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SCIENTIFIC INVESTIGATIONS

Nonadherence to CPAP Associated With Increased 30-Day Hospital Readmissions

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Study Objectives: The primary objective of this study was to determine if nonadherence to continuous positive airway pressure (CPAP) is associated with increased 30-day all-cause, cardiovascular-cause, and pulmonary-cause hospital readmissions.

Methods: Retrospective cohort study at a Veterans Affairs hospital of patients with obstructive sleep apnea (OSA) who were hospitalized from January 1, 2007 to December 31, 2015. Odds ratio of 30-day readmission was calculated for all-cause, cardiovascular-cause, and pulmonary-cause readmissions. Logistic regression model was used to evaluate odds of nonadherent versus adherent group while adjusting for age, sex, body mass index, living situation, race, comorbidities, and medication adherence.

Results: Out of 2,077 records reviewed, 345 patients (183 adherent and 162 nonadherent) met our inclusion criteria. The adherent group had a total of 215 initial admissions, and the nonadherent group had a total of 268 index admissions. Thirty-day all-cause readmission rate was significantly higher in the nonadherent group, with an adjusted odds ratio (OR) of 3.52 (95% confidence interval [CI], 2.04–6.08, $P < .001$). Thirty-day cardiovascular-cause readmission rate was significantly higher in the nonadherent group, with an adjusted OR of 2.31 (95% CI, 1.11–4.78, $P = .024$). Difference in 30-day pulmonary-cause readmissions was not statistically significant, with an adjusted OR of 3.66 (95% CI, 0.41–32.76, $P = .25$).

Conclusions: Nonadherence to CPAP is associated with increased 30-day all-cause and cardiovascular-cause readmission in patients with OSA. Ensuring CPAP adherence is crucial in addressing general and cardiovascular-related healthcare utilization and morbidity in patients with OSA.

Commentary: A commentary on this article appears in this issue on page 161.

Keywords: continuous positive airway pressure adherence, CPAP compliance, obstructive sleep apnea, readmissions

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Although it is well understood that untreated obstructive sleep apnea leads to a variety of worsened health outcomes, it is unclear if this translates into increased 30-day hospital readmissions. This study aimed to determine if nonadherence to continuous positive airway pressure (CPAP) is associated with increased 30-day cardiovascular-cause, pulmonary-cause, or all-cause readmissions.

Study Impact: Our results demonstrate that CPAP adherence is associated with decreased all-cause and cardiovascular-cause 30-day readmissions. This carries important implications because it suggests that CPAP therapy may be an important, modifiable target for reducing hospital readmissions and may affect local, state-based, and national interventions.

INTRODUCTION

The primary therapy for obstructive sleep apnea (OSA) is continuous positive airway pressure (CPAP), a device used to prevent upper airway collapse during sleep. Effective CPAP therapy is associated with improved cardiovascular and pulmonary-related morbidity and mortality.^{1–5} Nonadherence to CPAP leads to worsened health outcomes, but it is unclear whether this translates into increased 30-day hospital readmissions. Since the Affordable Care Act established the Hospital Readmission Reduction Program in 2012, 30-day readmissions have been touted as a key quality indicator for hospitals and a way to reduce health care costs.⁶ Preventable causes of readmissions were found to be from congestive heart failure, ischemic cardiomyopathy, obstructive lung disease, and diabetes, all which are linked to OSA.⁷

Most recently explored is the relationship between CPAP adherence and cardiac-related readmissions. A recent single-center study demonstrated that congestive heart failure patients with OSA who were adherent to CPAP had lower 6-month readmissions and emergency department visits than patients who were nonadherent.⁸ Similarly, in hospitalized cardiac patients, inpatient screening of OSA, diagnosis, and treatment initiation resulted in decreased 30-day cardiac readmissions.⁹

Although these studies support the notion that patients with untreated or undertreated OSA may have increased cardiac readmissions, little is known about its relationship with non-cardiac readmissions. Nonadherence to CPAP has been associated with increased chronic obstructive pulmonary disease (COPD) exacerbations, worsened insulin resistance, psychiatric illnesses, and lower urinary tract symptoms.^{10–13} We aim to

characterize the differences in admission types and readmission rates between patients with OSA who are adherent and nonadherent to CPAP. We hypothesized that those who are nonadherent to CPAP therapy for OSA would be associated with increased all-cause, cardiovascular-cause, and pulmonary-cause readmissions.

METHODS

Source of Data

This retrospective cohort study used data from the Veterans Affairs (VA) Long Beach Healthcare System and its institutional review board (IRB) approved this study. Informed consent was waived for retrospective review of patients.

Study Population

Our population included patients who have the diagnosis of OSA and had at least one hospitalization from January 2007 through December 2015 at the VA Long Beach Medical Center. OSA was defined as in the International Classification of Diseases, 9th revision (ICD-9 code 327.23) and later confirmed on polysomnography data on chart review. Patient characteristics were obtained from the electronic inpatient and outpatient data recorded at the Long Beach VA Medical Center. Baseline characteristics included: age on admission, sex, body mass index (BMI), living situation (alone or with others), race, baseline apnea-hypopnea index (AHI), residual AHI, comorbidities at the time of initial admission, and adherence to prescribed medications.

The comorbidities of interest included: hypertension, diabetes mellitus, coronary artery disease, atrial fibrillation/flutter, peripheral artery disease, congestive heart failure, cerebrovascular disease, chronic obstructive pulmonary disease (COPD), asthma, chronic kidney disease, and other arrhythmias. Other arrhythmias included atrial and ventricular arrhythmias that were not atrial fibrillation or flutter.

Medication adherence was derived from reviewing electronic VA pharmacy and calculating the medication possession ratio (MPR). MPR is calculated by dividing the number of the days a prescription supplies by the number of days elapsed during the period between refills. MPR was calculated only if the patient was prescribed the medication within 12 months preceding index admission. It was used to evaluate adherence for angiotensin-converting enzyme inhibitor, β -blocker, calcium channel blocker, diuretic, digoxin, insulin, metformin, β -agonist inhaler, or muscarinic inhaler. These medications were selected based on prior knowledge of nonadherence to β -blocker, angiotensin-converting enzyme inhibitor, and digoxin and its association with worsened health outcomes and hospitalizations, and extrapolated to diabetes and pulmonary medications.¹⁴ MPR is a commonly used measure for medication adherence in literature, and medication adherence has been arbitrarily defined as $\geq 80\%$ in both observational and randomized controlled clinical trials.¹⁵

$$\text{Medication Possession Ratio} = \frac{\text{No. days prescription supplied}}{\text{No. days within refill interval}}$$

Study Design

Patients with OSA were initially identified based on ICD-9 code, and then confirmed on polysomnography data. Patients were selected for review if they had CPAP adherence data within 12 months preceding the index hospital admission. If patients did not have available CPAP adherence data within the 12 months preceding the index admission, they were excluded. CPAP adherence is defined as CPAP use for 4 or more hours per night on 70% of nights during a consecutive minimum of 30-day period based on Medicare definition.¹⁶

Each index admission was followed for 30 days to evaluate if a readmission occurred. A patient can have multiple index admission, regardless of how far apart, as long as CPAP adherence data are available. Index admissions were categorized as cardiovascular, pulmonary, and other including gastrointestinal, infectious, musculoskeletal, neurologic, psychiatric, urologic, and planned procedure.

Readmissions were categorized as all-cause, cardiovascular-cause, or pulmonary-cause. Index admissions were excluded if the patient was discharged against medical advice or due to death. A readmission can count as an index admission, similar to methodologies of Healthcare Cost and Utilization Project developed by the Agency for Healthcare Research and Quality.¹⁷ Unlike the Healthcare Cost and Utilization Project, we do not link readmissions to diagnosis-related groups or major diagnostic criteria. All-cause, cardiovascular-cause, and pulmonary-cause readmissions are considered for all admissions. We also do not exclude planned admissions or readmissions.

Exclusion criteria included lack of objective CPAP adherence data, lack of polysomnography testing to confirm OSA diagnosis, in-hospital death during index admission, and same-day transfer to outside facility.

Outcome Characteristics

Thirty-day readmission was defined as an admission to the hospital within 30 days of a discharge of the index admission. Length of stay was also recorded for all readmissions. Readmissions were categorized as all-cause, cardiovascular-cause, and pulmonary-cause readmissions (Table S1 in the supplemental material).

All-Cause Readmissions

All-cause readmissions include cardiovascular-cause readmissions, pulmonary-cause readmissions, plus all other types of readmissions (gastrointestinal, infection, musculoskeletal, renal, urologic, neurologic, psychiatric, and planned procedures) within 30 days of index admission discharge date.

Cardiovascular-Cause Readmissions

Cardiovascular-cause readmissions include readmission for acute coronary syndrome, congestive heart failure, arrhythmia, hypertensive crisis, cerebrovascular accident, and peripheral vascular disease within 30 days of index admission discharge date.

Pulmonary-Cause Readmissions

Pulmonary-cause readmissions include readmission for asthma, COPD, pulmonary hypertension, obesity hypoventilation

syndrome, hypoxia, interstitial lung disease, and pulmonary embolism within 30 days of index admission discharge date.

Statistical Analysis

Demographic characteristics were summarized using means and standard deviations (SD) for continuous variables and frequencies for categorical variables. Continuous variables were compared using *t* test or analysis of variance, and binary variables were studied using χ^2 or Fisher exact tests. Odds ratio (OR) and their 95% confidence intervals (CIs) were calculated to indicate strength of influence between readmissions and CPAP nonadherence. Logistic regression model was used to evaluate odds of nonadherent versus adherent group while adjusting for age, sex, BMI, living situation, race, comorbidities, and medication adherence. These covariates were chosen based on data availability and prior studies that report demographic factors (male sex, race, social support) and clinical variables (obesity, comorbidities) may affect risk for readmission.^{18,19} Two-tailed values $P < .05$ were considered to indicate significance. Statistical analysis was performed by SPSS version 17 for Windows software (IBM Corp., Armonk, New York, United States).

RESULTS

Patient Characteristics

Of 2,077 patient records reviewed, 345 patients met our inclusion criteria (183 adherent and 162 nonadherent). The most common reason for exclusion was lack of available CPAP adherence data within 12 months preceding a hospitalization. The adherent and nonadherent groups had severe OSA with an average AHI of 46.6 versus 45.4 events/h, respectively, ($P = .78$). The average ages were 66.3 years in the adherent group versus 62.3 years in the nonadherent group ($P = .002$). The nonadherent group comprised more blacks than the adherent group (31 versus 19, $P = .02$). There was no difference in sex, BMI, living situation, baseline AHI, AHI while on CPAP, comorbidities, and medication adherence between the two groups (**Table 1**).

Index Admissions

The CPAP-adherent group had a total of 215 index admissions, and the nonadherent group had a total of 268 initial admissions. **Table 2** shows the frequency of each index admission type. The nonadherent group had fewer planned index admissions (24 (9.0%) versus 33 (15.3%), $P = .03$). The nonadherent group had more urologic (4.5% versus 0.5%, $P = .002$) index admissions compared to the adherent group. Mean length of stay for the nonadherent group was 4.62 days (SD 1.2), compared to 4.22 days (SD 1.6) in the adherent group ($P = .76$).

Readmissions

Patients who were nonadherent to CPAP were more likely to be readmitted within 30 days when compared to adherent counterparts (28.0% versus 10.2%, $P < .001$). Thirty-day all-cause readmission rate was higher in the CPAP nonadherent group with an OR of 3.41 (95% CI 2.04–5.71, $P < .001$) and adjusted OR of 3.52 (95% CI 2.04–6.08, $P < .001$). Similarly, 30-day cardiovascular-cause readmission rate was significantly higher

in the CPAP nonadherent group, with an OR of 2.21 (95% CI 1.11–4.42, $P = .024$) and adjusted OR of 2.31 (95% CI 1.11–4.78, $P = .02$).

The nonadherent group had OR of 5.74 (95% CI 0.70–47.02, $P = .08$) and adjusted OR of 3.66 (95% CI 0.41–32.76, $P = .25$) for pulmonary-cause readmissions. (**Table 3**).

Table 4 shows breakdown of all-cause, cardiovascular-cause, and pulmonary-cause readmissions.

DISCUSSION

This study supports our hypothesis that CPAP nonadherence is associated with increased 30-day readmissions. Patients with OSA who were not adherent with CPAP had higher 30-day all-cause and cardiovascular-cause readmissions after adjusting for age, sex, race, living situation, BMI, AHI, comorbidities, and medication adherence. Cardiovascular and pulmonary health benefits of CPAP use are well documented,^{1,3–5,20} and this study demonstrates a link between baseline CPAP adherence and readmissions for all hospitalization types. Our study builds upon prior single-site studies showing a relationship between effective OSA treatment and readmission.^{8,9}

Nonadherence to CPAP was associated with higher 30-day cardiovascular-cause readmissions. The cardiovascular-cause readmissions in the nonadherent group were most commonly due to atrial fibrillation (29.0%), myocardial ischemia (22.5%), and congestive heart failure (19.3%) (**Table 4**). These findings are expected, as atrial fibrillation is known to occur more frequently with increased number of apneic episodes and severity of hypoxemia, and CPAP therapy is associated with improved left ventricular systolic function and decreased atrial fibrillation occurrence.^{1,4,5} Effective use of CPAP has also been associated with decreased sympathetic activity, improved blood pressure, and overall decreased cardiovascular events.^{3,20}

Pulmonary-related readmissions were higher in the CPAP nonadherent group, but did not reach the level of significance. Pulmonary-related readmissions in the nonadherent group were primarily due to COPD (71.4%) (**Table 4**). We expected pulmonary-related readmissions to be higher in the nonadherent group based on literature on overlap syndrome. Those with OSA and COPD are considered to have overlap syndrome, and without CPAP therapy are at higher risk for COPD exacerbation requiring hospitalization, pulmonary hypertension, and mortality.¹³ CPAP therapy may reduce 6-month hospital readmissions and emergency department visits in overlap syndrome.²¹ However, the number of patients with pulmonary readmissions was very small, and analysis did not reach statistical or clinical significance.

The most common (noncardiac and nonpulmonary) causes of all-cause readmissions in the nonadherent group were: urologic (10.7%), infection (8.0%), and psychiatric (5.3%) (**Table 4**). Although the reasons for these readmissions seem broad and unrelated, there is a growing body of evidence that supports increased urinary tract symptoms, immune dysfunction, and psychiatric disorders in OSA.

Urologic readmissions were predominantly due to benign prostate hypertrophy (BPH), lower urinary tract symptoms

Table 1—Baseline demographics of adherent and nonadherent groups.

Baseline Characteristics	Adherent (n = 183)	Nonadherent (n = 162)	P
Age, mean (SD)	66.3 (11.4)	62.3 (12.1)	.002
BMI, mean (SD)	34.4 (7.5)	33.0 (7.9)	.10
Sex, n (%)			
Male	174 (95.1)	153 (94.4)	.79
Female	9 (4.9)	9 (5.6)	
Living situation, n (%)			
With others	128 (69.9)	108 (66.7)	.63
Alone	39 (21.4)	40 (24.7)	
Not available	16 (8.7)	14 (8.6)	
Comorbidities, n (%)			
Hypertension	153 (83.6)	132 (81.5)	.61
Diabetes mellitus	92 (50.3)	86 (53.1)	.60
Coronary artery disease	39 (21.3)	41 (25.3)	.38
Atrial fibrillation/flutter	32 (17.5)	28 (17.3)	.96
Other arrhythmia	32 (17.5)	25 (15.4)	.61
Peripheral artery disease	21 (11.5)	24 (14.8)	.36
Congestive heart failure	20 (10.9)	25 (15.4)	.22
Stroke/transient ischemic attack	19 (10.4)	19 (11.7)	.69
Chronic obstructive pulmonary disease	38 (20.8)	31 (19.1)	.71
Asthma	19 (10.4)	26 (16)	.12
Chronic kidney disease	52 (28.4)	50 (30.9)	.62
Race, n (%)			
White	139 (76)	110 (67.9)	.1
Black	19 (10.4)	31 (19.1)	.02
Other	25 (13.7)	21 (13.0)	.85
Medication adherence, (%) ^a			
ACE inhibitor	89.4	70.1	.86
Digoxin	83.3	100.0	.13
Insulin	71.1	73.5	.68
β-blocker	65.0	28.0	.68
Metformin	63.9	66.2	.98
Muscarinic inhaler	62.5	46.4	.16
Diuretic	60.0	68.0	.72
Calcium channel blocker	58.6	67.9	.24
β-agonist inhaler	36.0	56.8	.55
Sleep apnea characteristics, mean (SD)			
AHI	46.6 (33.1)	45.4 (44.2)	.78
Residual AHI	3.03 (3.5)	3.60 (6.7)	.32
CPAP adherence average	0.93 (0.1)	0.20 (0.2)	< .001

^a = defined as medication possession ratio. ACE inhibitor = angiotensin-converting enzyme inhibitor, AHI = apnea-hypopnea index, BMI = body mass index, CPAP = continuous positive airway pressure, SD = standard deviation.

(LUTS), and urinary retention. Untreated OSA is associated with increased risk for BPH and worsened LUTS, and CPAP therapy is associated with reduced nocturnal urinary symptoms.^{12,22} The mechanism is unclear, but autonomic dysfunction or increased atrial natriuretic peptides have been proposed as possible mechanisms for nocturnal polyuria.²³ It is important to note that nighttime LUTS may lead to CPAP nonadherence, and therefore patients with severe BPH and worsened LUTS may consequently have more urologic-related admissions and lower CPAP adherence. However, a small case control VA study found that BPH symptoms did not have an effect on CPAP adherence in veteran patients.

Infection was the second most common cause of all-cause readmission. The higher risk for infection among patients with

OSA who are nonadherent to CPAP may be due to impaired immunity in sleep deprivation. Sleep deprivation in OSA is commonly from apnea and hypopnea-related arousals leading to sleep fragmentation. Chronic sleep deprivation has been associated with reduced natural killer cell activity, suppressed I-2 production, altered monocyte proinflammatory cytokine response, and attenuated antibody response to immunizations.^{24,25}

The third most common reason for all-cause readmission was psychiatric, specifically posttraumatic stress disorder (PTSD). PTSD is common among veterans, and a growing body of literature suggests a bidirectional relationship between OSA and PTSD. Patients with OSA and PTSD are less likely to use CPAP, but adherence to CPAP for patients who are veterans and have OSA and PTSD have been demonstrated

Table 2—Index admission characteristics between adherent and nonadherent group.

Index Admission Type	Adherent (n = 215)	Nonadherent (n = 268)	P
Cardiovascular	59 (27.4)	76 (28.4)	.84
Infection	28 (13)	24 (9)	.18
Pulmonary	22 (10.2)	19 (7.1)	.25
Gastrointestinal	17 (7.9)	30 (11.2)	.28
Musculoskeletal	15 (7)	12 (4.5)	.24
Psychiatric	8 (3.7)	21 (7.8)	.08
Renal	3 (1.4)	10 (3.7)	.16
Neurologic	2 (0.9)	10 (3.7)	.07
Urologic	1 (0.5)	12 (4.5)	.01
Planned procedure	33 (15.3)	24 (9.0)	.03
Other	27 (12.6)	30 (11.2)	.67

Values are presented as n (%).

Table 3—Comparison of 30-day readmission characteristics and adjusted odds ratio between adherent and nonadherent group.

Readmission Type	Adherent (n = 215)	Nonadherent (n = 268)	Adjusted OR (95% CI)	P
All-cause	22 (10.2)	75 (28.0)	3.52 (2.04–6.08)	< .001
Cardiovascular-cause	12 (5.6)	31 (11.6)	2.31 (1.11–4.78)	.02
Pulmonary-cause	1 (0.47)	7 (2.6)	3.66 (0.41–32.76)	.25

Values are presented as n (%). CI = confidence interval, OR = odds ratio.

Table 4—Breakdown of all-cause, cardiovascular-cause, and pulmonary-cause readmissions.

All-Cause Readmission Breakdown *	Adherent (n = 215)	Nonadherent (n = 268)
Urologic	0	8
Infection	1	6
Psychiatric	0	4
Gastrointestinal	2	3
Neurologic	0	3
Oncologic	0	3
Diabetes	1	2
Musculoskeletal	1	1
Planned procedure	4	1
Other	0	6
Cardiovascular-Cause Readmission Breakdown	Adherent (n = 12)	Nonadherent (n = 31)
Atrial fibrillation	3	9
Myocardial ischemia	1	7
Congestive heart failure	2	6
Cerebrovascular disease	1	4
Arrhythmia	2	2
Peripheral vascular disease	0	2
Hypertension	3	1
Pulmonary-Cause Readmission Breakdown	Adherent (n = 1)	Nonadherent (n = 7)
COPD	1	5
Asthma	0	2

* = all-cause also includes cardiovascular-cause and pulmonary-cause readmissions. COPD = chronic obstructive pulmonary disease

to improve PTSD symptoms.²⁶ The observed increase in psychiatric readmissions in the nonadherent group in this study

may denote more severe baseline psychiatric disorder that prevented adherent CPAP use.

Although analyzing index admissions was not our main objective, it is important to comment on the differences seen in index admission type between the adherent and nonadherent group. The CPAP-nonadherent group had significantly higher urologic-related index admissions, likely attributable to increased risk for BPH, LUTS, and urinary retention.^{12,22,23} The CPAP-nonadherent group also had fewer planned procedures, which may indicate that the nonadherent group was an unhealthier population with fewer planned admissions and elective procedures.

Interestingly, there was a difference in age and race between the adherent and nonadherent groups. The average age of the adherent group was 4 years older than that of the nonadherent group (62.33 versus 66.26, $P = .002$). Because the Sleep Heart Health Study and other studies have shown an increase in cardiovascular events and ischemic strokes in older patients with OSA, one might expect the adherent group to have more index readmissions.^{27–29} However, despite the inherent independent risk for cardiovascular events due to age, the adherent group still had fewer cardiovascular-cause and all-cause readmissions in this study. Moreover, there were more blacks in the nonadherent group than the adherent group (10.4% versus 19.1%, $P = .02$). This is consistent with prior studies that demonstrate black race was a factor independently associated with worse CPAP adherence.^{30,31} Blacks have lower daily CPAP usage (about 1.5 hours less), possibly due to shorter sleep duration from less sleep opportunity, and fewer CPAP attempts than those who are not black.³² The reason for poor CPAP adherence in the black race remains complex and not fully understood, and future studies are warranted to identify barriers in at-risk populations.

This study has several limitations that merit discussion. (1) This study was performed in a single Veterans Affairs Medical Center, limiting generalizability. Veterans within the system are likely to be white, male, have more chronic illness, substance abuse, and lower income.³² However, it is important to note that despite these differences in baseline features, the readmission rates in our CPAP-adherent population and the Medicare and general VA population are relatively similar. Medicare patients' readmission rates range from 8%³³ to 21%,³⁴ the general veterans' overall readmission rate is 13.8%,³⁵ and the 30-day all-cause readmission rate of the adherent group in this study was found to be 10.2%. (2) As with all retrospective studies, the design limits the ability to prove a causal relationship. (3) Also with retrospective studies, there is potential for confounders that may bias results. To the best of our ability, we attempted to mitigate confounders by using multiregression analysis to adjust for baseline demographics, social conditions, comorbidities, and medication adherence. However, there are many more factors we did not adjust for, including health literacy, discharge planning, socioeconomic status, and psychiatric conditions. (4) Most of the 2,077 patients were excluded due to lack of sleep clinic follow-up within 12 months preceding index admission. Selection bias may have occurred, as lack of annual follow-up at a sleep clinic may indicate nonadherent health behaviors, and the outcomes of patients who do not follow-up in clinic were not captured in this study. (5) Readmissions were not linked with index admissions by major

diagnostic criteria or diagnostic-related group. Therefore, this study does not attempt or have the ability to draw clinical or physiologic conclusions as to how readmissions are related to index admissions. The aim of this study was to characterize the differences in admissions and readmissions between patients who are CPAP adherent and nonadherent. (6) CPAP and medication adherence was dichotomized using arbitrary cutoffs, and not evaluated as dose effect. The arbitrary cutoffs, however, have been used in most observational studies and randomized controlled trials.^{14,36,37} (7) We used an ICD-9 code to identify OSA. As with other coding-based studies, we cannot rule out the presence of coding errors in the clinical setting, and many patients with OSA may have been missed. (8) Readmissions to non-VA hospitals were not identified. However, we believe non-VA hospital admissions are negligible, because prior studies found only 2.9% of veterans are readmitted to non-VA hospitals within 30 days.³⁸ (9) Finally, because of the small size of the cohort, this study may be underpowered to detect some differences between the adherent and nonadherent groups. Future prospective studies are warranted to validate our findings.

In summary, CPAP nonadherence may be associated with increased all-cause and cardiovascular-cause 30-day readmission rates. The modifiable nature of OSA, its high prevalence, and link to multiorgan health and increased healthcare utilization makes it an important clinical and public health disease to target.

ABBREVIATIONS

AHI, apnea-hypopnea index
 BMI, body mass index
 BPH, benign prostate hypertrophy
 CI, confidence interval
 COPD, chronic obstructive pulmonary disease
 CPAP, continuous positive airway pressure
 LUTS, lower urinary tract symptoms
 MPR, medication possession ratio
 OSA, obstructive sleep apnea
 SD, standard deviation
 VA, Veterans Affairs

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