



# Changes in Positive Airway Pressure Use in Adults with Sleep-Related Breathing Disorder During the COVID-19 Pandemic: A Cross-Sectional National Community-Based Survey

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## Abstract

**Purpose** To better understand: (i) a positive airway pressure (PAP) therapy use during the pandemic, (ii) how PAP use may relate to sleep, health, and COVID-19-related outcomes, and (iii) factors associated with PAP use during the pandemic.

**Methods** This study is based on data collected between Apr 2020 and Jan 2021 as part of an online cross-sectional national community-based survey. The included participants were located in North America, 18 years and older, with self-reported sleep-related breathing disorder (SBD) and usage of a PAP device in the last month before the COVID-19 pandemic.

**Results** Of all respondents, 7.2% (41/570) stopped using PAP during the pandemic over a median time since the pandemic declaration of 62.0 days (IQR = 8.0). There were no significant differences between individuals who continued and stopped using PAP in the time elapsed since the pandemic declaration, age, sex, education level, occupational status, family income, or the proportions of individuals endorsing symptoms that could be related to COVID-19. Compared to individuals who continued using PAP, those who stopped had significantly shorter sleep time, lower sleep efficiency, and poorer sleep quality. Higher stress levels and living with someone who experienced symptoms that could be attributable to COVID-19 were independently associated with stopping PAP use.

**Conclusions** In this survey study, most individuals with SBD continued PAP therapy during the pandemic. However, even 7% of participants who stopped using PAP cannot be ignored. Identifying individuals at risk of discontinuing PAP treatment may help design targeted interventions for people with SBD and health professionals to improve PAP use.

**Keywords** Sleep-related breathing disorder · Positive airway pressure use · COVID-19 pandemic · Sleep quality

## 1 Introduction

Positive airway pressure (PAP) treatment, a recommended therapy for significant sleep-related breathing disorder (SBD), is considered a high-risk aerosol-generating

procedure, potentially facilitating viral dispersion and transmission of infection [1]. However, cessation of PAP treatment is associated with returning symptoms, with possible cardiometabolic and immune consequences [2].

Early recommendations on PAP use at the beginning of the COVID-19 pandemic could have been confusing for individuals with SBD [1] and may have led to unnecessary PAP treatment discontinuation. More recent guidelines recommended continuing PAP at home while taking steps to distance PAP users from vulnerable household members or stop PAP for a short time [3]. There is limited and inconsistent evidence on how PAP use was affected by the COVID-19 pandemic. Some studies suggested limited changes in PAP use during the COVID-19 pandemic [4–7]. However, those studies were limited to specific populations, were mostly descriptive, and focused on the early stages of the pandemic. Conversely, a large survey of 13,000 adults in 13 countries demonstrated a significant drop in PAP use in the

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community since the pandemic [8]. Fears that PAP could contribute to the spread of the COVID-19 infection, stress, social isolation and the disruption to regular life have been suggested as possible factors contributing to PAP discontinuation. As such, more research is needed [4] to better understand: (i) the trajectories of PAP use in the community during the pandemic, (ii) how PAP use may relate to sleep, health, and COVID-19-related outcomes, and (iii) factors associated with PAP therapy discontinuation during the pandemic.

## 2 Methods

This study is based on data collected between April 3, 2020, and January 28, 2021, as part of an online survey on the psychosocial impacts of the pandemic approved by the Clinical Trials Ontario-Qualified Research Ethics Board (Protocol #2131). A total of 6635 respondents completed the sleep portion of this survey over this period. The survey was distributed via social media, websites, and several organizations and hospitals across Canada, with some posts reaching the United States. Further details are provided elsewhere [9] (ClinicalTrials.gov: NCT04369690).

Participants included in the current report were located in North America, 18 years and older, with self-reported SBD diagnosis and usage of a PAP device before the pandemic. Participants were divided into two groups of PAP usage: Continued or Stopped based on their responses to the following questions: "Have you been using a Positive Airway Pressure machine (e.g., CPAP; "breathing machine"): (i) In the last month before the outbreak and (ii) Past 7 days."

In addition to demographics and customary questions about health and PAP usage, respondents completed the Pittsburgh Sleep Quality Index (PSQI) to characterize total sleep time, sleep efficiency and global subjective sleep quality [10], the Perceived Stress Scale (PSS-10) [11], Generalized Anxiety Disorder 7 (GAD-7) [12] and Quick Inventory of Depressive Symptomatology (QIDS-SR-16) [13]. COVID-19-related outcomes were: (i) having tested positive for COVID-19; (ii) C19 symptoms index (0–30 scale) reflective of the number and severity of symptoms possibly related to COVID-19, such as fever, cough, difficulty breathing or shortness of breath, sore throat and tiredness, among others [9, 14].

Descriptive statistics were used to characterize PAP use since the pandemic. Participants' characteristics (Table 1) were compared across the Continued and Stopped groups with Mann–Whitney *U* and Chi-squared tests, as applicable. ANCOVAs controlling for relevant covariates compared total sleep time, sleep efficiency and global sleep quality between groups (a square root transformation was used to improve normality for total PSQI scores). Mixed multiple

linear regression models, clustered by period (before vs. during the pandemic) and individuals (random effect), were also used to quantify the relationship between PAP use and total sleep time, sleep efficiency and global sleep quality, controlling for confounders (fixed effect) as well as the interaction term effect between PAP use and period on measures of sleep quality to understand if the pandemic modifies this relationship (Table 2). Multiple logistic regression was used to identify factors associated with stopping using PAP.

## 3 Results

Among 595 individuals with SBD using PAP in the last month before the pandemic, 570 (95.8%) answered the PAP usage question for the past week (99.1% [565/570] located in Canada and the rest in the United States). The median time elapsed since the pandemic declaration by the World Health Organization (WHO) on March 11, 2020, was 62.0 days (IQR = 8.0). Of all respondents, 7.2% (41/570) stopped using PAP during the pandemic. The frequencies of stopping PAP treatment ("past 7 days") vs. continuing as a function of the time elapsed since the pandemic declaration by the WHO are presented in Fig. 1.

There were no significant differences between individuals who continued and stopped using PAP in terms of the time elapsed since the pandemic declaration, age, education level, occupational status, family income, or the proportions of individuals endorsing symptoms that could be related to COVID-19 (Table 1). Compared to the Continued group, the Stopped group counted a slightly higher proportion of females, although this was not significant (Chi-squared (1) = 3.7,  $p = 0.058$ ). There was also no significant group difference in the proportion of respondents endorsing a worsening in their physical health since the start of the pandemic [Stopped: 32.5% (13/40); Continued: 26.9% (136/505); Chi-squared = 0.58,  $p = 0.447$ ]. Compared to individuals who continued using PAP, a significantly higher proportion of those who stopped using PAP reported getting tested for COVID-19 (Stopped: 14.6% (6/41); Continued: 6.0% (32/529); Chi-squared (1) = 4.5,  $p = 0.034$ ). Of all respondents, only one tested positive among those who stopped using PAP.

Compared to individuals who continued using PAP, those who stopped had significantly shorter total sleep time, lower sleep efficiency, and poorer sleep quality (adjusted for the time elapsed since the start of the pandemic, age, sex, self-reported diagnoses of chronic illness and insomnia;  $p$  values < 0.001) (Fig. 2). These results were confirmed in mixed multiple linear regression models (Table 2): specifically, a reduction in sleep efficiency of about 7% (95% CI 3–12), a reduction in total sleep time of about 0.7 h (95% CI 0.3–1.1) and a worsening in global subjective sleep quality by a drop

**Table 1** Factors associated with stopping a positive airway pressure (PAP) treatment ("in the past 7 days") since the pandemic identified using a multivariable logistic regression model

Characteristics <sup>a</sup>	Continued PAP ( <i>n</i> = 529)		Stopped using PAP ( <i>n</i> = 41)		Odds ratios (95% Confidence Interval)	<i>p</i> values
	Median /Percent	IQR /Frequency <sup>b</sup>	Median /Percent	IQR /Frequency <sup>b</sup>		
Time since pandemic declaration by the WHO, days (per week increase)	62.0	7.0	62.0	11.0	1.00 (0.98–1.01)	0.743
General demographics						
Age, years (per 10 years increase)	62.0	16.0	59.0	14.5	1.00 (0.95–1.04)	0.928
Sex: Males (vs. females)	54.6%	289/529	39.0%	16/41	0.39 (0.15–1.03)	0.058
Education: No university (vs. university)	41.8%	221/529	46.3%	19/41	1.37 (0.56–3.38)	0.494
Employed (vs unemployed)	43.9%	205/467	45.5%	15/33	0.97 (0.35–2.72)	0.957
Income: < 40 K/year (vs. > 40 K/year)	11.4%	55/481	15.4%	6/39	2.13 (0.34–13.28)	0.417
Physical/Mental Health						
Has chronic illness (vs. none)	84.1%	440/523	80.5%	33/41	1.04 (0.30–3.56)	0.951
Stress, by PSS-10, 0–40 scale (per 5 units increase)	14.0	12.0	20.5	13.0	<b>1.13 (1.02–1.25)</b>	<b>0.016</b>
Anxiety, by GAD-7, 1–24 scale (per 5 units increase)	4.0	9.0	7.0	9.3	0.93 (0.81–1.06)	0.277
Depression, by QIDS-SR16, 4–20 scale (per 5 units increase)	8.0	7.0	9.0	7.0	0.94 (0.82–1.07)	0.332
Living situation and COVID-19 symptoms						
Lives alone (vs. lives with others)	20.9%	110/527	17.1%	7/41	1.34 (0.43–4.18)	0.611
Has children < 18 y.o. (vs. none)	12.7%	64/502	21.6%	8/37	0.65 (0.15–2.87)	0.569
Had ≥ 3 COVID-19 symptoms (vs. < 3)	32.7%	173/529	43.9%	18/41	0.96 (0.37–2.49)	0.936
Someone else in household had COVID-19 symptoms (vs. not)	13.0%	67/514	24.4%	10/41	<b>3.05 (1.00–9.31)</b>	<b>0.049</b>

Estimates presented as odds ratios and 95% confidence intervals

PSS-10 Perceived Stress Scale-10, GAD-7 Generalized Anxiety Disorder-7, QIDS-SR16 Quick Inventory of Depressive Symptomatology, WHO the World Health Organization

<sup>a</sup>A unit of change (continuous variable) or reference group (categorical variable) for odds ratios calculations is reported in a bracket

<sup>b</sup>For frequencies, a denominator reflects the number of responders with no missing values on the variable of interest

Statistically significant relationships are in bold

of 1.7 points on the PSQI (95% CI 0.6–2.8) associated with stopping vs. continuing on PAP. The effect of the interaction terms between PAP use and time was not statistically significant (*p* values > 0.22).

Higher stress levels (odds ratio [OR] = 1.13, 95% confidence interval [CI]: 1.02–1.25) and living with someone who experienced symptoms that could be attributable to COVID-19 (OR = 3.05, 95% CI 1.00–9.31) were independently associated with stopping using PAP (Table 2).

## 4 Discussion

Utilizing a cross-sectional national survey on the consequences of the COVID-19 pandemic on 570 North American adults with SBD, we found that most individuals with SBD continued PAP therapy during the COVID-19 pandemic. However, 7% of participants who stopped using PAP cannot be ignored. The odds of discontinuing PAP were threefold greater among individuals living with a cohabitant with symptoms suggestive of COVID-19 (vs. not) and 1.13 greater per 5 units increase on the stress scale (PSS). Interestingly, having potential COVID-19-related symptoms was not associated with PAP discontinuation. Further,

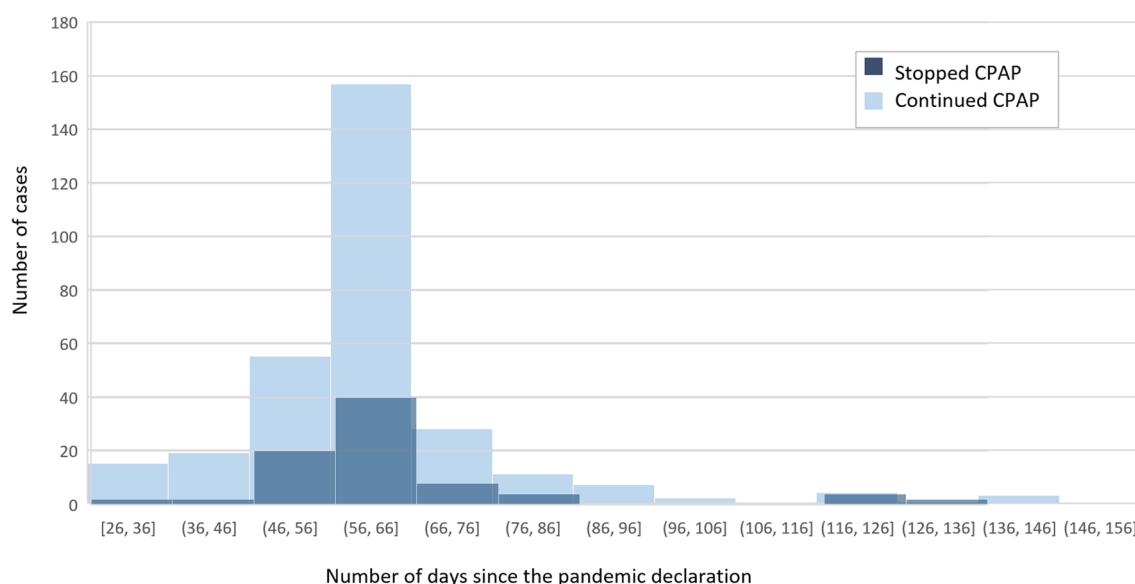
**Table 2** Estimates and 95% confidence interval of changes in the total sleep time, sleep efficiency (SE) and total Pittsburgh Sleep Quality Index (PSQI) from mixed multiple linear regression models

	Change in SE (%)	Change in total sleep time (hours)	Change in PSQI, total (from 0 to 21)
Continued PAP vs. not	<b>7.46 (3.40–11.52), <math>p = 0.000</math></b>	<b>0.69 (0.26–1.12), <math>p = 0.002</math></b>	<b>-1.70 (-2.75 to -0.64), <math>p = 0.002</math></b>
Period (Before vs. during pandemic) <sup>a</sup>	<b>1.58 (0.49–2.66), <math>p = 0.004</math></b>	<b>0.15 (0.05–0.26), <math>p = 0.005</math></b>	<b>-0.64 (-0.87 to -0.42), <math>p = 0.000</math></b>
Sex (female vs male)	-1.08 (-3.16–1.00), $p = 0.309$	0.13 (-0.09 to 0.35), $p = 0.256$	<b>0.75 (0.22–1.29), <math>p = 0.006</math></b>
Chronic illness: None vs Any	1.01 (-1.87–3.89), $p = 0.492$	-0.03 (-0.33 to 0.27), $p = 0.846$	<b>-0.83 (-1.57 to -0.09), <math>p = 0.028</math></b>
Insomnia: No vs. Yes	<b>6.51 (2.71–10.31), <math>p = 0.001</math></b>	<b>0.56 (0.16–0.96), <math>p = 0.006</math></b>	<b>-3.88 (-4.86 to -2.91), <math>p = 0.000</math></b>
Time since pandemic declaration by the WHO, per day increase	-0.03 (-0.07 to 0.01), $p = 0.160$	0.00 (-0.01 to 0.00), $p = 0.136$	0.01 (0.00–0.02), $p = 0.177$
Age, per year increase	0.02 (-0.07 to 0.10), $p = 0.348$	0.00 (-0.01 to 0.01), $p = 0.459$	<b>-0.03 (-0.06 to -0.01), <math>p = 0.003</math></b>

Fixed effect: PAP use, period (before vs. during a pandemic), sex (male vs female), chronic illness (vs. none), insomnia (vs. none), time since pandemic declaration by the WHO, and age; Random effect: period (before vs. during a pandemic), subjects. The effect of the interaction term between PAP use and period (before vs. during a pandemic) on measures of sleep quality was not significant ( $p$  values > 0.22); therefore, the interaction term was not included in the final model

<sup>a</sup>Period: Before vs. during pandemic refers to the two-time referents: the last month before the outbreak vs the past 7 days

Statistically significant relationships are in bold



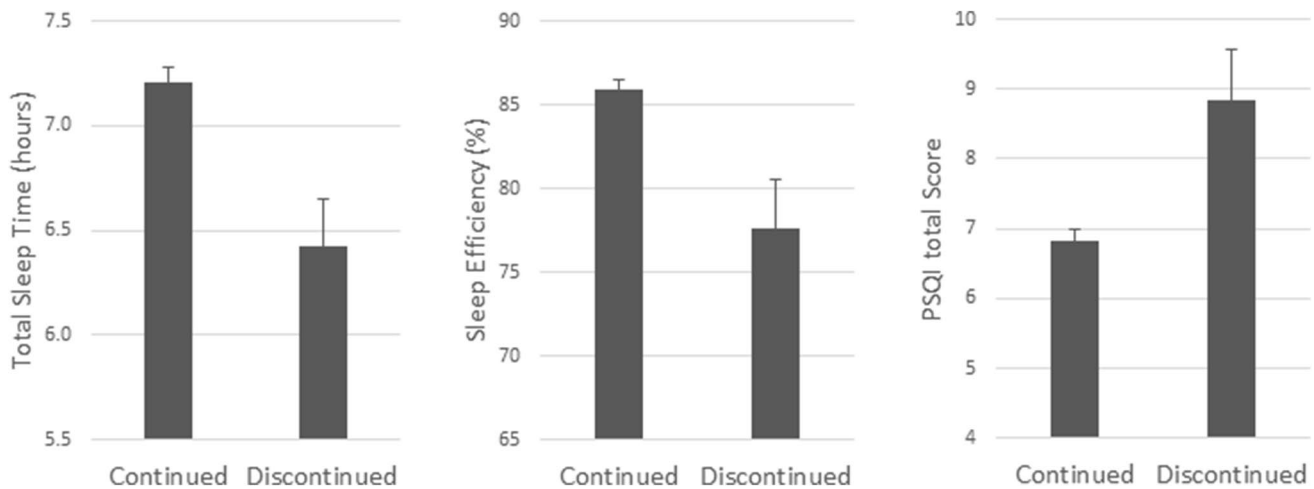
**Fig. 1** The frequencies of stopping a positive airway pressure treatment ("past 7 days") vs. continuing since the pandemic declaration by the World Health Organization on March 11, 2020

individuals who stopped using PAP reported poorer sleep quality than those who continued using PAP. However, this relationship was not modified by the pandemic, supporting the previous notion that poor sleep quality may be a risk factor for poorer CPAP adherence [15]. Identifying individuals at risk of discontinuing PAP treatment would help design targeted interventions for people with SBD and health professionals to improve PAP use.

Our study covers different stages of the pandemic compared to other published studies. We also investigated mental health and different aspects of sleep quality. However,

our study is limited by its cross-sectional nature, not being primarily designed to focus on PAP usage, its lack of precise objective assessment of PAP usage, its relatively small sample size, unmeasured confounders, recall bias, a lack of objective sleep measures, a major decline in overall respondents after about three months since the start of the COVID-19 pandemic, and the online recruitment strategy and volunteer bias which limits the representativeness and generalizability of our findings.

Our results are consistent with other studies showing the limited impact of the COVID-19 pandemic on PAP use



**Fig. 2** Measures of sleep quality among individuals who continued using positive airway pressure (PAP) treatment in community during the COVID-19 pandemic vs. those who discontinued. Based on subjective estimates retrieved from the Pittsburgh Sleep Quality Index (PSQI), those who stopped PAP use had significantly shorter total

sleep time ( $F(6, 552)=5.0, p<0.001, np^2=0.05$ ), lower sleep efficiency ( $F(6, 551)=4.8, p<0.001, np^2=0.05$ ), and poorer sleep quality ( $F(6, 546)=14.8, p<0.001, np^2=0.14$ ) compared to individuals who continued using PAP

[4, 7], which might be explained by the ability to monitor PAP adherence remotely and changing sleep habits during the lockdown. Identifying factors associated with PAP treatment discontinuation highlight the importance of patient education. For example, the fact people discontinued PAP, even temporarily, if others in the house have symptoms and not themselves identified a potential knowledge gap. However, at the same time, this may reflect public knowledge of asymptomatic COVID-19 infection, and patients may have stopped PAP therapy for this reason—a hypothesis which requires further exploration. Reducing stress through cognitive behavioral therapy may help to improve PAP use.

Future studies with longer follow-up since the pandemic are required to better understand the possible impacts of the pandemic on SBD diagnosis and treatment and assess if different components of SBD-related health care during the pandemic are associated with an increased risk of adverse COVID-19-related outcomes. Along with our study, these findings would provide knowledge that could be applied to avoid health care disruptions in individuals with SBD during future pandemics.

**Author Contributions** All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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**Availability of Data and Material** Proposals to access data from this study can be submitted to the corresponding author and may be made available upon data sharing agreement.

**Code Availability** Available upon request.

## Declarations

**Conflict of Interest** All authors report that they have no conflicts of interest or financial conflicts related to this manuscript. T Kendzerska received a speaker honorarium from AstraZeneca Canada Inc. and is a Clinical Consultant at Pitolisant Medical Advisory Board (Paladin Labs Inc.).

**Ethics Approval** This study was approved by the Clinical Trials Ontario-Qualified Research Ethics Board (Protocol #2131) (Clinical-Trials.gov: NCT04369690).

**Consent to Participate** All participants consented to be included in the research before starting the survey.

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