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Knowledge, attitude, and practice of inpatients with cardiovascular disease regarding obstructive sleep apnea

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There is a significant interrelationship between cardiovascular disease and obstructive sleep apnea (OSA), as they share common risk factors and comorbidities. This study aimed to investigate the knowledge, attitude, and practice (KAP) of inpatients with cardiovascular disease towards OSA. This cross-sectional study was conducted between January, 2022 and January, 2023 at Zhongda Hospital Affiliated to Southeast University among inpatients with cardiovascular disease using a self-administered questionnaire. A self-designed questionnaire was used to assess KAP, and the STOP-Bang questionnaire was applied to evaluate participants' OSA risk. Spearman correlation and path analyses were conducted to explore relationships among KAP scores and high OSA risk. Subgroup analyses were conducted within the high-risk population identified by the STOP-Bang questionnaire. In a study analyzing 591 questionnaires, 66.33% were males. Mean scores were 6.81 ± 4.903 for knowledge, 26.84 ± 4.273 for attitude, and 14.46 ± 2.445 for practice. Path analysis revealed high risk of OSA positively impacting knowledge (β = 2.351, P < 0.001) and practice (β = 0.598, P < 0.001) towards OSA. Knowledge directly affected attitude (β = 0.544) and practice (β = 0.139), while attitude influenced practice (β = 0.266). Among high OSA risk individuals, knowledge directly impacted attitude (β = 0.645) and practice (β = 0.133). Knowledge indirectly influenced practice via attitude (β = 0.197). Additionally, attitude directly affected practice (β = 0.305). These findings provide insights into the interplay between OSA risk, knowledge, attitude, and practice. Inpatients with cardiovascular disease demonstrated inadequate knowledge, moderate attitude, and practice towards OSA. The findings highlighting the need for targeted educational interventions to improve awareness and management of OSA.

Keywords Knowledge, Attitude, Practice, Cardiovascular Disease, Obstructive sleep apnea, Cross-sectional study

Obstructive Sleep Apnea (OSA), a widespread sleep disorder affecting around one billion adults globally, is characterized by repeated episodes of obstructive apnea and hypopnea during sleep[1–3]. Despite being the most prevalent respiratory sleep disorder, OSA often goes undiagnosed[4]. It shares common risk factors and comorbid conditions with cardiovascular disease, establishing itself as an independent risk factor for this condition[5]. The diagnosis rate for OSA is notably low, estimated at approximately 34% in men and 17% in women in the general population, highlighting its significant health implications, especially for individuals with cardiovascular issues[6]. The severe disruption to sleep quantity and quality caused by OSA results in sleep deprivation, emphasizing its critical status as a public health concern, particularly for those with cardiovascular disease[4].

OSA is characterized by intermittent narrowing or collapse of the upper airway during sleep, leading to partial or complete cessation of airflow. These repeated episodes of airway obstruction result in disrupted breathing and fragmented sleep patterns. The obstruction of the airway in OSA patients triggers several pathophysiological processes, including decreased oxygen saturation, elevated carbon dioxide levels, fluctuations in intrathoracic pressure, sympathetic nervous system activation, and frequent arousals, with hypoxemia being a key pathological factor[7,8]. The intermittent hypoxia induced by OSA leads to a cascade of events that contribute to the onset and

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progression of cardiovascular diseases. Specifically, OSA-related hypercapnia, increased intrathoracic negative pressure, and arousal fluctuations exacerbate the progression of cardiovascular conditions[9]. Additionally, OSA is associated with a prothrombotic state, characterized by elevated levels of thrombogenic factors such as fibrinogen and platelet activation, which further heightens the risk of cardiovascular complications[10].

Prior research has revealed that the prevalence of OSA among individuals with coronary artery disease (CAD) ranges from 30 to 69%. Furthermore, OSA has been shown to substantially increase the risk of cardiovascular morbidity and mortality, particularly in individuals already suffering from cardiovascular conditions. Given the clear relationship between these two ailments, individuals with cardiovascular disease must be cognizant of the necessity to identify and address OSA[11–13].

The Knowledge, Attitude, and Practices (KAP) survey functions as a research tool, providing insights into a group's comprehension, beliefs, and actions on a specific subject, particularly within the realm of health literacy, based on the premise that knowledge positively influences attitudes, which in turn shape behaviors[14–16]. Given the intricate interplay between OSA and cardiovascular disease, it is crucial to investigate the knowledge, attitudes, and behaviors of individuals affected by cardiovascular ailments regarding OSA. This exploration holds significance in identifying risk factors among cardiovascular disease inpatients, which may enable the implementation of relevant interventions such as OSA screening and treatment to mitigate the risks of cardiovascular events. Additionally, examining into the awareness and conduct of cardiovascular disease inpatients regarding OSA provides insights that empower healthcare professionals to better educate and guide this specific patient cohort. This, in turn, fosters improved adherence to treatment regimens, with the ultimate goal of enhancing the efficacy of treatment and cardiovascular disease management. It is important to note that while there is a wealth of KAP research focused on healthcare practitioners regarding OSA, there is a conspicuous dearth of research concerning inpatients with cardiovascular disease[17–19].

Therefore, this study aimed to investigate the KAP of inpatients with cardiovascular disease towards OSA.

Methods

Study design and participants

This cross-sectional study was conducted between January, 2022 and January, 2023 at Zhongda Hospital Affiliated to Southeast University among inpatients with cardiovascular disease by random sampling. The study received ethical approval from the Ethics Committee of Zhongda Hospital Affiliated to Southeast University and obtained informed consent from all participants.

Inclusion Criteria: (1) Patients requiring inpatient treatment in the cardiology department due to cardiovascular disease; (2) aged > 18 years old.

Exclusion Criteria: (1) Inability to understand the questionnaire correctly, (2) inability to cooperate in answering the questionnaire, (3) mental disorders, and other factors that may affect the authenticity of the questionnaire, (4) Patients who were diagnosed with OSA or under treatment for OSA.

Questionnaire

The final questionnaire is presented in the Chinese language and encompasses five distinct sections: the STOP-Bang questionnaire, demographic characteristics, knowledge dimension, attitude dimension, and practice dimension.

The STOP-Bang questionnaire was specifically designed to fulfill the demand for a dependable, succinct, and user-friendly screening instrument. It comprises eight binary (yes/no) items pertaining to the clinical characteristics of sleep apnea, with a total score spanning from 0 to 8, and patients scoring ≥ 3 were considered at high risk of OSA, demonstrating high sensitivity and specificity among Chinese population[20–22]. The STOP-BANG questionnaire was completed with the assistance of trained medical staff. The staff collected objective measurements such as height, weight, and neck circumference upon admission and asked relevant questions to both the participants and their cohabitants. Based on these responses, healthcare providers assessed the risk of OSA.

The development of the KAP questionnaire was informed by previous study[23] and clinical experience. Subsequently, the initial design was refined through feedback received from 3 senior experts (one expert in OSA with experience over 20 years and two experts in cardiovascular disease with experience over 20 years), ensuring content validity. A pilot study was then conducted among 22 patients, which yielded a reliability coefficient (Cronbach's α) of 0.814, indicated a good internal consistency. During the pilot study, no items in the questionnaire were deemed unreadable after explanation, suggesting adequate face validity. A post hoc Confirmatory Factor Analysis (CFA) was conducted to evaluate construct validity. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for the questionnaire was 0.960 ($P < 0.001$), indicating that the data were highly suitable for factor analysis. CFA demonstrated that the model had an acceptable fit. The chi-square to degrees of freedom ratio (CMIN/DF) was 3.544, falling within the 'Good' range (1–3: Excellent, 3–5: Good). The Root Mean Square Error of Approximation (RMSEA) was 0.066, which is below the 0.08 threshold, indicating a good fit. Additionally, the Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) were 0.814, 0.805, and 0.813, respectively, all exceeding the acceptable threshold of 0.8 (**Supplementary Fig. 1**) (**Supplemental Table 1**).

The KAP survey assessed three dimensions: knowledge, focused on awareness of OSA's symptoms, risk factors, associated conditions, and treatment options; attitude, which examined perceptions of the impact and treatability of OSA; and practice, which explored behaviors related to monitoring, prevention, and willingness to seek treatment for OSA. In the knowledge dimension, questions 1–5 are allotted a scored 2 points for correct responses and 0 points for incorrect answers. Conversely, questions 6–9 are evaluated based on participants' comprehension of relevant issues, with a scoring system of 0 points for participants who expressed understanding

for 0–3 items, 1 point for those understanding 4–6 questions, and 2 points for those understanding 7 or more questions. The cumulative knowledge score ranges from 0 to 18 points. For the attitude dimension, seven questions are rated on a five-point Likert scale, spanning from "strongly agree" (5 points) to "strongly disagree" (1 point), yielding scores ranging from 7 to 35. In the practice dimension, five questions are presented, with questions 1–4 utilizing a five-point Likert scale. Scores in this dimension range from 4 to 20 points. For high-risk OSA patients, additional inquiries were made in the attitude dimension regarding their attitudes towards OSA prevention and in the practice dimension regarding their willingness to engage in OSA treatment and prevention. Given the limited number of participants at high risk of OSA, only descriptive analysis was conducted for these additional questions. The demographic characteristics and KAP dimensions were collected using electronic questionnaires generated by "Questionnaire Star" platform. Participants generally completed the questionnaires independently, although trained research assistants were available to provide unbiased assistance if participants encountered confusion or difficulties.

Participants who scored above 80% of the total were categorized as having adequate knowledge, positive attitude, and proactive practice. Those with scores in range of 60–80% of the total indicated inadequate knowledge, attitude, and practice. Scores below 60% of the total were indicative of inadequate knowledge, negative attitude, and inactive practice[24].

Statistical analysis

SPSS version 26.0 (IBM Corp., Armonk, N.Y., USA) was utilized for statistical analysis. Continuous variables were summarized as mean ± standard deviation (SD), and compared by t-tests or analysis of variance (ANOVA). Categorical variables were presented as n (%). Spearman correlation analysis was employed to assess the correlations among knowledge, attitude, and practice scores. A path analysis was conducted to explore the relationships among the three dimensions (knowledge, attitude, and practice) and high risk of OSA. Subgroup analysis was conducted within the high risk population identified by the STOP-Bang questionnaire. A two-sided P-value of less than 0.05 was considered to indicate statistical significance.

Results

Demographic characteristics

Initially, a total of 678 questionnaires were collected in the study, and 87 of them were excluded for too short responses time ($n=67$), logical errors ($n=9$), or obvious patterns of responses ($n=11$). Therefore, 591 valid questionnaires were analyzed, with a validity rate of 87.17%. Among them, 392 (66.33%) were male, 366 (61.93%) were aged over 55. Out of the participants, 288 (48.73%) had sought medical assistance for coronary heart disease, while 311 (52.62%) reported snoring but had not sought medical attention. A total of 196 (33.16%) had experienced daytime sleepiness, lack of concentration, or similar issues during the day. Moreover, 148 (25.04%) were assessed to be at high risk of OSA. The majority of participants reported acquiring health information through online media (65.65%, $n=388$) and traditional media such as TV and newspapers (64.13%, $n=379$), followed by conversations with family and friends (42.64%, $n=252$) and education from healthcare professionals (40.44%, $n=239$), with a smaller proportion relying on other sources (5.08%, $n=30$) (Table 1).

KAP towards OSA

The mean knowledge, attitude, and practice scores were 6.81 ± 4.90 (possible range: 0–18), 26.84 ± 4.27 (possible range: 7–35), and 14.46 ± 2.45 (possible range: 4–20), respectively. The knowledge, attitude, and practice scores varied from inpatients across weight, residence, education, monthly income, medical-related occupation, snoring, experience of daytime sleepiness, lack of concentration, or similar issues during the day, and whether they are at high risk of OSA (all of $P<0.01$). Meanwhile, those with different occupation and different reasons for seeking care are more likely to have different knowledge and attitude scores (all of $P<0.05$). Furthermore, differences in age ($P=0.003$), type of medical insurance ($P=0.001$), and BMI ($P=0.018$) may also lead to differences in knowledge scores (Table 1).

The knowledge dimension of the overall population shows that 54.15% are aware that OSA leads to increased respiratory effort, decreased oxygen saturation, and increased cardiac load (K1), and 61.42% are aware that snoring does not equate to a good sleep quality (K2), while 51.61% are still uncertain about the correlation between the degree of snoring and the severity of OSA (K5). When it comes to factors that increase the risk of OSA (K6), the most well-known are obesity (68.53%) and being male (54.15%). Regarding symptoms caused by OSA (K7), the most known were snoring (55.5%) and breathing pauses (44.33). However, only 44.84% and 40.61% participants were aware that OSA may be associated with hypertension and coronary artery disease, respectively (K8). For the treatment of OSA (K9), weight loss (58.71%) and exercise (54.99%) were the most known (**Supplemental Fig. 2**).

Regarding the attitude, 68.86% agreed or strongly agreed that treatment of OSA is necessary (A2). The vast majority (86.8%) believed that learning about OSA is necessary (A6). Meanwhile, 83.93% agreed to varying degrees that OSA is more dangerous for patients with heart and cardiovascular diseases (A7) (**Supplemental Fig. 3**). The practices also varied considerably, 57.36% reported a willingness to seek medical attention when experiencing symptoms of OSA (P3), and 87.48% reported a willingness to improve lifestyle habits in order to prevent the onset of OSA (P4). It is noteworthy that participants preferred to be educated about OSA by communicating with their doctor, either online or offline, much more than any other method (P5) (**Supplemental Fig. 4**).

Variables	*N*(%)	Knowledge, mean ± SD	*P*	Attitude, mean ± SD	*P*	Practice, mean ± SD	*P*
N = 591							
Total Score		6.81 ± 4.903		26.84 ± 4.273		14.46 ± 2.445	
Gender			0.680		0.238		0.261
Male	392 (66.33)	6.86 ± 4.87		26.99 ± 4.29		14.54 ± 2.48	
Female	199 (33.67)	6.69 ± 4.97		26.55 ± 4.24		14.30 ± 2.37	
Age, years			0.003		0.564		0.055
≤ 55	225 (38.07)	7.56 ± 4.95		26.97 ± 4.34		14.71 ± 2.47	
> 55	366 (61.93)	6.34 ± 4.82		26.76 ± 4.23		14.31 ± 2.42	
Height, cm			0.665		0.625		0.078
≤ 165	254 (42.98)	6.70 ± 4.90		26.74 ± 4.22		14.26 ± 2.39	
> 165	337 (57.02)	6.88 ± 4.91		26.91 ± 4.32		14.61 ± 2.48	
Weight, kg			0.003		0.001		< 0.001
≤ 70	318 (53.81)	6.25 ± 4.71		26.32 ± 3.93		14.13 ± 2.33	
> 70	273 (46.19)	7.45 ± 5.06		27.45 ± 4.58		14.85 ± 2.53	
BMI			0.094		0.123		0.018
< 25	326 (55.16)	6.42 ± 4.80		26.56 ± 4.00		14.23 ± 2.35	
25.0-29.9	217 (36.72)	7.34 ± 4.93		27.04 ± 4.65		14.65 ± 2.48	
> 29.9	48 (8.12)	7.04 ± 5.32		27.79 ± 4.21		15.13 ± 2.76	
Residence			< 0.001		0.005		0.001
Rural	224 (37.90)	5.91 ± 4.81		26.21 ± 4.58		14.04 ± 2.54	
Urban	367 (62.10)	7.35 ± 4.89		27.22 ± 4.04		14.72 ± 2.35	
Ethnicity			0.945		0.837		0.884
Han	588 (99.49)	6.80 ± 4.91		26.84 ± 4.28		14.46 ± 2.45	
Minority	3 (0.51)	7.00 ± 3.61		26.33 ± 2.08		14.67 ± 1.53	
Education			< 0.001		< 0.001		< 0.001
Primary school or below	137 (23.18)	5.05 ± 4.95		25.39 ± 5.00		13.48 ± 2.66	
Middle school/High school/Technical secondary school	291 (49.24)	6.27 ± 4.53		26.76 ± 4.01		14.58 ± 2.26	
Junior college / Undergraduate	151 (25.55)	9.19 ± 4.56		28.19 ± 3.71		15.05 ± 2.38	
Postgraduate or above	12 (2.03)	9.75 ± 5.33		28.25 ± 2.18		15.25 ± 1.91	
Medical-related occupation			0.003		0.004		0.009
Yes	113 (19.12)	8.04 ± 4.58		27.88 ± 4.09		15.00 ± 2.15	
No	478 (80.88)	6.51 ± 4.94		26.59 ± 4.28		14.33 ± 2.49	
Monthly income, Yuan			< 0.001		0.004		< 0.001
< 5,000	199 (33.67)	5.85 ± 4.58		26.44 ± 3.82		14.13 ± 2.28	
5,000–9,999	224 (37.90)	6.99 ± 4.99		26.75 ± 4.79		14.25 ± 2.68	
10,000–19,999	121 (20.47)	7.17 ± 4.80		26.84 ± 4.00		15.06 ± 2.17	
≥ 20,000	47 (7.95)	9.06 ± 5.23		28.96 ± 3.64		15.34 ± 2.18	
Marital Status			0.109		0.895		0.499
Unmarried	56 (9.48)	7.80 ± 4.44		26.91 ± 4.08		14.25 ± 2.38	
Married	535 (90.52)	6.70 ± 4.94		26.83 ± 4.30		14.48 ± 2.45	
Reason for Seeking Medical Care			< 0.001		< 0.001		0.087
Coronary heart disease	288 (48.73)	6.52 ± 4.84		26.49 ± 4.44		14.39 ± 2.55	
Hypertension	88 (14.89)	8.11 ± 4.91		28.01 ± 4.08		15.10 ± 2.43	
Heart failure	28 (4.74)	5.54 ± 3.81		27.14 ± 3.15		13.89 ± 1.87	
Arrhythmia	63 (10.66)	8.19 ± 5.37		28.48 ± 3.96		14.44 ± 2.51	
Myocardial disease/heart valve disease	8 (1.35)	10.63 ± 3.96		27.88 ± 1.64		15.25 ± 1.67	
Other diseases	116 (19.63)	5.82 ± 4.66		25.78 ± 4.12		14.24 ± 2.25	
Smoking Habit			0.152		0.071		0.271
Yes	204 (34.52)	6.41 ± 4.75		26.40 ± 4.25		14.61 ± 2.39	
No	387 (65.48)	7.02 ± 4.98		27.07 ± 4.27		14.38 ± 2.47	
Type of Medical Insurance			0.001		0.318		0.188
Social or commercial only	505 (85.45)	7.10 ± 4.91		26.90 ± 4.33		14.44 ± 2.47	
Both social and commercial	57 (9.64)	4.88 ± 4.47		26.07 ± 4.23		14.93 ± 2.19	
None	29 (4.91)	5.41 ± 4.59		27.31 ± 3.23		13.97 ± 2.34	
Snoring			< 0.001		< 0.001		< 0.001
Continued							

Variables	*N*(%)	Knowledge, mean ± SD	*P*	Attitude, mean ± SD	*P*	Practice, mean ± SD	*P*
Yes, and sought medical attention for it	27 (4.57)	10.78 ± 3.39		29.15 ± 4.03		16.11 ± 2.10	
Yes, but have not sought medical attention	311 (52.62)	7.14 ± 4.96		27.22 ± 4.13		14.68 ± 2.42	
No	253 (42.81)	5.98 ± 4.72		26.13 ± 4.35		14.02 ± 2.41	
Experience of daytime sleepiness, lack of concentration, or similar issues during the day			< 0.001		< 0.001		< 0.001
Yes	196 (33.16)	8.60 ± 5.06		27.85 ± 4.41		15.28 ± 2.46	
No	395 (66.84)	5.92 ± 4.58		26.34 ± 4.12		14.06 ± 2.34	
OSA patients around			0.157		0.294		0.249
Yes	156 (26.40)	7.28 ± 4.35		27.15 ± 3.90		14.65 ± 2.52	
No	435 (73.60)	6.63 ± 5.08		26.73 ± 4.40		14.39 ± 2.42	
high risk of OSA			< 0.001		0.004		< 0.001
Yes	148 (25.04)	8.57 ± 4.86		27.71 ± 4.67		15.39 ± 2.60	
No	443 (74.96)	6.22 ± 4.78		26.55 ± 4.09		14.15 ± 2.31	
Ways of acquiring health information (multiple choices)							
Traditional media such as TV and newspapers	379 (64.13)	7.01 ± 4.91		27.25 ± 3.97		14.62 ± 2.32	
Online media such as public accounts and short videos	388 (65.65)	7.23 ± 4.73		27.18 ± 4.04		14.74 ± 2.30	
Education and information from healthcare professionals	239 (40.44)	8.89 ± 4.93		28.43 ± 4.06		15.27 ± 2.29	
Conversations with family and friends	252 (42.64)	8.18 ± 5.18		27.77 ± 4.77		14.98 ± 2.63	
Other	30 (5.08)	7.77 ± 5.03		28.30 ± 5.25		14.70 ± 3.32	

Table 1. Demographic characteristics and knowledge, attitude, and practice.

	Knowledge	Attitude	Practice
Knowledge	1		
Attitude	0.615 ($P < 0.001$)	1	
Practice	0.569 ($P < 0.001$)	0.568 ($P < 0.001$)	1

Table 2. Correlation analysis.

			Estimate	S.E.	C.R.	P
Knowledge	<---	High risk of OSA	2.351	0.455	5.163	< 0.001
Attitude	<---	Knowledge	0.544	0.028	19.407	< 0.001
Practice	<---	Knowledge	0.139	0.019	7.320	< 0.001
Practice	<---	Attitude	0.266	0.022	12.341	< 0.001
Practice	<---	High risk of OSA	0.598	0.169	3.532	< 0.001

Table 3. Path analysis.

Correlation among KAP

The correlation analysis identified significant positive correlations between knowledge and attitude ($r = 0.615$, $P < 0.001$), knowledge and practice ($r = 0.569$, $P < 0.001$), as well as attitude and practice ($r = 0.568$, $P < 0.001$), respectively (Table 2). Path analysis results revealed a direct positive impact of high risk for OSA on knowledge ($\beta = 2.351$, $P < 0.001$) and practice ($\beta = 0.598$, $P < 0.001$) towards OSA. Conversely, knowledge exerted a direct positive effect on attitude ($\beta = 0.544$, $p < 0.001$) and practice ($\beta = 0.139$, $P < 0.001$), meanwhile, attitude also significantly and directly influenced practice ($\beta = 0.266$, $P < 0.001$) (Table 3).

Subgroup analysis among participants at high risk of OSA

A subgroup analysis was conducted among participants at high risk of OSA (Table 4). Among participants with high risk of OSA, 68.25% of them were willing to undergo regular screening for OSA (P6), and when OSA was diagnosed, the most accepted treatment was by improving lifestyle habits (89.86%) (**Supplementary Fig. 5A**). The most desired reasons for receiving treatment were to improve sleep quality (68.92%) and to reduce snoring (64.19%) (**Supplementary Fig. 5B**). When it comes to the reasons for choosing not to receive treatment, the most important reasons were uncertainty about the efficacy of the treatment (50.00%) and the high cost (49.32%) (**Supplementary Fig. 5C**). Only 20.95% fully complied with the medical advice to wear a ventilator (P14), and the most important factors affecting their willingness to do so were, in descending order, the inconvenience of

Variables	*N*(%)	Knowledge, mean ± SD	*P*	Attitude, mean ± SD	*P*	Practice, mean ± SD	*P*
N = 148							
Total Score		8.57 ± 4.86		27.71 ± 4.68		15.39 ± 2.60	
Gender			0.447		0.261		0.788
Male	138 (93.24)	8.49 ± 4.91		27.83 ± 4.56		15.37 ± 2.63	
Female	10 (6.76)	9.70 ± 4.06		26.10 ± 6.06		15.60 ± 2.22	
Age, years			0.959		0.672		0.783
≤ 55	59 (39.86)	8.54 ± 5.53		27.51 ± 5.75		15.46 ± 2.98	
> 55	89 (60.14)	8.58 ± 4.38		27.84 ± 3.83		15.34 ± 2.33	
Height, cm			0.250		0.704		0.496
≤ 165	34 (22.97)	9.41 ± 4.58		27.44 ± 5.14		15.12 ± 2.60	
> 165	114 (77.03)	8.32 ± 4.93		27.79 ± 4.55		15.46 ± 2.60	
Weight, kg			0.978		0.738		0.919
≤ 70	48 (32.43)	8.58 ± 4.86		27.90 ± 3.96		15.42 ± 2.28	
> 70	100 (67.57)	8.56 ± 4.88		27.62 ± 5.00		15.37 ± 2.75	
BMI			0.544		0.676		0.837
< 25	57 (38.51)	8.82 ± 4.64		28.33 ± 3.82		15.53 ± 2.23	
25.0-29.9	69 (46.62)	8.68 ± 4.86		27.28 ± 5.39		15.23 ± 2.96	
> 29.9	22 (14.86)	7.55 ± 5.47		27.45 ± 4.26		15.50 ± 2.37	
Residence			0.053		0.081		0.025
Rural	55 (37.16)	7.56 ± 4.86		26.84 ± 5.63		14.76 ± 3.10	
Urban	93 (62.84)	9.16 ± 4.78		28.23 ± 3.95		15.75 ± 2.19	
Education			0.001		0.004		0.025
Primary school or below	19 (12.84)	6.84 ± 5.54		25.37 ± 6.64		14.37 ± 3.59	
Middle school/High school/Technical secondary school	87 (58.78)	7.79 ± 4.46		27.26 ± 4.54		15.18 ± 2.49	
Junior college / Undergraduate	40 (27.03)	10.83 ± 4.54		29.73 ± 3.03		16.35 ± 2.02	
Postgraduate or above	2 (1.35)	13.50 ± 6.36		29.00 ± 1.41		14.50 ± 2.12	
Medical-related occupation			0.419		0.694		0.246
Yes	26 (17.57)	9.27 ± 4.47		28.04 ± 5.61		15.92 ± 2.37	
No	122 (82.43)	8.42 ± 4.94		27.64 ± 4.47		15.27 ± 2.64	
Monthly income, Yuan			0.004		0.002		0.003
< 5,000	58 (39.19)	7.02 ± 4.39		25.98 ± 4.84		14.43 ± 2.70	
5,000–9,999	53 (35.81)	9.42 ± 4.60		28.58 ± 4.64		15.89 ± 2.54	
10,000–19,999	25 (16.89)	8.80 ± 5.12		28.52 ± 3.58		16.28 ± 1.84	
≥ 20,000	12 (8.11)	11.83 ± 5.51		30.50 ± 3.42		15.92 ± 2.54	
Marital Status			0.527		0.035		0.004
Unmarried	3 (2.03)	10.33 ± 4.93		33.33 ± 2.08		19.67 ± 0.58	
Married	145 (97.97)	8.53 ± 4.87		27.59 ± 4.65		15.30 ± 2.55	
Reason for Seeking Medical Care			0.619		0.649		0.725
Coronary Heart Disease	80 (54.05)	8.74 ± 4.75		27.26 ± 5.16		15.44 ± 2.76	
Hypertension	35 (23.65)	8.66 ± 4.82		28.60 ± 4.26		15.46 ± 2.60	
Heart Failure	8 (5.41)	7.63 ± 4.10		28.13 ± 3.68		14.13 ± 2.59	
Arrhythmia	14 (9.46)	8.36 ± 5.72		28.50 ± 4.43		15.79 ± 2.39	
Myocardial Disease	1 (0.68)	16.00 ± 0.00		30.00 ± 0.00		17.00 ± 0.00	
Heart Valve Disease	/	/		/			
Other Diseases	10 (6.76)	7.20 ± 5.43		26.50 ± 2.68		15.00 ± 1.49	
Smoking Habit			0.058		0.793		0.682
Yes	74 (50.00)	7.81 ± 5.01		27.61 ± 4.33		15.47 ± 2.39	
No	74 (50.00)	9.32 ± 4.61		27.81 ± 5.02		15.30 ± 2.81	
Type of Medical Insurance			0.387		0.238		0.537
Social or commercial only	134 (90.54)	8.72 ± 4.77		27.50 ± 4.74		15.32 ± 2.59	
Both social and commercial	8 (5.41)	8.00 ± 5.86		29.50 ± 3.34		16.38 ± 2.00	
None	6 (4.05)	6.00 ± 5.55		30.00 ± 4.00		15.50 ± 3.56	
Snoring			0.113		0.586		0.295
Yes, and sought medical attention for it	18 (12.16)	10.50 ± 3.50		28.78 ± 2.98		16.28 ± 1.71	
Yes, but have not sought medical attention	111 (75.00)	8.49 ± 4.95		27.58 ± 5.00		15.24 ± 2.67	
Continued							

Variables	*N*(%)	Knowledge, mean ± SD	*P*	Attitude, mean ± SD	*P*	Practice, mean ± SD	*P*
No	19 (12.84)	7.21 ± 5.07		27.47 ± 4.03		15.37 ± 2.79	
Experience of daytime sleepiness, lack of concentration, or similar issues during the day			0.139		0.435		0.041
Yes	86 (58.11)	9.07 ± 4.94		27.97 ± 4.51		15.76 ± 2.48	
No	62 (41.89)	7.87 ± 4.70		27.35 ± 4.91		14.87 ± 2.69	
OSA patients around			0.279		0.121		0.271
Yes	63 (42.57)	8.06 ± 4.48		27.02 ± 4.27		15.11 ± 2.44	
No	85 (57.43)	8.94 ± 5.12		28.22 ± 4.91		15.59 ± 2.70	
Ways of acquiring health information (multiple choices)							
Traditional media such as TV and newspapers	91 (61.49)	9.04 ± 4.97		28.35 ± 4.39		15.64 ± 2.40	
Online media such as public accounts and short videos	112 (75.68)	8.76 ± 4.61		27.72 ± 4.63		15.49 ± 2.52	
Education and information from healthcare professionals	66 (44.59)	10.21 ± 4.83		29.12 ± 4.53		16.17 ± 2.40	
Conversations with family and friends	72 (48.65)	9.51 ± 4.43		28.93 ± 4.19		15.96 ± 2.56	
Other	9 (6.08)	5.89 ± 4.91		26.67 ± 6.52		15.33 ± 4.58	
Being educated about OSA by doctor			< 0.001		0.014		0.012
Yes	80 (54.05)	9.90 ± 4.81		28.58 ± 4.67		15.88 ± 2.67	
No	68 (45.95)	7.00 ± 4.45		26.69 ± 4.51		14.81 ± 2.40	
Being recommended by doctor for further OSA tests			0.001		0.058		0.030
Yes	75 (50.68)	9.83 ± 4.95		28.43 ± 4.37		15.84 ± 2.58	
No	73 (49.32)	7.27 ± 4.44		26.97 ± 4.89		14.92 ± 2.55	
Participated in an OSA-related educational programme			< 0.001		< 0.001		< 0.001
Yes	41 (27.70)	11.73 ± 4.85		30.44 ± 3.72		16.83 ± 2.47	
No	107 (72.30)	7.36 ± 4.30		26.66 ± 4.59		14.83 ± 2.44	
High risk factors in BANG questionnaire							
Snoring			0.117		0.068		0.229
Yes	106 (71.62)	8.96 ± 4.83		28.15 ± 5.08		15.55 ± 2.76	
No	42 (28.38)	7.57 ± 4.83		26.60 ± 3.24		14.98 ± 2.12	
Feel tired			0.025		0.282		0.016
Yes	78 (52.70)	9.41 ± 5.04		28.10 ± 5.00		15.87 ± 2.68	
No	70 (47.30)	7.63 ± 4.50		27.27 ± 4.27		14.84 ± 2.41	
You stop breathing or gasping are noticed by someone else			0.035		< 0.001		0.046
Yes	48 (32.43)	7.35 ± 4.73		25.60 ± 5.25		14.77 ± 2.87	
No	100 (67.57)	9.15 ± 4.83		28.72 ± 4.02		15.68 ± 2.42	
High blood pressure			0.213		0.153		0.431
Yes	120 (81.08)	8.81 ± 4.78		26.57 ± 5.57		15.04 ± 3.07	
No	28 (18.92)	7.54 ± 5.15		27.98 ± 4.43		15.47 ± 2.48	
Obese							
Yes	9 (6.08)						
No	139 (93.92)						
Aged over 50 years			0.521		0.544		0.927
Yes	103 (69.59)	8.74 ± 4.56		27.86 ± 3.94		15.40 ± 2.33	
No	45 (30.41)	8.18 ± 5.52		27.36 ± 6.07		15.36 ± 3.16	
Thick neck			0.511		0.038		0.385
Yes	11 (7.43)	7.64 ± 5.10		24.91 ± 5.92		14.73 ± 2.80	
No	137 (92.57)	8.64 ± 4.85		27.93 ± 4.51		15.44 ± 2.59	

Table 4. Demographic characteristics and KAP among high-risk subgroup (STOP-Bang score ≥ 3).

use, feeling congested nose, the need to wear a mask tightly, tight mask fit, and the high cost of the treatment (more than 40% in each item) (**Supplementary Fig. 5D**) **(Supplemental Table 2)**. And the path analysis showed that their knowledge directly affects attitude ($\beta = 0.645$, $P < 0.001$) and practice ($\beta = 0.133$, $P < 0.001$), and that their knowledge also has an indirect effect on practice through attitude ($\beta = 0.197$, $P = 0.005$), moreover, their attitude also directly affects practice ($\beta = 0.305$, $P < 0.001$) (**Supplemental Table 3**).

Discussion

This study represents the first exploration of KAP toward OSA among inpatients with cardiovascular disease. Our findings reveal inadequate knowledge, moderately positive attitudes, and suboptimal practices among this population, consistent with previous research on OSA awareness in the general population[25]. Given the established bidirectional relationship between OSA and cardiovascular outcomes, addressing these deficiencies is critical for improving patient care and outcomes. To address this deficiency, healthcare providers should consider implementing targeted educational interventions that emphasize the interplay between OSA and cardiovascular health. Such interventions could include the development of evidence-based educational materials and the integration of OSA discussions into routine cardiovascular consultations. These recommendations are supported by previous research underscoring the importance of patient education and effective healthcare provider communication in enhancing health outcomes among individuals with cardiovascular conditions[26,27].

Notably, these scores exhibited considerable variability based on several demographic and health-related factors. Furthermore, the age of patients and the type of medical insurance they hold demonstrated statistically significant associations with differences in knowledge scores. These findings highlight the need for tailored interventions that consider the multifaceted nature of these determinants to improve clinical practice, resonate with the previous study, where similar demographic factors played a pivotal role in shaping patient attitudes and practices[28]. To address this, healthcare providers should consider implementing educational initiatives targeting these specific factors, thereby enhancing knowledge, attitudes, and practices related to OSA in patients with cardiovascular disease[29]. Moreover, these results call for further investigation into the effectiveness of such tailored interventions and their impact on clinical outcomes and patient well-being, thereby promoting more patient-centered and holistic care[30,31].

In our study, patients diagnosed with cardiovascular disease displayed a concerning lack of knowledge about OSA. This knowledge deficit is highlighted by the low percentages of correct responses to questions related to OSA, especially its symptoms, risk factors, and treatment options. To address these deficiencies and improve clinical practice, healthcare providers should prioritize patient education and awareness initiatives that cover a comprehensive range of OSA-related topics[29,32].

Our analysis revealed that patient attitudes toward OSA were moderately positive, with many recognizing it as a treatable condition impacting overall health. However, a significant portion expressed neutral or negative attitudes regarding its effects on daily life and treatment outcomes. These findings suggest a need for more comprehensive patient education programs that not only provide factual information but also address misconceptions and emphasize the potential benefits of early diagnosis and treatment. Such programs could potentially improve patient attitudes and, consequently, treatment adherence, as suggested by previous studies on the relationship between patient attitudes and health behaviors[33,34].

The results of this study illuminate critical aspects of patients' practices regarding OSA and underscore opportunities for improvement in clinical practice. To enhance clinical practice, it is imperative to harness these observations. Tailored educational programs, particularly those focusing on the self-assessment of OSA symptoms, should be developed and offered to patients[35,36].

Within this study, we explored high-risk OSA populations as distinct subgroups, shedding light on their perspectives and behaviors. A significant proportion of this high-risk group exhibited a willingness to undergo regular screening for OSA, reflecting a proactive stance in managing their health. However, this optimism is countered by a notable compliance gap, with only a fraction adhering to medical advice regarding ventilator use, despite their willingness to screen for OSA. This deviation from established recommendations contrasts with existing research, where continuous positive airway pressure is consistently identified as the preferred treatment for OSA[37,38]. This compliance deficiency is exacerbated by a range of factors, including the inconvenience of device use, discomfort related to mask fit, and concerns about treatment costs. Intriguingly, the most sought-after aspects of treatment revolved around improving sleep quality and reducing snoring, emphasizing patients' desires for enhanced sleep experiences and an improved quality of life. Conversely, the decision to forego treatment appeared to be rooted in concerns about treatment efficacy and financial burden, raising questions about the perceived effectiveness of OSA interventions and access to affordable care.

Aligned with existing literature, the findings highlight the profound impact of socio-demographic factors on OSA-related KAP among the high-risk subgroup. Higher education levels have been consistently linked to improved health literacy and better health literacy[39]. Similarly, increased income facilitates access to healthcare resources and promotes healthier behaviors[40]. Urban residency is associated with better healthcare access and information, which aligns with findings of improved practice outcomes among urban residents[41]. Furthermore, participation in educational programs has shown to effectively enhance knowledge and self-management skills[42], which is consistent with the observed improvement among participants in educational programs. Additionally, higher BMI, often associated with OSA, necessitates targeted interventions focusing on weight management to improve OSA outcomes. Based on a detailed analysis of the inter-group comparison results among high-risk populations, tailored recommendations can be devised to address specific needs and circumstances across demographic and socio-economic groups. For individuals with lower educational attainment and income levels, targeted educational interventions are essential to bridge knowledge gaps and foster positive attitudes towards OSA management, in addition to financial assistance programs to alleviate cost burdens. In contrast, among those with higher education and income levels, initiatives should focus on enhancing adherence to treatment plans through personalized counseling and leveraging digital health platforms, while workplace wellness programs can promote healthy sleep habits[43]. Additionally, involving spouses or partners in educational sessions can facilitate mutual support and shared decision-making. By customizing interventions to the unique needs and circumstances of diverse demographic groups, healthcare providers can effectively optimize OSA management outcomes and improve overall quality of life for high-risk populations.

Our correlation analysis demonstrated significant positive relationships between knowledge, attitude, and practice components of OSA management. These findings are consistent with established health behavior models and emphasize the interconnected nature of these elements in shaping patient behavior[42,44,45].

To enhance the role of healthcare providers in OSA management, several evidence-based strategies could be implemented. These include the development of standardized OSA screening protocols for cardiovascular inpatients, the establishment of interdisciplinary sleep health teams, and the provision of continuing education on OSA management for healthcare professionals. Such approaches have been shown to improve the detection and management of comorbid conditions in other areas of medicine and may be equally beneficial in the context of OSA and cardiovascular disease[46,47].

This study has several limitations. The cross-sectional design restricts our ability to infer causal relationships. A path analysis was performed as a surrogate of causality, but the results must be interpreted cautiously since they were statistically inferred[48]. Additionally, potential biases in self-reported data and sampling limitations may affect the generalizability of the findings. The study's focus on inpatients with cardiovascular disease also limits the broader applicability of the results. Social desirability bias and the omission of variables that could influence knowledge, attitude, and practice are additional potential limitations.

In conclusion, this study highlights significant deficiencies in knowledge, attitudes, and practices regarding OSA among cardiovascular inpatients. These findings underscore the need for comprehensive, evidence-based interventions to improve OSA management in this high-risk population. By addressing knowledge gaps, fostering positive attitudes, and promoting treatment adherence, we may potentially improve both OSA management and cardiovascular outcomes. Future research should focus on developing, implementing, and evaluating the effectiveness of targeted interventions to optimize patient care and health outcomes in this population.

Data availability

All data generated or analysed during this study are included in this published article [and its supplementary information files].

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Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical statement

All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The study received ethical approval from the Ethics Committee of Zhongda Hospital Affiliated to Southeast University (2020ZDSYLL278-P01) and obtained informed consent from all participants.All methods were carried out in accordance with relevant guidelines and regulations.

Additional information

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