

Tracking continuous positive airway pressure adherence in obstructive sleep apnea patients before, during, and after the COVID-19 lockdown

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Abstract:

BACKGROUND: This study aimed to examine the impact of the COVID-19 lockdown on adherence to continuous positive airway pressure (CPAP) therapy among Saudi patients with obstructive sleep apnea (OSA). It also sought to assess the influence of demographic variables and comorbidities on CPAP adherence.

METHODS: A prospective cohort study was conducted at the University Sleep Disorders Center at King Saud University Medical City. The study included 67 OSA patients who exclusively used CPAP for treatment across three distinct intervals: prelockdown, during lockdown, and postlockdown. Adherence to CPAP therapy was objectively measured using “mask-on on-time monitoring” data from the CPAP machines.

RESULTS: The study found a significant decrease in the number of days with CPAP usage during the lockdown period, which persisted postlockdown. Approximately half of the patients adhered to CPAP treatment throughout the three study intervals. The decrease in CPAP usage days during lockdown was particularly noticeable among patients younger than 50 and older than 65 years of age. The presence of comorbidities, body mass index, and sex did not significantly influence CPAP treatment adherence.

CONCLUSION: The COVID-19 lockdown significantly impacted CPAP treatment adherence among OSA patients, with a decrease in adherence persisting postlockdown. This highlights the need for interventions to support CPAP adherence during challenging times such as a pandemic. Further research is needed to understand the long-term effects of the pandemic on CPAP therapy adherence.

Keywords:

Compliance, culture, positive airway pressure therapy, sleep disorders, sleep-disordered breathing

In December 2019, the emergence of a lethal respiratory infection caused by SARS-CoV-2 in Wuhan, China, marked the beginning of the COVID-19 pandemic.^[1] The World Health Organization declared the outbreak a public health emergency of international concern in January 2020

and a pandemic in March.^[2] Saudi Arabia reported its first COVID-19 case on March 2, 2020, followed by a surge in cases in the subsequent months. The country implemented travel restrictions and a nationwide partial curfew on March 23, 2020, which was later extended to a 24-h curfew.^[3,4]

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The psychological effects of the COVID-19 pandemic and lockdown are well documented, with a global systematic review linking the pandemic to a significant increase in insomnia symptoms.^[5,6] A recent systematic review and meta-analysis found a decline in sleep quality during the COVID-19 lockdown compared to the prelockdown period, with sleep quality worsening as evidenced by an increase in the Pittsburgh Sleep Quality Index global scores and sleep-onset latency times.^[7] Moreover, the prevalence of psychological consequences, such as anxiety, depression, and stress, increased during the pandemic.^[8,9]

Obstructive sleep apnea (OSA) is a prevalent condition characterized by the repeated narrowing or collapse of the pharyngeal airway during sleep, resulting in a decrease (hypopnea) or total stoppage (apnea) of airflow despite continued breathing efforts.^[10] Continuous positive airway pressure (CPAP) treatment is the standard of care for patients with OSA, acting as a pneumatic splint that maintains air passage in the upper airway during sleep.^[11] A prominent issue regarding CPAP usage is patient adherence to treatment.

One of the indirect effects of the COVID-19 pandemic that remains underexplored is its impact on chronic disorders, particularly OSA and its treatment adherence. The primary treatment for OSA, CPAP, is notably sensitive to adherence issues, and the pandemic-associated anxiety and sleep disturbances might have further complicated this dynamic.^[12] Given the multifaceted nature and unprecedented scale of the COVID-19 crisis, it is crucial to understand its impact on OSA patients' adherence to CPAP therapy and develop interventions to support CPAP adherence during these challenging times.

During the COVID-19 pandemic and lockdown, adherence to CPAP therapy among patients with OSA showed mixed results. A few studies have investigated CPAP adherence among patients with OSA.^[12-16] In a large prospective cohort, CPAP adherence significantly increased during the lockdown.^[13] However, another study ($n = 101$, severe OSA patients) reported that women, patients < 58 years, and those with good prelockdown CPAP adherence were more adherent during the lockdown.^[14] Considering comorbidities, body mass index (BMI), and anxiety, older males were less inclined to increase CPAP usage during lockdown.^[14]

Although there are a few data from assessing CPAP adherence during the COVID-19 pandemic, none have been conducted in Arab countries. Race and culture have been shown to affect adherence, which necessitates studying this topic in different cultures and races.^[12,17,18] Moreover, some of the previous studies have limitations,

such as cross-sectional design,^[16] focus on specific populations, and reliance on self-reported data.^[15] Our study prospectively followed a sample of Saudi patients with OSA before, during, and after the lockdown, providing a more comprehensive understanding of CPAP adherence among Saudi patients and considering the entire lockdown period and its aftermath.

We hypothesized that increased rates of insomnia, worsening sleep quality, and fear of aerosolization concomitant with the spread of COVID-19 decrease CPAP treatment adherence among OSA patients.^[15,19,20]

The primary objective of the study was to examine CPAP therapy adherence among Saudi patients with OSA during the COVID-19 lockdown. A secondary objective of the study was to assess comorbidities and demographic variables (including age, sex, and BMI) as predictors of CPAP adherence among Saudi OSA patients.

Methods

In this prospective cohort study at the University Sleep Disorders Center at King Saud University Medical City, we evaluated the influence of the COVID-19 pandemic on adherence to CPAP treatment among 67 OSA patients. Data were collected across three distinct intervals: from December 2, 2019, to February 2, 2020 (prelockdown); from March 2, 2020, to May 2, 2020 (during lockdown); and from June 2, 2021, to August 2, 2021 (postlockdown). This is part of ongoing prospectively collected data to assess CPAP adherence among patients with OSA.

The Institutional Review Board approved the study at the College of Medicine, King Saud University (E-22-7045), and consent was obtained.

The study included patients (≥ 18 years) diagnosed with OSA who exclusively used CPAP for treatment during the specified intervals. Exclusions were made for patients who employed other treatment methods or were diagnosed with comorbid obesity hypoventilation syndrome, narcolepsy, or insomnia. In addition, patients who decided to withdraw, did not complete the study, or had COVID-19 during the study period were excluded from the study. We started with 227 patients with OSA were initially surveyed; 11 refused to participate, 125 patients did not meet all the three periods' visits, and 7 patients had COVID-19.

The adherence to PAP therapy was recorded by extracting "mask-on-time monitoring" data from the PAP machines. This method allowed for objectively measuring commitment to PAP therapy.^[21] We used

the American Thoracic Society's definition of CPAP adherence: CPAP use for more than 4 h per day for more than 70% of days.^[22] Other variables measuring CPAP usage collected included average CPAP usage per day per interval, cumulative CPAP usage, and percentage of days with CPAP usage per interval.

Statistical analysis

Data were analyzed using SPSS statistical software (Windows, Version 26.0; Armonk, NY, USA: IBM Corp.). Mean and standard deviation (SD) were presented as mean \pm SD to describe quantitative variables, and frequencies (*n*) and percentages (%) were used for categorical variables. For analyzing data between groups, nonparametric tests were used because the data were not normally distributed when tested using the Kolmogorov–Smirnov test. Accordingly, the Wilcoxon and Kruskal–Wallis tests were used when appropriate. $P = 0.05$ and a 95% confidence interval were used to emphasize the statistical significance and accuracy of the results.

Results

Initially, 227 patients were surveyed [Figure 1]; however, a total of 67 OSA patients treated with CPAP completed the study. On average, patients started CPAP 5.98 ± 3.84 years before the study period, with a median of 5.96 years. The general demographics and comorbidities of the study population are shown in Table 1. Most patients were older than 50 years of age, with a mean age of 57 years. Most of the patients had a BMI above the normal range, with 12 patients (17.9%) being overweight and 48 (71.6%) being obese. The most diagnosed comorbidities were hypertension, diabetes mellitus, bronchial asthma, and allergic rhinitis,

with almost half of the cohort having diabetes and hypertension. In accordance with the guidelines of the American Thoracic Society, patients who used CPAP for 4 or more hours per night for at least 70% of the days in the interval were considered to have good adherence.^[22] Throughout the three study intervals, approximately half the cohort proved to be adherent to CPAP treatment.

There was a significant change in the number of days with CPAP usage ($P = 0.025$) when comparing the three study intervals, shown in Table 2. *Post hoc* analysis demonstrates a decrease in the number of days with CPAP usage during the lockdown period ($P < 0.001$). This decrease in days in which patients used CPAP devices persisted postlockdown. Comparing the lockdown with postlockdown period yields no statistical significance. Other variables of treatment adherence (percentage of days with 4 or more hours of usage, cumulative usage, and average usage per day) showed a decrease that was not significant throughout the study periods.

Table 3 presents the treatment adherence across different age groups. Both the under-50 and over-65 age groups experienced a drop in CPAP usage days during lockdown. This decline persisted postlockdown for those under 50 ($P = 0.015$) and those over 65 ($P < 0.001$). However, despite this drop during lockdown, the over-65 age group still showed higher CPAP adherence compared to other age groups throughout the entire study.

The presence of comorbidities in a patient did not significantly influence CPAP treatment adherence; neither did other demographic variables (BMI and sex).

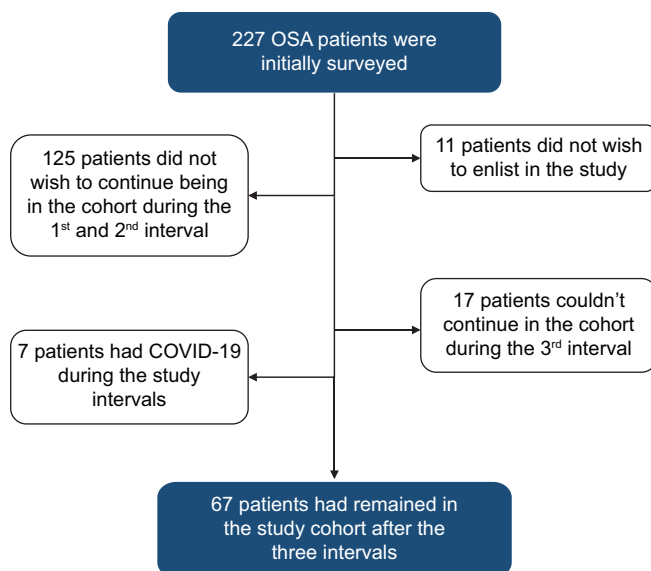


Figure 1: Flowchart of patient participation in the study

Table 1: General demographics and common comorbidities of the patient population

Variable	Frequency (%)
Sex	
Female	32 (47.8)
Male	35 (52.2)
Age group	
<50	18 (26.9)
50–65	28 (41.8)
>65	21 (31.3)
BMI	
Normal	7 (10.4)
Overweight	12 (17.9)
Obese	20 (29.9)
Morbidly obese	28 (41.8)
Comorbidities	
Hypertension	35 (52.2)
Diabetes mellitus	33 (49.3)
Bronchial asthma	23 (34.3)
Allergic rhinitis	26 (38.8)
Hypothyroidism	12 (17.9)

BMI=Body mass index

Table 2: Continuous positive airway pressure treatment adherence in the three study intervals

Variable	Median (IQR)			P
	Prelockdown	Lockdown	Postlockdown	
Days with CPAP usage (day)	54.18 (14.65)	53.73 (14.35)	50.43 (17.55)	0.025*
Days with CPAP usage ≥ 4 h (%)	67% (33%)	66% (34%)	64% (35%)	0.891
Cumulative CPAP usage (h)	325.46 (159.47)	325.33 (162.17)	311.10 (163.47)	0.919
Average CPAP usage per day (h/day)	5.80 (2.09)	5.80 (2.21)	5.74 (2.08)	0.951

*Statistical significance. *P* value was calculated using nonparametric Friedman's test. *Post hoc* analysis showed *P* value of (<0.001) when comparing prelockdown and lockdown intervals, while the difference between lockdown and postlockdown was not significant. CPAP=Continuous positive airway pressure, IQR=Interquartile range

Table 3: Effect of COVID-19 lockdown on treatment adherence among different age groups expressed as (mean \pm standard deviation)

Variable	Prelockdown	Lockdown	Postlockdown	P
<50 age group				
Days with CPAP usage (day)	53.61 \pm 14.76	50.67 \pm 14.60	46.94 \pm 20.88	0.015
Percentage of days with CPAP usage ≥ 4 h	62.08 \pm 32.96	57.63 \pm 32.75	60.84 \pm 37.57	0.296
Cumulative CPAP usage (h)	300.97 \pm 160.48	290.68 \pm 163.94	298.46 \pm 170.86	0.322
Average CPAP usage per day (h/day)	5.38 \pm 2.07	5.38 \pm 2.18	5.44 \pm 2.20	0.296
50–65 age group				
Days with CPAP usage (day)	50.96 \pm 17.14	52.75 \pm 16.24	48.46 \pm 17.88	0.035
Percentage of days with CPAP usage ≥ 4 h	62.50 \pm 28	66.67 \pm 31	57.89 \pm 33	0.125
Cumulative CPAP usage (h)	298.91 \pm 142.06	315.85 \pm 144.35	274.39 \pm 152.98	0.356
Average CPAP usage per day (h/day)	5.69 \pm 1.67	5.88 \pm 1.81	5.51 \pm 1.87	0.377
>65 age group				
Days with CPAP usage (day)	58.95 \pm 9.38	57.67 \pm 10.79	56.05 \pm 12.83	<0.001
Percentage of days with CPAP usage ≥ 4 h	75.68 \pm 36.36	73.39 \pm 39.48	74.20 \pm 34.58	0.386
Cumulative CPAP usage (h)	381.85 \pm 172.98	366.03 \pm 181.53	369.14 \pm 161.59	0.433
Average CPAP usage per day (h/day)	6.31 \pm 2.55	6.05 \pm 2.73	6.32 \pm 2.22	0.433

CPAP=Continuous positive airway pressure

Discussion

In our study, CPAP treatment adherence among OSA patients decreased significantly during the COVID-19 lockdown, and this decrease persisted during the postlockdown study interval, supporting our initial hypothesis. This study uniquely demonstrates the persistence of decreased adherence to CPAP therapy postlockdown, suggesting potential prolonged effects of the COVID-19 lockdown or other lasting impacts of the pandemic on OSA patients. While previous research has emphasized the need to investigate the effects of the pandemic on OSA patients after the lockdown,^[12] to our knowledge, this is the first study to prospectively track CPAP adherence in OSA patients before, during, and specifically after the COVID-19 lockdown.

Maintaining adherence to CPAP therapy for OSA patients has always been a challenge, and this was further accentuated in various regions by the disruptions of the COVID-19 pandemic and its subsequent lockdowns. Throughout our study intervals, CPAP therapy adherence remained consistently low, with roughly only half of the patients fully adhering to the treatment. This mirrors findings from other studies, which commonly report suboptimal CPAP adherence rates.^[23,24]

However, these findings contrast with some studies conducted in other regions. For instance, a study in France reported a significant increase in CPAP adherence during the COVID-19 lockdown.^[13] Another study in France found that adherence to CPAP improved during the lockdown, particularly among individuals with poor adherence before the pandemic. The authors noted the importance of studying the evolution of these changes postlockdown.^[12] However, a study in the United States reported no significant impact on CPAP adherence during the COVID-19 lockdown.^[15]

Differences in CPAP adherence during the COVID-19 lockdown may be attributed to cultural variations in sleep habits,^[25,26] lockdown procedures, access to CPAP suppliers, and access to medical services. This is supported by studies that underscore the influence of cultural factors, such as socioeconomic status, health literacy, self-efficacy, and race/ethnicity, on CPAP adherence among patients with OSA.^[17,18,27]

Furthermore, variations in lockdown procedures per country reported spread of the virus, and mortality rates among the infected are all factors contributing to differences in the effect of the pandemic and the lockdown. However, none of the studies in the current literature included a postlockdown period to allow comparison.

This underscores the importance of understanding cultural nuances and lockdown procedures in addressing CPAP adherence during global health crises such as the COVID-19 pandemic. Furthermore, it emphasizes the need for longitudinal studies to better understand and manage such variations in future pandemics.

In our study, patients younger than 50 and older than 65 years of age showed a marked decrease in the number of days with CPAP usage during the COVID-19 interval; this decrease persisted postlockdown. The 50–65 age group did not show such a decrease. The disparity in CPAP use among younger adults during the lockdown could be attributed to several factors. The shift to working from home, which was more prevalent among younger, employed individuals, introduced new challenges that could have disrupted sleep patterns. A study found that more than 45% of those able to work from home reported worsened mental well-being and loneliness, which could potentially affect sleep quality and CPAP use.^[28]

In addition to the changes in work habits, younger adults also faced increased caregiving duties during the lockdown. These duties, such as homeschooling children or caring for elderly relatives, could have further disrupted sleep patterns and reduced CPAP use among this demographic.^[14] Moreover, the lockdown measures disproportionately affected the mobility of working-age people, especially those below 45 years of age.^[29] This could have resulted in increased stress and anxiety, further affecting sleep patterns and CPAP use. The combination of these factors could have contributed to the observed disparity in CPAP use among younger adults during the lockdown.

The decline in CPAP adherence among older adult patients with OSA during the lockdown can be compared to the decline in medication use among older adult patients with other chronic diseases, such as diabetes mellitus. Both groups of patients faced similar challenges during the lockdown, which may have contributed to the decline in adherence to their respective treatments. A study focusing on patients with diabetes mellitus found that adherence to medications has drastically reduced during the pandemic and has not reached pre-COVID-19 levels again.^[30] Older and poorly educated patients seem to have suffered more from the restrictions imposed by lockdowns and fear of contagion.^[30]

While a systematic review on the impact of the COVID-19 pandemic on adherence to chronic therapies also highlighted the significant disruption in health-care services for patients with chronic conditions.^[31] The pandemic has exacerbated the problems that were already causing people not to take their medications, such as lockdowns, social distancing, and economic hardships,

especially for older adults. Moreover, most older adult patients were dependent on a family member when taking medication; hence, disruption of daily routines may have had disproportionality worse effects on the older adults.^[32] Factors such as lockdown restrictions, fear of contagion, and limited access to health-care services have contributed to this decline in adherence.^[30-32]

Despite this decrease in adherence among older patients during and post-COVID-19 lockdown, the above-65 age group still demonstrated the highest adherence overall during the study period compared to other age groups.

This study has several strengths. First, by including a postlockdown period, inferences could be made regarding the lasting effects of the lockdown on CPAP adherence. This was the case in our study, as the decrease in days with CPAP usage continued postlockdown. Second, no studies in the Middle East and North Africa region assessing the effects of COVID-19 on CPAP therapy adherence were found. Third, only objective data in the form of electronic medical records and machine-generated CPAP reports were used in this study, whereas some studies in the literature heavily relied on subjective surveys regarding sleep duration and CPAP treatment adherence.^[15,33]

The study had certain limitations. First, the sample size was constrained due to challenges in reaching out to patients during the lockdown – a period when many found communication and ability to attend the clinics is particularly challenging. In addition, the study did not include a psychological assessment of the patients, which could have provided valuable insights into the impact of mental health on CPAP adherence, especially during the stressful period of the COVID-19 lockdown.

Conclusion

Our study is the first to report the postlockdown period and investigate the impact of the COVID-19 lockdown on CPAP adherence in the Middle East and North Africa region. We found that adherence to CPAP treatment decreased significantly during the lockdown and continued to remain low after the lockdown (2 months), particularly among patients under 50 and those over 65 years old. Despite comorbidities known to be risk factors of OSA, demographic variables and the presence of comorbidities did not consistently correlate with adherence, apart from age.

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Conflicts of interest

There are no conflicts of interest.

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