

The Relationship Between Sleep Apnea and Chronic Kidney Disease: A Scoping Review

**Rifda El Mahroos ^{1*}, Rifka Wangiana Yulia Putri ², Shellya Puti Sudesty ³, Zulfan Febriawan¹,
Aktaruddin Arief Santoso ⁴**

¹ Department of Physiology, Faculty of Medicine, Universitas Pembangunan Nasional “Veteran” Jawa Timur, Surabaya, East Java, 60294, Indonesia

² Department of Medicine, Faculty of Medicine, Muhammadiyah University of Surakarta, Central Java, Sukoharjo 57169, Indonesia

³ Departement of Medical Biology, Molecular Biology, and Physiology, Faculty of Medicine, University of Lampung, Bandar Lampung, 35145, Indonesia

⁴ Department of Internal Medicine, Universitas Pembangunan Nasional “Veteran” Jawa Timur, Surabaya, East Java, 55283, Indonesia

Corresponding Author

Rifda El Mahroos

Universitas Pembangunan Nasional “Veteran” Jawa Timur

+62-85-22-2272-100

Email: rifdaelmahroos@gmail.com

ABSTRACT

Sleep apnea and chronic kidney disease (CKD) have a complex bidirectional effect. Sleep apnea accelerates the decline of kidney function through various mechanisms. CKD can worsen the severity of sleep apnea. This study aims to conduct a scoping review of studies discussing the relationship between sleep apnea and CKD. A scoping review was conducted through a systematic literature search in PubMed, Google Scholar, and ScienceDirect using keywords related to sleep apnea, CKD, and CPAP therapy. A total of 18 peer-reviewed articles meeting the inclusion criteria were analyzed. The prevalence of sleep apnea among CKD patients was found to be high, with a bidirectional relationship worsening both conditions. Sleep apnea was identified as an independent risk factor accelerating the progression of CKD. CPAP therapy demonstrated significant benefits in improving kidney function and reducing biomarkers of kidney injury, especially among patients with good treatment adherence. Variability in diagnostic methods and population characteristics influenced the study results. The relationship between sleep apnea and CKD is multifactorial and requires a multidisciplinary management approach. CPAP therapy has the potential to slow the progression of CKD.

Keyword : Chronic kidney disease; continuous positive airway pressure; hypoxia; sleep apnea syndromes

Introduction

Sleep apnea is a breathing disorder characterized by repeated episodes of upper airway obstruction or complete cessation of airflow during sleep, leading to intermittent hypoxia, recurrent arousals, and fragmented sleep architecture.¹ The most common form, obstructive sleep apnea (OSA), affects a substantial proportion of the adult population worldwide, with prevalence estimates ranging from 9% to 38% depending on the diagnostic criteria and population studied. Beyond its immediate impact on sleep quality, sleep apnea is associated with excessive daytime sleepiness, cognitive impairment, reduced work productivity, and impaired quality of life¹. Moreover, it is increasingly recognized as an independent risk factor for a wide range of systemic diseases, including hypertension, coronary artery disease, heart failure, stroke, arrhythmias, and metabolic disorders such as insulin resistance and type 2 diabetes mellitus². These cardiovascular and metabolic consequences are largely attributed to the chronic intermittent hypoxia and sympathetic nervous system activation that characterize the disorder.

One systemic condition that has gained particular attention in relation to sleep apnea is chronic kidney disease (CKD). CKD is defined as abnormalities of kidney structure or function present for more than three months, with implications for health. It is a major global health problem, affecting approximately 10–15% of adults worldwide, and its prevalence continues to rise due to the increasing burden of diabetes, hypertension, and aging populations.³ CKD is associated with serious complications, including cardiovascular disease, anemia, mineral and bone disorders, and progression to end-stage kidney disease requiring dialysis or transplantation³. The economic and societal costs of CKD are substantial, making early identification and management of modifiable risk factors a public health priority.

The link between sleep apnea and CKD has attracted growing interest over the past two decades. Epidemiological studies have consistently shown that the two conditions frequently coexist, and evidence suggests a bidirectional relationship in which each can exacerbate the other⁴. On one hand, sleep apnea may contribute to the development and progression of CKD through multiple pathophysiological mechanisms. Intermittent hypoxia, the hallmark of sleep apnea, triggers sympathetic nervous system overactivity, activation of the renin angiotensin aldosterone system, oxidative stress, and systemic inflammation⁵. These processes promote endothelial dysfunction, glomerular hypertension, tubulointerstitial injury, and fibrosis, ultimately accelerating kidney damage^{5,6}. On the other hand, kidney dysfunction can worsen sleep apnea severity. Fluid retention and nocturnal

rostral fluid shift, uremic neuropathy, altered chemoreflex sensitivity, and metabolic derangements in CKD patients may predispose to upper airway collapse and central apneas, creating a vicious cycle that amplifies both conditions ⁶.

Despite the growing body of evidence, several important gaps remain. The prevalence of sleep apnea in CKD populations varies widely across studies, partly due to differences in diagnostic methods and definitions. The precise mechanisms linking the two conditions are still not fully elucidated, and the extent to which sleep apnea independently contributes to CKD progression remains debated. Furthermore, the impact of therapeutic interventions, particularly continuous positive airway pressure (CPAP), on kidney outcomes in patients with sleep apnea is not well established. Some studies suggest that CPAP therapy may improve renal function markers, reduce proteinuria, and slow CKD progression, while others show inconsistent results, often limited by short follow-up, poor adherence, and heterogeneous patient populations ⁷.

Given the significant health burden posed by both sleep apnea and CKD, a comprehensive understanding of their relationship is essential for clinicians, researchers, and policymakers. This scoping review aims to systematically map the existing literature on the association between sleep apnea and CKD, focusing on prevalence, pathophysiological mechanisms, risk of progression, diagnostic approaches, and the effectiveness of CPAP therapy in improving kidney prognosis. By synthesizing current evidence and identifying knowledge gaps, this review seeks to inform clinical practice and guide future research directions.

Material and Methods

The method used in this article was a scoping review. A systematic literature search was conducted in three major databases: PubMed, Google Scholar, and ScienceDirect, using a combination of keywords: "sleep apnea," "chronic kidney disease," "continuous positive airway pressure," "kidney function," and other related terms. The search included articles published between January 2021 and May 2025.

Inclusion criteria consisted of peer-reviewed, English-language articles that explicitly addressed the relationship between sleep apnea and CKD, including observational studies, clinical trials, and meta-analyses. Irrelevant studies, narrative articles, editorials, and studies on kidney or respiratory disorders other than sleep apnea were excluded.

Article selection was conducted in stages. The selection results and literature search flow were documented using a PRISMA diagram for transparency (Figure 1).

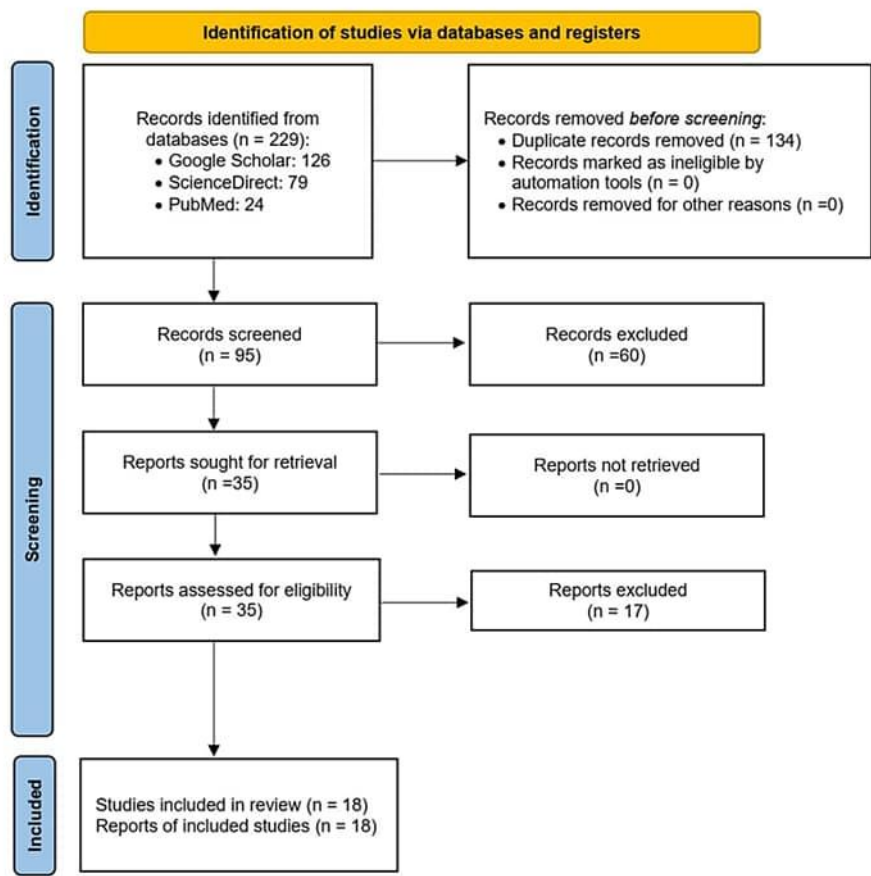


Figure 1. Study Selection Flow Chart

Results

Only 18 articles met all criteria and were included in the final synthesis. The search for articles meeting the criteria consisted of 12 articles from Google Scholar, 1 article from PubMed, and 5 articles from ScienceDirect. A summary of the main findings is presented in **Table 1.**

Table 1. Summary of Included Studies

No	Titles	Authors (Years) & Country	Problem Statement	Research Purposes	Study Design	Main Finding
1	Obstructive Sleep Apnea Risk Factor for Chronic Kidney Disease: A Systematic Review and Meta-analysis	Loayza-Castro et al. (2023), Peru	OSA is associated with CKD, but this relationship is not fully understood and has rarely been thoroughly analyzed through systematic studies and meta-analyses.	To determine whether there is a relationship between OSA and CKD based on data from observational studies analyzed systematically and meta-analyzed.	Systematic review and meta-analysis of observational studies.	- OSA increases the risk of CKD (HR=2.00) - Data from 5 studies (n=6,710) - Consistency of results between studies is quite high
2	Sleep apnoea syndrome prevalence in chronic kidney disease and end-stage kidney disease patients: a systematic review and meta-analysis	Pisano et al. (2023), Italy & USA	Sleep apnea is common in patients with CKD and end-stage renal disease (ESKD), but its reported prevalence varies. Accurate estimates using objective diagnostic methods are needed.	Determining the prevalence of sleep apnea in CKD and ESKD patients using meta-analysis of tool-based and questionnaire-based studies.	Systematic review and meta-analysis of 123 studies	- Prevalence of SA: 57% (CKD), 49% (ESKD). - Diagnostic tools are more accurate than questionnaires. - Instrumental monitoring shows a higher prevalence.
3	Association of Estimated Glomerular Filtration Rate with the Incidence of Sleep Apnea Syndrome	Azegami et al. (2024), Japan	The role of decreased kidney function in the risk of sleep apnea syndrome (SAS) is not fully understood. Conversely, the relationship between SAS and kidney function has been more widely explored. This reverse causality is an important issue in longitudinal studies.	To examine the relationship between eGFR decline and the incidence of SAS using administrative data and health examinations.	Retrospective cohort study based on administrative claims and health checkup data; n = 1,589,259; median follow-up 1167 days, health checkup (2014–2022).	- Decreased eGFR increases the risk of SAS. - The risk of SAS increases in a dose-responsive manner. - Consistent in all sensitivity analyses.
4	Patients with Obstructive Sleep Apnea Have Altered Levels of Four Cytokines Associated with Cardiovascular and Kidney Disease, but Near Normal Levels with Airways Therapy	Wang et al. (2021), USA	OSA causes chronic intermittent hypoxia that triggers an increase in proinflammatory cytokines, increasing the risk of cardiovascular and kidney disease. The role of other specific cytokines and the impact of airway therapy remain unclear.	To assess the levels of four inflammatory cytokines in OSA patients with and without airway therapy and compare them with the control group.	Cross-sectional; 46 patients (19 OSA without therapy, 19 OSA with therapy, 8 controls); serum cytokine measurements (MMP2, MMP3, TWEAK, CD163) using Bio-Plex.	- MMP2 and CD163 are decreased in OSA. - MMP3 is increased in OSA. - Airway therapy normalizes cytokine levels.
5	Association between obstructive sleep apnea and chronic kidney disease: A cross-sectional and Mendelian randomization study	Wang et al. (2025), China	Obstructive sleep apnea (OSA) is associated with an increased risk of chronic kidney disease (CKD), but evidence for a causal relationship remains unclear, and mediating mechanisms such as obesity and hypertension have not been extensively studied.	Assess the causal relationship between OSA and CKD and the role of mediators such as obesity and hypertension.	Cross-sectional + Mendelian Randomization (MR)	- OSA is associated with CKD - Hypertension and obesity as mediators - MR: OSA genetically decreases eGFR, increases BUN and creatinine
6	Prevalence of Sleep Apnea and Its Associated Factors in Chronic Kidney Disease Patients	Moradzadeh et al. (2021), Iran	Sleep apnea is common in patients with chronic kidney disease (CKD), but factors associated with its prevalence are not fully understood. Given the high risk of cardiovascular comorbidities, it is important to understand its prevalence and risk factors specifically in CKD patients.	To determine the prevalence of sleep apnea and related factors in CKD patients using the STOP-BANG questionnaire and the AHI index.	Cross-sectional, 47 CKD patients, using the STOP-BANG & AHI questionnaire, logistic regression analysis	- Prevalence of sleep apnea: 53.2% - BMI significantly positive - BUN significantly negative - AUC of the regression model: 0.7982 - STOP-BANG has good validity
7	Association of insomnia and short sleep duration, alone or with comorbid obstructive sleep apnea, and the risk of chronic kidney disease	Beaudin et al. (2022), Canada	OSA, insomnia, and short sleep duration have each been associated with chronic kidney disease (CKD), but have not been directly compared in a single cohort to examine their independent and combined contributions to CKD progression.	To assess the impact of OSA, insomnia, and short sleep duration on the risk of CKD progression separately and in combination.	Cross-sectional study of 732 patients with PSG/HSAT testing, questionnaires, and blood and urine analysis.	- OSA increases the risk of CKD. - Insomnia and short sleep do not increase the risk of CKD. - COMISA does not increase the risk further than OSA alone.
8	Risk of chronic kidney disease in patients with obstructive sleep apnea	Beaudin et al. (2022), Canada	OSA and CKD often co-occur, but few studies have used the combination of eGFR and ACR to assess the risk of CKD progression and patient awareness of this condition.	To assess the relationship between OSA and the risk of CKD progression and patient awareness of their kidney function.	Observational multicenter, cross-sectional cohort with eGFR and ACR data from OSA patients at five sleep centers in Canada.	- The risk of CKD increases in moderate and severe OSA. - The odds ratios are 2.63 and 2.96, respectively. 73% of patients are unaware of having kidney problems.

No	Titles	Authors (Years) & Country	Problem Statement	Research Purposes	Study Design	Main Finding
9	Obstructive sleep apnea is associated with impaired renal function in patients with diabetic kidney disease	Zamarrón et al. (2021), Spain	The effect of OSA on kidney function in patients with treated DKD is still unknown, although the two often coexist and cause serious complications.	Evaluating the contribution of OSA and sleep parameters to UACR and eGFR in DKD patients.	Observational, multicenter, cross-sectional (n = 214 DKD patients, sleep study + biomarker lab test).	- Severe OSA: Higher UACR, lower eGFR. - AHI and ODI are independent predictors of UACR and eGFR. - Independent of HbA1c and blood pressure.
10	Continuous Positive Airway Pressure Effect on Albuminuria Progression in Patients with Obstructive Sleep Apnea and Diabetic Kidney Disease: A Randomized Clinical Trial	Zamarrón et al. (2022), Spain	The effect of CPAP on the progression of diabetic kidney disease (DKD) in patients with obstructive sleep apnea (OSA) remains unclear, especially in the context of randomized controlled trials focusing on the progression of albuminuria.	To assess the effect of CPAP on the progression of albuminuria in patients with DKD and OSA in a randomized controlled trial.	Randomized Clinical Trial (multicenter, open-label, parallel-group, 52 weeks, n=185 patients)	- CPAP does not significantly reduce albuminuria in general. - Effective in compliant patients (≥4 hours/night). - Improves glycemic control and quality of life.
11	A meta-analysis of the correlation between obstructive sleep apnea syndrome and renal injury	Yang et al. (2024), China	The correlation between OSAS and kidney injury remains debated. Some studies show a strong link, while others are inconclusive. The specific mechanisms are not fully understood.	To determine the correlation between OSAS and indicators of kidney injury through meta-analysis of data from various studies.	Systematic meta-analysis of 8 observational-based studies (n=981), evaluating Cystatin C, creatinine, and urea nitrogen.	- Cystatin C, creatinine, and urea nitrogen were higher in OSAS. - Statistically significant correlation. - No publication bias.
12	Obstructive Sleep Apnea during Rapid Eye Movement Sleep in Patients with Diabetic Kidney Disease	Nishimura et al. (2021), Japan	It is not known whether OSA during REM/NREM sleep is associated with DKD, although OSA has an impact on metabolic complications.	To determine whether sleep phase OSA (REM/NREM) is independently associated with DKD.	Cross-sectional study using polysomnography in 303 type 2 diabetes patients to analyze the relationship between OSA, REM and DKD	- REM-AHI is significant for DKD - NREM-AHI is not significant - Hypoxemia also has an effect
13	CPAP Improves Renal Function in Obese Patients with OSA	Perticone et al. (2021), Italy	Obstructive sleep apnea syndrome (OSAS) negatively impacts cardiovascular and kidney function, particularly in obese patients. CPAP therapy is recommended, but its effect on kidney function in obese patients with OSAS remains uncertain.	To assess the effect of CPAP on e-GFR in obese patients with moderate-severe OSA.	Prospective cohort study evaluating the effects of CPAP therapy for 6 months in 165 obese patients with OSAS and normal renal function.	- CPAP ↑ e-GFR - AHI ↓ → e-GFR ↑ - Microalbuminuria decreases
14	Associations between obstructive sleep apnea and sleep characteristics with chronic kidney disease in rural Pennsylvania	Sanders et al. (2024), USA	OSA and sleep disturbances are thought to increase the risk of CKD, but few studies have assessed this association in rural populations like Appalachia, which experience health disparities.	Assessing the relationship of OSA and sleep characteristics to CKD in a rural adult population in Pennsylvania.	Observational, retrospective, cross-sectional (2009–2019), using PSG and HER data, n=23,643 participants	- msOSA increases the prevalence of CKD by 13% - Short sleep duration, low sleep efficiency, and hypoxemia are significantly associated with CKD - No significant effect modification by gender, rurality, or socioeconomic status
15	Obstructive sleep apnea is associated with cardiac structural and functional alterations in patients with advanced diabetic kidney disease	Nielsen et al. (2025), Denmark	OSA is common in T2DM, but the relationship of OSA to cardiac structure and function in advanced DKD patients with decreased kidney function is unclear and understudied.	To examine the relationship between OSA and changes in cardiac structure and function in advanced DKD patients.	Observational, cross-sectional	- DKD patients with moderate-to-severe OSA had higher LAVI, LVMI, and RVD. - GLS was reduced in the OSA group. - LVEF was not significantly different. - OSA was independently associated with these cardiac parameters.
16	Obstructive sleep apnea, coronary calcification and arterial stiffness in patients with diabetic kidney disease	Nielsen et al. (2024), Denmark	DKD patients have a high risk of cardiovascular disease, but the relationship between OSA and coronary calcification and large artery stiffness has not been specifically studied in this population.	To examine the relationship between OSA, coronary calcification, and large artery stiffness in DKD patients.	Observational, cross-sectional, n= 114 patients with acceptable AHI recordings	- Severe OSA is associated with high PWV - OSA is not significant for CAS after adjustment - OSA = second most important risk factor for PWV
17	The relationship between obstructive sleep apnea and risk of renal impairment in patients with hypertension, a longitudinal study	Liu et al. (2023), China	The relationship between OSA and kidney damage is unclear, especially in hypertensive patients who are at high risk for CKD. Previous longitudinal studies are limited and the results are inconsistent.	To assess whether OSA is an independent risk factor for CKD in hypertensive patients.	Longitudinal, retrospective cohort (2011–2022), Cox regression and PSM analysis	- OSA increases the risk of CKD (HR 1.21) - Risk increases in severe OSA - Consistent in subgroup and sensitivity analyses
18	Continuous positive airway pressure treatment reduces renal tubular damage in patients with obstructive sleep apnea: A retrospective single-center cohort study	Moriya et al. (2023), Japan	The effect of intermittent hypoxia due to OSA on renal tubular damage is not well understood, even though CKD is common in OSA patients and renal damage often occurs in the tubules.	To evaluate the impact of intermittent hypoxia due to OSA and the effect of CPAP therapy on renal tubular damage.	Retrospective, cohort, observational, single-center	- UNHCR increases with 3% KODI - UNHCR decreases after CPAP - 3% ODI is significantly associated with UNCR - Severe OSA cluster: high risk of tubular injury

Discussion

The findings of this scoping review suggest a complex and reciprocal relationship between sleep apnea and CKD. Consistently reported across studies, the prevalence of sleep apnea in patients with CKD and end-stage renal disease (ESKD) is high.^{8–10} A cross-sectional study by Moradzadeh et al.⁹ reported that 53.2% of CKD patients experienced sleep apnea. Another study, a systematic review and meta-analysis of 123 studies by Pisano et al.⁸, demonstrated a sleep apnea prevalence of 57% in CKD and 49% in ESKD cases. Nielsen et al.¹¹ and Sanders et al.¹⁰ further highlighted the association between OSA and cardiovascular complications, as well as distinctive sleep patterns in CKD patients, particularly in rural populations and individuals with diabetes and reduced renal function. Environmental and sociodemographic factors (such as rural residence) influence this relationship, so indicating the need for context-specific screening.

A meta-analysis by Loayza-Castro et al.¹² revealed a consistent association between OSA and CKD. Sleep apnea is recognized as an independent risk factor for CKD progression.¹³ Recent research further adds that decreased kidney function (measured by eGFR) is directly proportional to the risk of developing sleep apnea.^{14–16} One study found that approximately 30% of patients with severe OSA had a threefold higher risk of developing CKD compared to those with mild or no OSA.¹⁵ These findings provide evidence that the OSA-CKD relationship is not a one-way street, but rather a bidirectional mechanism that worsens both conditions.

The findings of elevated biomarkers such as serum cystatin C, creatinine, and urea nitrogen in meta-analyses support the evidence of kidney damage in OSA patients.¹⁷ OSA significantly contributes to decreased kidney function and is an independent risk factor for the development of CKD. Thus, OSA is not only a comorbidity but also plays an active role in the pathophysiological mechanisms of kidney injury.

The most widely accepted pathophysiological mechanisms linking sleep apnea and CKD are through chronic intermittent hypoxia, sympathetic nervous system activation, systemic inflammation, and endothelial dysfunction. All of these mechanisms contribute to the formation of renal vascular and tubular injury due to the formation of oxidative stress and fluid imbalance in OSA patients, which further exacerbates renal dysfunction and accelerates the progression of CKD.^{6,7,18,19} A study by Wang et al.⁴ combining National Health and Nutrition Examination Survey (NHANES) data and Mendelian randomization (MR) analysis of the pathways mediating obesity and hypertension showed that OSA genetically decreases renal function (indicated by lower eGFR; higher BUN & creatinine).

Independently, sleep apnea is also associated with a higher risk of functional and structural renal injury in the hypertensive population.²⁰

To mitigate the detrimental effects of OSA on the kidneys, several studies have suggested that CPAP therapy may act as a key intervention. Studies by Perticone et al.²¹ and Moriya et al.⁷ showed that consistent CPAP use improved kidney function and reduced biomarkers of tubular injury. Although a study by Zamarrón et al.²² reported that CPAP did not significantly reduce overall albuminuria, supplemental CPAP therapy was able to reduce albuminuria long-term compared with usual care alone. This protective effect is likely mediated through reduced oxidative stress, inflammation, and activation of the renin-angiotensin system.⁶ However, adherence to CPAP remains a significant challenge that significantly impacts treatment outcomes. The long-term effectiveness of CPAP also requires further investigation through larger, longer-duration clinical studies to confirm these findings.

Variability in sleep apnea diagnostic methods poses challenges in prevalence estimation and clinical management. Therefore, the use of polysomnography and population-validated screening tools is highly recommended to improve diagnostic accuracy.^{11,23} Biomarkers such as serum cystatin C have been shown to be sensitive early indicators of kidney injury and may improve monitoring effectiveness.¹⁷ The complex relationship between OSA CKD, and others comorbits requires a multidisciplinary approach involving sleep specialists, nephrologists, and cardiologists to optimize outcomes.^{11,24}

Also in this scoping review, a study by Sanders et al.¹⁰ in a vulnerable rural population in Pennsylvania highlighted health disparities between rural and urban communities that warrant further investigation. However, this study also suggests that OSA and poor sleep quality frequently coexist with CKD.

Conclusion

This review provides current evidence on the bidirectional relationship between OSA and CKD, integrating data on epidemiology, mechanisms, diagnostics, and CPAP therapeutic strategies. OSA plays a crucial role in accelerating the progression of kidney damage through complex pathophysiological mechanisms. CPAP therapy has shown promise in improving kidney function and slowing the progression of CKD in patients with OSA. To strengthen the causal link between OSA and CKD, future high-quality prospective and interventional studies are needed, as well as evaluation of the long-term effects of CPAP therapy. These findings also reinforce the need for routine OSA screening to integrate with

CKD clinical practice.

Declaration of Generative AI in Scientific Writing

The authors affirm that the usage of generative artificial intelligence tools, including Chat GPT and Gemini AI, is intended solely for improvement scientific writing. These tools were not used for generating content, data analysis, or interpretation. The authors are fully responsible for the accuracy and integrity of the content as well as the conclusions presented in this study

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