infection compared to a similar age population receiving care in a large, racially, and socioeconomically diverse healthcare system. Among patients with COVID-19 infection, OSA was associated with increased risk of hospitalization and approximately double the risk of developing respiratory failure.

**Keywords** COVID-19 · Coronavirus · Obstructive sleep apnea · Outcomes

## Introduction

Identifying risk factors for coronavirus 2019 (COVID-19) infection and severe disease course facilitates personalizing preventative measures, targeting surveillance and diagnostic

testing, and managing active infections. Several common, chronic conditions have been identified as risk factors, notably hypertension, diabetes, and obesity [1]. Obstructive sleep apnea (OSA) is one of the most common pulmonary diseases, estimated to affect nearly 1 billion individuals with a prevalence of nearly 50% in some countries [2]. A relationship between COVID-19 risk and OSA has been speculated, but is not clearly established [3]. The objective of this study was to study the relationship between OSA and risk of COVID-19 infection and disease severity, identified by the need for hospitalization and progression to respiratory failure.

## Methods

We queried the electronic medical record system for Northwestern Medicine, a system of 10 hospitals in the Chicago metropolitan area, for patient encounters and associated

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data from January 1, 2020 to June 25, 2020. Diagnoses were defined by ICD-10-CM coding as follows: COVID-19 as U07.\*, OSA as G47.33, type 2 diabetes mellitus as E11.\*, hypertension as I10.\*, and respiratory failure as J96.\*, where \* indicates inclusion of all subcategories. Age was dichotomized at 50 years old, body mass index (BMI) was categorized according to World Health Organization criteria, and sex and race according to patient self-report.

We evaluated the risk for COVID-19 diagnosis, hospitalization, and respiratory failure associated with OSA by comparing proportions using Fisher's exact test and calculating odds ratios by logistic regression. To account for potential confounding in the association between OSA, COVID-19 hospitalization and progression to respiratory failure, we adjusted for diabetes, hypertension, and BMI.

Acquisition and analysis of these data, which involved no human subject interaction and no collection of identifiable information, was determined to be non-human subjects research that did not require IRB review.

## Results

We evaluated 5,544,884 patient records and identified 9405 COVID-19 infections. Patients with COVID-19 did not differ from the overall health system population by age (age < 50 years 55.5% versus 55.0%,  $p = 0.3$ ), but a greater proportion were male (45.9% versus 41.7%,  $p < 0.0001$ ), Black race (11.9% versus 7.1%,  $p < 0.0001$ ) and had a diagnosis of OSA (6.3% versus 0.8%,  $p < 0.0001$ ; unadjusted odds ratio 8.6, 95% confidence interval (7.9, 9.3)).

Among COVID-19 patients, 3185 (33.9%) were hospitalized and 1779 (18.9%) were diagnosed with respiratory failure. OSA was more prevalent among patients requiring hospitalization than those who did not (15.3% versus 3.4%,  $p < 0.0001$ ; OR 5.20, 95% CI (4.43, 6.12)), and among those who progressed to respiratory failure (19.4% versus 4.5%,  $p < 0.0001$ ; OR 5.16, 95% CI (4.41, 6.03)). After adjustment for diabetes, hypertension, and BMI, OSA was associated with increased risk for hospitalization (OR 1.65; 95% CI (1.36, 2.02)) and respiratory failure (OR 1.98; 95% CI (1.65, 2.37); see the Table 1).

## Discussion

Patients with OSA experienced approximately 8-fold greater risk for COVID-19 infection compared to a similar age population receiving care in a large, racially, and socioeconomically diverse healthcare system. Among patients with COVID-19 infection, OSA was associated with increased risk of hospitalization and approximately double the risk of developing respiratory failure. Prior work has associated OSA with

**Table 1** Adjusted risk models for COVID-19-related hospitalization and respiratory failure

COVID-19-related hospitalization model	
Risk factor	Odds ratio (95% confidence interval)
Obstructive sleep apnea	1.65 (1.36, 2.02)
Body mass index	
Underweight or normal	Reference category
Overweight	0.91 (0.79, 1.06)
Class 1 obesity	0.90 (0.76, 1.06)
Class 2 obesity	0.78 (0.64, 0.95)
Class 3 obesity	0.73 (0.59, 0.91)
Diabetes mellitus	2.81 (2.45, 3.22)
Hypertension	2.48 (2.21, 2.79)
COVID-19-related respiratory failure model	
Risk factor	Odds ratio (95% confidence interval)
Obstructive sleep apnea	1.98 (1.65, 2.37)
Body mass index	
Underweight or normal	Reference category
Overweight	0.93 (0.79, 1.10)
Class 1 obesity	0.91 (0.76, 1.09)
Class 2 obesity	0.89 (0.72, 1.10)
Class 3 obesity	0.91 (0.72, 1.14)
Diabetes mellitus	2.33 (2.05, 2.66)
Hypertension	2.09 (1.84, 2.38)

higher risk for community-acquired pneumonia [4, 5]. Moreover, SARS-CoV-2 cell entry depends on ACE2, and angiotensin-converting enzyme activity is increased in OSA [6]. These findings extend a recent observation that treated OSA was a risk factor for poor outcomes in diabetic patients hospitalized with COVID-19 [7].

Some limitations are notable. Coding of administrative data is imprecise, but hypertension and diabetes are among the most reliably coded comorbidities in administrative data, and BMI was obtained by direct measurement, but some recognized COVID-19 risk factors (e.g., immunosuppressed state) are not reliably ascertainable [8]. OSA is widely underdiagnosed in many populations, but when coded in administrative data by ICD-10, it is 98% specific for true disease [2, 9]. These data reflect OSA as it is diagnosed in the general US population rather than true prevalence as would be determined by complete assessment. It is difficult to estimate whether OSA may be overrepresented or underrepresented in COVID-19 cases due to selection bias for testing and healthcare avoidance behaviors during the pandemic.

In conclusion, by leveraging a large patient sample and controlling for major recognized comorbidities, these data provide reasonable estimates of the influence of OSA on COVID-19 disease in the US population. Given the prognostic relevance of OSA for disease course severity, OSA

screening with simple instruments like the four question STOP-Bang Questionnaire may be helpful in guiding management decisions in COVID-19 patients [10].

**Authors' contributions** Drs. Maas and Zee conceptualized and designed the study. Dr. Maas acquired the data, performed the analyses, and drafted the manuscript, and all authors contributed to the data interpretation and critical revision of the manuscript for important intellectual content.

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**Data availability** All data retrieved by query are reported here.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflicts of interest.

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