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Knowledge, attitude, and practice of cardiac rehabilitation referral among healthcare professionals in China: A mediation model

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ABSTRACT

Objective: Despite proven clinical benefits, cardiac rehabilitation referral rates remained insufficient and low globally. Healthcare professionals' knowledge and attitudes of cardiac rehabilitation may affect their referral behaviors, yet their interrelationships are rarely studied in China. This study aims to examine the cardiac rehabilitation referral rate among Chinese healthcare professionals and explore the associations among knowledge, attitude, and practice (KAP) of cardiac rehabilitation referral.

Methods: From July to August 2021, a cross-sectional study was conducted among 321 healthcare professionals from 40 hospitals in Hunan Province of China. The participants completed an online questionnaire to assess their KAP of cardiac rehabilitation referral. Mediation analysis was conducted using logistic regression analysis, Sobel test and Bootstrap method.

Results: About one-third of healthcare professionals never recommended cardiac rehabilitation to their patients. The correlation analysis showed that cardiac rehabilitation knowledge was positively correlated with cardiac rehabilitation referral attitude ($r = 0.57$, $P < 0.001$). There was a robust positive association between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice, which was partially mediated by cardiac rehabilitation referral attitude, with the mediating effect accounting for 4.3 %.

Conclusion: The low cardiac rehabilitation referral rate among healthcare professionals indicates an urgent need to improve cardiac rehabilitation referral. Our mediation model suggests that enhancing cardiac rehabilitation knowledge and promoting positive attitudes through education and training may effectively promote cardiac rehabilitation referral. Furthermore, the findings underscore the necessity of establishing an organized cardiac rehabilitation system to facilitate structured cardiac rehabilitation implementation and improve patient outcomes.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality worldwide (Roth et al., 2020), accounting for one-third of all deaths worldwide (GBD 2019 Demographics Collaborators, 2020). Cardiac rehabilitation is a multidisciplinary CVD management program aimed at promoting recovery from a cardiac event and reducing mortality through comprehensive lifestyle interventions such as exercise prescription, cardiac risk factor interventions, patient education, and behavioral guidance (American Association of Cardiovascular and Pulmonary Rehabilitation, 2021). Mounting evidence demonstrates the significant benefits of cardiac rehabilitation. For instance, a retrospective study reported that cardiac rehabilitation completion was associated with a 33 % reduction in all-cause mortality and a 43 % reduction in cardiovascular mortality (Rouleau et al., 2024). Duscha et al. (2024) reported that patients who participated in cardiac rehabilitation had a greater reduction in the risk of readmission or mortality (42–47 %). In addition to its clinical benefits, cardiac rehabilitation has been demonstrated to be highly cost-effective (Briffa et al., 2005). Given these robust findings, cardiac rehabilitation has been endorsed as a Class I

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recommendation by both the American Heart Association and the European Society of Cardiology for patients with coronary heart disease and chronic heart failure (Mehra et al., 2020).

Despite the known benefits of cardiac rehabilitation for secondary prevention of CVD, studies have shown low rates of patient referral to and participation in cardiac rehabilitation (Grace et al., 2021). A recent survey across 24 European countries showed that only half of patients were referred to cardiac rehabilitation after a cardiac event (Kotseva et al., 2018). A national study in the US reported that only 25 % of Medicare beneficiaries who were eligible for cardiac rehabilitation participated in cardiac rehabilitation programs, which is far below the 70 % participation goal (Ritchey et al., 2020). In Asian countries, the cardiac rehabilitation participation rate was reported to be 39 % in Japan (Kanazawa et al., 2021), 31 % in Korea (Im et al., 2018), and only 5 % in China (Liu et al., 2020). Low cardiac rehabilitation participation is associated with poor recovery of cardiac function, extended length of hospitalization, and increased healthcare burden (Grace et al., 2021; Supervia et al., 2019). Thus, it is essential to identify risk factors of cardiac rehabilitation participation to guide targeted intervention to address the global underutilization of cardiac rehabilitation.

Previous studies have identified a wide range of factors affecting patients' cardiac rehabilitation participation, including patient factors (e.g., demographic and disease-related), clinician factors (e.g., endorsement and referral), and system factors (geographic and financial) (Elsakr et al., 2019; Li et al., 2018; Mathews and Brewer, 2021). Among the various influencing factors, the failure of healthcare professionals to make referrals is the most significant modifiable factor preventing patients from completing cardiac rehabilitation after an acute myocardial infarction (Brouwers et al., 2021). A systematic review showed that the recommendation of cardiac rehabilitation by clinicians and nurses was the main factor in encouraging subsequent patient involvement in cardiac rehabilitation (Clark et al., 2013). However, a nationwide survey in the US showed that only 34 % of patients with heart disease were recommended by their healthcare professionals to participate in cardiac rehabilitation at the time of discharge from the hospital (Hermann et al., 2018). Studies in China have shown that approximately half of healthcare professionals possess a good cardiac rehabilitation knowledge, and about three-quarters of general practitioners express a high willingness to offer cardiac rehabilitation services (Dong et al., 2021; Zheng et al., 2022). Qi et al. (2019) revealed that a lack of cardiac rehabilitation knowledge among cardiology nurses negatively predicted nurses' willingness to undertake early cardiac rehabilitation training for patients. However, the specific association between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice is unclear.

Despite the significant impact of healthcare professionals' cardiac rehabilitation knowledge on their subsequent cardiac rehabilitation referral practice, studies have demonstrated a discrepancy between cardiac rehabilitation knowledge and cardiac rehabilitation recommendation behavior (Farah et al., 2021). One study showed that although about 60–80 % of healthcare professionals had moderate or high cardiac rehabilitation knowledge, only 48 % would refer their patients to cardiac rehabilitation, indicating other factors may affect such an association (Farah et al., 2021). Healthcare professionals' attitudes, values, and beliefs about cardiac rehabilitation referral have been shown to play an essential role in linking cardiac rehabilitation knowledge and cardiac rehabilitation referral practice (Gallagher et al., 2020). Moradi et al. (2011) also noted that cardiologists' lack of perception and recognition of cardiac rehabilitation benefits were barriers to their cardiac rehabilitation referral practice. It is likely that attitude toward cardiac rehabilitation referral may mediate the association between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice, which, however, has not yet been tested. Therefore, we conducted the current study to assess the cardiac rehabilitation referral rate and investigate the relationship between knowledge, attitudes, and practices of cardiac rehabilitation among healthcare professionals based on the knowledge, attitude, and practice model, with the following research hypotheses (As shown in **Fig. 1**):

Hypothesis one: Cardiac rehabilitation knowledge was positively correlated with the cardiac rehabilitation referral practice of healthcare professionals.

Hypothesis two: Cardiac rehabilitation referral attitude mediated the association between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice.

2. Methods

2.1. Study design and participants

The China Society of Cardiopulmonary Prevention and Rehabilitation Registry Platform showed that as of 2021, there were 159 accredited cardiac rehabilitation centers nationwide, including three in Hunan Province (Zhang et al., 2023). This multicenter cross-sectional study was conducted among cardiovascular healthcare professionals in Hunan Province, China. Participants were clinicians and nurses from 40 hospitals in 12 cities in Hunan, China, recruited from the Hunan Cardiology Specialist Training Base from July to August 2021. The inclusion criteria were as follows: 1) aged over 18 years old; 2) working in the cardiology or cardiac surgery department; 3) with work experience of over one year; 4) had a physician's or nurse's license and practicing certificate. We excluded those in training, internship, or off-duty due to sick leave, maternal leave, or other reasons. The study was reported in accordance with the Strengthening the Reporting of Observational studies in Epidemiology reporting guidelines.

2.2. Sample size

The independent variables in this study included 11 variables covering sociodemographic information, cardiac rehabilitation knowledge, and cardiac rehabilitation referral attitude. Following the sample size requirement of 15–20 times per independent variable for logistic regression analysis (Ogundimu et al., 2016; Schönbrodt and Perugini, 2013), we calculated the sample size at 20 samples per variable, equaling 220. Considering a rejection rate of 20 %, we expanded the final sample size to 264.

2.3. Measurements

2.3.1. Sociodemographic characteristics

The sociodemographic information included gender, age, education, occupation, work unit, years of work, hospital type, hospital level, and professional title.

2.3.2. Cardiac rehabilitation knowledge

Cardiac rehabilitation knowledge was assessed by a four-item cardiac rehabilitation knowledge questionnaire. The cardiac rehabilitation knowledge questionnaire was self-designed through group discussions, with reference to the Chinese Guidelines for Cardiac Rehabilitation and Secondary Prevention (Yuan and Ding, 2019). Each item is scored on a

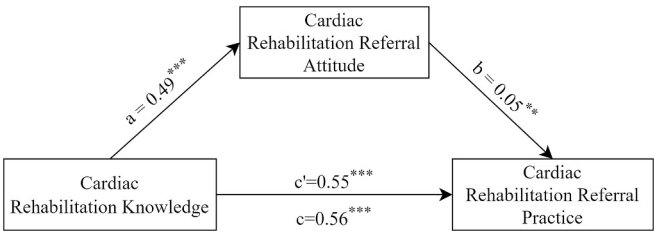

Fig. 1. Schematic Representation of the Mediating Model.
Note: a-path and b-path show indirect effects, c'-path shows direct effect, c-path shows total effect, $^{**}P < 0.01$, $^{***}P < 0.00$ s1.

four-point Likert scale from one (very unaware) to four (very aware). The total score ranges from four to sixteen, with a higher score indicating better cardiac rehabilitation knowledge. In the current study, the questionnaire demonstrated good internal consistency with a Cronbach's α of 0.96. The construct validity analysis showed a Kaiser-Meyer-Olkin value of 0.85, and Bartlett's test of sphericity with $P < 0.001$, indicating suitability for factor analysis. Additionally, all four items had loadings above 0.88 on the first main factor, indicating a high correlation with this factor and suggesting that the questionnaire has good unidimensional construct validity. The specific items of the questionnaire can be found in the Supplementary material 1.

2.3.3. Cardiac rehabilitation referral attitude

Cardiac rehabilitation referral attitude was assessed by the Chinese version of the Recommending Cardiac Rehabilitation (ReCaRe) scale initially developed by Ski et al. (2019). The ReCaRe scale was used to assess healthcare professionals' attitudes, values and beliefs to cardiac rehabilitation referral (Ski et al., 2019). The Chinese version of the questionnaire, which was translated by Qin et al. (2022b), includes 16 items under three dimensions: perceived severity and susceptibility, perceived service accessibility, and perceived benefits and barriers. Each item is scored on a five-point Likert scale from one (strongly disagree) to five (strongly agree). The total score ranges from 16 to 80, with a higher score indicating a more positive attitude toward cardiac rehabilitation referral. The Chinese version had a Cronbach's α of 0.87, and a content validity index of 0.88, indicating good reliability and validity Qin et al. (2022b)). In the current study, the ReCaRe demonstrated good internal consistency with a Cronbach's α of 0.87.

2.3.4. Cardiac rehabilitation referral practice

Cardiac rehabilitation referral practice was assessed by the following question: "Have you ever recommended cardiac rehabilitation to your patient?". The item is scored on a four-point Likert scale from one(never) to four(always), with a higher score indicating more cardiac rehabilitation referral practice.

2.4. Data collection

Data were collected through an online platform, Sojump (https://www.wjx.cn/), which is one of China's largest online research platforms for questionnaire design, questionnaire distribution, data collection, and data analysis (Zhang et al., 2017). After contacting the hospital administrators and obtaining their consent, we invited them to distribute the online questionnaire link to their hospital's cardiology or cardiac surgery departments via WeChat groups. On the front page of the questionnaire, the objectives and contents of this survey were described. Each participant completed the online questionnaire anonymously and independently. The following three methods were used to improve the quality of the online data: 1) each WeChat account was limited to complete the questionnaire once to avoid duplicate responses; 2) the questionnaire could only be submitted after all required items were completed to prevent missing data; 3) the time limit for completing the survey should fall in the range of 60–3000 s to be regarded as valid. In this survey, there were 357 respondents. Among them, 10 did not meet the departmental requirements, and 23 exceeded the time limit for filling out the survey, thus they were excluded. Ultimately, there were 321 valid responses.

2.5. Ethical considerations

This study was approved by the Institutional Review Board of the Third Xiangya Hospital, Central South University (No: I 21090). All participants provided electronic informed consent before completing the questionnaire.

2.6. Data analysis

Categorical variables were described by frequencies and percentages. The cardiac rehabilitation knowledge score and cardiac rehabilitation referral attitude score were determined to have a normal distribution due to skewness $< |1|$ and kurtosis $< |1|$; hence, mean ± standard deviation (SD) was used to describe them. Comparisons of cardiac rehabilitation referral practice by different sociodemographic groups were conducted by Mann-Whitney U Test and Kruskal-Wallis test. The relationships between knowledge, attitude, and practice of cardiac rehabilitation referral were assessed by Pearson correlation coefficient and Kendall rank correlation coefficient.

Since the dependent variable, cardiac rehabilitation referral practice, was a categorical variable, mediation analysis was conducted by logistic regression, with the product of standardized coefficients used to test for mediating effects (Iacobucci, 2012; Fang et al., 2017). A common test for the product estimator was the Sobel test (Iacobucci, 2012; Sobel, 1982). In this study, regression analysis was carried out in the following three steps:

(1) A logistic regression with cardiac rehabilitation referral practice as the dependent variable and cardiac rehabilitation knowledge as the independent variable.
(2) A linear regression with cardiac rehabilitation referral attitude as the dependent variable and cardiac rehabilitation knowledge as the independent variable.
(3) A logistic regression with cardiac rehabilitation referral practice as the dependent variable and cardiac rehabilitation knowledge and cardiac rehabilitation referral attitude as the independent variables.

Then, the significance of the mediating effect was tested by Sobel, with an absolute value of Sobel Z greater than 1.96 indicating a statistically significant mediating effect. To enhance the robustness of the mediation analysis, we also used the Bootstrap method (1000 resampling) to estimate the confidence intervals of the mediation effects and calculate the effect proportions. The statistical software SPSS 26.0 and R 4.4.1 were used for data analysis.

3. Results

3.1. Sociodemographic characteristics and comparison of cardiac rehabilitation referral practice

Among the 321 healthcare professionals, the average age was (31.50 ± 7.14) years. Most were female (83.8 %), nurses (74.5 %), with an undergraduate degree (65.4 %), and working in the cardiology department (98.8 %) of general hospitals (99.4 %) and tertiary hospitals (90.7 %). About one-third (34.3 %) had work experience of over ten years. A minority (11.2 %) held the professional title of associate senior or senior. Univariate analyses revealed that age, years of work, hospital type, and professional title were significantly associated with cardiac rehabilitation referral practice ($P < 0.05$). More details are shown in Table 1.

3.2. Knowledge, attitude, and practice of cardiac rehabilitation referral

The average scores for cardiac rehabilitation knowledge and cardiac rehabilitation referral attitude were 8.60 ± 3.10, 63.36 ± 7.37, respectively. The mean score of each cardiac rehabilitation referral attitude dimension was shown in Table 2. Nearly one-third of healthcare professionals (29.0 %) never recommended cardiac rehabilitation to their patients, and only 5.6 % always recommended it.

The correlation analysis (Table 2) showed that cardiac rehabilitation knowledge was positively correlated with cardiac rehabilitation referral attitude ($r = 0.20$, $P < 0.001$) and cardiac rehabilitation referral practice ($\tau = 0.57$, $P < 0.001$), the latter two were also positively correlated ($\tau =$

Table 1
Sociodemographic characteristics and comparison of cardiac rehabilitation referral practice of heathcare professionals in China (2021).

Variables	N (%)	Cardiac Rehabilitation Referral Practice (N (%))				Mean rank	*P*-value
		Never	Occasionally	Often	Always		
Gender							0.31 [a]
Male	52 (16.2)	13 (25.0)	23 (44.2)	12 (23.1)	4 (7.7)	172.1	
Female	269 (83.8)	80 (29.7)	123 (45.7)	52 (19.3)	14 (5.2)	158.9	
Age, yr							<0.001 [b]
≤ 25	73 (22.7)	32 (43.8)	27 (37.0)	12 (16.4)	2 (2.7)	135.4	
25–30	82 (25.5)	27 (32.9)	40 (48.8)	10 (12.2)	5 (6.1)	148.9	
30–35	86 (26.8)	25 (29.1)	36 (41.9)	18 (20.9)	7 (8.1)	165.6	
> 35	80 (24.9)	9 (11.3)	43 (53.8)	24 (30.0)	4 (5.0)	191.9	
Education							0.22 [b]
Technical	22 (6.9)	3 (13.6)	16 (72.7)	3 (13.6)	0 (0.0)	164.5	
Undergraduate	210 (65.4)	66 (31.4)	85 (40.5)	43 (20.5)	16 (7.6)	161.6	
Master	59 (18.4)	20 (33.9)	29 (49.2)	8 (13.6)	2 (3.4)	145.2	
Doctor	30 (9.3)	4 (13.3)	16 (53.3)	10 (33.3)	0 (0.0)	185.6	
Occupation							0.07 [a]
Clinician [c]	82 (25.5)	16 (19.5)	42 (51.2)	20 (24.4)	4 (4.9)	175.9	
Nurse	239 (74.5)	77 (32.2)	104 (43.5)	44 (18.4)	14 (5.9)	155.9	
Work unit							0.11 [a]
Cardiology	317 (98.8)	93 (29.3)	144 (45.4)	63 (19.9)	17 (5.4)	160.1	
Cardiac surgery	4 (1.2)	0 (0.0)	2 (50.0)	1 (25.0)	1 (25.0)	229.3	
Years of work							0.02 [b]
≤ 1	55 (17.1)	24 (43.6)	23 (41.8)	8 (14.5)	0 (0.0)	129.6	
1–5	81 (25.2)	25 (30.9)	35 (43.2)	12 (14.8)	9 (11.1)	161.4	
5–10	75 (23.4)	19 (25.3)	36 (48.0)	17 (22.7)	3 (4.0)	165.9	
> 10	110 (34.3)	25 (22.7)	52 (47.3)	27 (24.5)	6 (5.5)	173.1	
Hospital type							0.01 [a]
General	319 (99.4)	93 (29.2)	146 (45.8)	64 (20.1)	16 (5.0)	160.1	
Specialist	2 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	312.5	
Hospital level							0.99 [b]
Tertiary	291 (90.7)	86 (29.6)	129 (44.3)	60 (20.6)	16 (5.5)	160.9	
Secondary	28 (8.7)	7 (25.0)	15 (53.6)	4 (14.3)	2 (7.1)	162.1	
Primary	2 (0.6)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	166.5	
Professional title							0.02 [b]
Junior	108 (33.6)	34 (31.5)	47 (43.5)	20 (18.5)	7 (6.5)	157.8	
Intermediate	177 (55.1)	57 (32.2)	78 (44.1)	32 (18.1)	10 (5.6)	155.3	
Associate senior	29 (9.0)	2 (6.9)	19 (65.5)	7 (24.1)	1 (3.4)	188.6	
Senior	7 (2.2)	0 (0.0)	2 (28.6)	5 (71.4)	0 (0.0)	241.5	

Note, N, Number of Observations; **P*<0.05; ****P* <0.001.
[a] Tested by Mann-Whitney U Test (*Z*).
[b] Tested by Kruskal-Wallis test (*H*).
[c] Clinician, doctors who work in cardiology or cardiac surgery, including cardiologist, cardiac surgeon and interventional cardiologist.

Table 2
Correlations among cardiac rehabilitation knowledge, referral attitudes, and referral practices among healthcare professionals in China (2021).

	Score (*Mean* ± *SD*)	Cardiac rehabilitation knowledge (*r* [c])	Cardiac rehabilitation referral practice (*τ* [d])
Cardiac rehabilitation knowledge [a]	8.60 ± 3.10	–	0.57***
Cardiac rehabilitation referral attitude [b]	63.36 ± 7.37	0.20***	0.21***
Perceived Severity and Susceptibility	28.79 ± 4.13	0.28***	0.26***
Perceived Service Accessibility	8.94 ± 3.01	0.12*	0.08
Perceived Severity and Susceptibility	25.63 ± 3.03	0.22***	0.22***

Note, SD, Standard Deviation; *r*, Pearson correlation coefficient; *τ*, Kendall's tau-b coefficient; **P*<0.05, ****P*<0.001.
[a] Points on Cardiac rehabilitation knowledge questionnaire: 4–16 points.
[b] Points on ReCaRe scale: Perceived Severity and Susceptibility: 7–35 points; Perceived Service Accessibility: 3–15 points; Perceived Severity and Susceptibility: 6–30 points.
[c] Tested by Pearson correlation analysis.
[d] Tested by Kendall rank correlation analysis.

0.21, $P < 0.001$).

3.3. Mediation analysis

As shown in Table 3, the mediation analysis was conducted in three parts representing the following associations: cardiac rehabilitation knowledge-referral practice, cardiac rehabilitation knowledge-referral attitude, and cardiac rehabilitation referral attitude-referral practice. First, after controlling for the confounding variables (age, working years, hospital type, and professional title), an ordered logistic regression analysis showed that cardiac rehabilitation knowledge was positively associated with cardiac rehabilitation referral practice ($c = 0.56$, $P < 0.001$). Second, univariate analysis revealed no significant differences in cardiac rehabilitation referral attitude among the sociodemographic groups; therefore, a simple linear regression analysis was conducted and showed cardiac rehabilitation knowledge was positively associated with cardiac rehabilitation referral attitude ($a = 0.49$, $P<0.001$). Third, after controlling for confounding variables, an ordered logistic regression analysis showed that cardiac rehabilitation knowledge and referral attitude were positively associated with cardiac rehabilitation referral practice ($b = 0.05$, $P<0.01$; $c' = 0.55$, $P<0.001$). (Fig. 1).

A Sobel test found that the mediating effect was significant (Sobel $Z = 2.40>1.96$, $P = 0.02$), indicating that cardiac rehabilitation referral attitude mediated the relationship between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice (Indirect effect =

Table 3
The mediating effect of cardiac rehabilitation referral attitude on the association between cardiac rehabilitation knowledge and referral practice among heathcare professionals in China (2021).

Association	Coefficient [e]	SE	P-value [f]
Cardiac Rehabilitation Knowledge-Referral Practice [a,d]	0.56	0.05	<0.001
Cardiac Rehabilitation Knowledge-Referral Attitude [b,d]	0.49	0.13	<0.001
Cardiac Rehabilitation Referral Attitude-Referral Practice [c,d]			
Effect of Cardiac Rehabilitation Referral Attitude	0.05	0.02	<0.01
Effect of Cardiac Rehabilitation Knowledge	0.55	0.05	<0.001

Note, SE, Standard Error.
[a] A logistic regression with cardiac rehabilitation referral practice as the dependent variable and cardiac rehabilitation knowledge as the independent variable.
[b] A linear regression with cardiac rehabilitation referral attitude as the dependent variable and cardiac rehabilitation knowledge as the independent variable.
[c] A logistic regression with cardiac rehabilitation referral practice as the dependent variable and cardiac rehabilitation knowledge and cardiac rehabilitation referral attitude as the independent variables.
[d] Adjusted for age, working years, hospital type, and professional title.
[e] The estimated effect size of the predictor variable on the dependent variable.
[f] Tested by regression Coefficient Test.

0.02, Direct effect = 0.55). The percentage of the indirect effect to the total effect was 4.3 %. See Table 4 for details. Further analysis was conducted to test the mediating effect using the Bootstrap method with 1000 resampling iterations. The results showed that the estimated value of the indirect effect was 0.02, with a 95 % confidence interval ranging from 0.01 to 0.05. As the confidence interval did not include zero, the indirect effect was statistically significant. The estimated effect proportion was 4.3 %, with a 95 % confidence interval ranging from 0.01 to 0.09, which also indicated that the effect proportion is statistically significant. See Supplementary material 2 for details.

4. Discussion

To our knowledge, this is the first study to investigate the cardiac rehabilitation referral practice among Chinese healthcare professionals and test the associations among knowledge, attitude, and practice of cardiac rehabilitation referral using a mediation model. The results showed a very low cardiac rehabilitation referral rate among Chinese healthcare professionals. Cardiac rehabilitation knowledge was positively correlated with cardiac rehabilitation referral practice, and such an association was partially mediated by cardiac rehabilitation referral attitude. Our findings have important implications for future intervention and research priorities to improve healthcare professionals' cardiac rehabilitation referrals.

Our study revealed that only 5.6 % of healthcare professionals always recommended cardiac rehabilitation to their patients, which is much lower than that reported by previous studies in other countries, indicating an urgent need to improve cardiac rehabilitation referral. However, it is to be noted that not all cardiac patients are eligible for cardiac rehabilitation, and therefore, measuring referral solely based on the proportion of healthcare professionals who 'always' recommend cardiac rehabilitation may not fully reflect the actual patient-level referral rate. Future research should incorporate patient-level referral data to better assess cardiac rehabilitation uptake and identify additional barriers to referral. Our findings indicated significant differences in cardiac rehabilitation referral rates based on sociodemographic and professional factors. Older, more experienced, and highly qualified practitioners, particularly those in specialized hospitals, demonstrated higher referral rates, highlighting the need for targeted education and training strategies. Additionally, fostering mentorship programs between specialized and general hospitals may facilitate knowledge transfer and reduce inter-institutional gaps. Cuenza et al. (2016) suggested that identifying clinician barriers and attitudes was an essential aspect of how we could work to circumvent the problem of low cardiac rehabilitation referral rates. In our study, we found that cardiac rehabilitation referral attitude and its three dimensions of perceived severity and susceptibility, perceived service accessibility and perceived service availability were all significantly and positively associated with cardiac rehabilitation referral practice. This suggested that the greater the healthcare professionals' awareness of the severity and susceptibility of cardiac rehabilitation, as well as the higher the perceived service availability and accessibility, the greater the likelihood that they would recommend cardiac rehabilitation, and therefore an emphasis on shaping positive referral attitudes among healthcare professionals may be an important strategy to promote cardiac rehabilitation referrals.

Supporting hypothesis one, our study showed that cardiac rehabilitation knowledge was positively associated with cardiac rehabilitation referral practice, which was congruent with previous studies. Ghisi et al. (2018) demonstrated that cardiologists who were more knowledgeable about cardiac rehabilitation were more likely to recommend cardiac rehabilitation to more patients. Moreover, studies have shown that healthcare professionals' lack of knowledge about indications and contraindications for cardiac rehabilitation was associated with a lower likelihood of cardiac rehabilitation referral practice (Scott and Allen, 2004). Kellar et al. (2021) found healthcare professionals' cardiac rehabilitation knowledge determined the length of conversation they had when recommending cardiac rehabilitation to patients, which further influenced their cardiac rehabilitation referrals. However, Santiago et al. (2020) pointed out that educational intervention focusing on improving healthcare professionals' cardiac rehabilitation knowledge did not significantly change their cardiac rehabilitation referral practice. This may be because education and training focused solely on cardiac rehabilitation knowledge, without fostering positive cardiac rehabilitation referral attitudes, are insufficient to promote cardiac rehabilitation referral practices (Zhu et al., 2020).

Supporting hypothesis two, our study revealed that cardiac rehabilitation referral attitude played a mediating role between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice, with the mediation effect accounting for 4.3 % of the total effect. Our findings were partially in line with previous studies. A study showed that cardiologists with higher cardiac rehabilitation knowledge had better cardiac rehabilitation referral attitudes and beliefs (Ghisi et al., 2018). Gallagher et al. (2020) noted that clinicians' perceived severity of patients' illness and belief about their suitability for cardiac rehabilitation influenced their cardiac rehabilitation referral practice. Critically, attitudes themselves are shaped by external factors such as patient characteristics (e.g., disease severity, gender) and perceived service accessibility (e.g., availability of cardiac rehabilitation programs). Scott and Allen (2004) also discovered that healthcare professionals' perceived barriers and benefits, i.e., negative attitudes toward female patients' motivation and benefits of participating in cardiac rehabilitation, might prevent them from referring or discussing cardiac rehabilitation with female patients. This underscores the need for targeted

Table 4
Indirect, Direct, and Total Effects of Cardiac Rehabilitation Referral Attitude in the Mediation Model Using the Sobel Test Among Healthcare Professionals in China (2021).

	Estimate	*Standard Error*	Sobel Test	
			Z	P-value
Indirect effect	0.02	0.01	2.40	0.02
Direct effect	0.55	0.05		
Total effect	0.56	0.05		
Effect Proportion	4.3 (%)			

education programs that address implicit biases and promote equitable cardiac rehabilitation referral practices. In addition, structural barriers, including limited access to cardiac rehabilitation facilities, insufficient insurance coverage, and lack of standardized referral pathways, may significantly hinder cardiac rehabilitation implementation (Qin et al., 2022a; Field et al., 2022). Therefore, we call on health policymakers not only to strengthen training and education but also to develop an organized, integrated cardiac rehabilitation system. Such a system should include comprehensive post-discharge follow-up measures to monitor and support patients, ensuring both the quality and sustainability of cardiac rehabilitation services (Field et al., 2022). Moreover, evidence suggests that cardiac rehabilitation programs need to be of sufficient duration and designed for long-term engagement to achieve optimal outcomes (Medina-Inojosa et al., 2021). By addressing these structural challenges, health policy makers can significantly improve cardiac rehabilitation referral rates and ultimately, the well-being of the Chinese population.

5. Limitations

There are several limitations. First, the cross-sectional study design cannot establish a causal relationship between variables, and therefore, the mediating association warrants replication in a longitudinal study. Second, given that participation was voluntary and recruitment was mediated by hospital administrators, we could not determine the total number of eligible healthcare professionals who received the survey link. we acknowledge that this limitation may introduce potential selection bias, where healthcare professionals with greater cardiac rehabilitation awareness or referral experience might have been more likely to participate, potentially leading to an overestimation of actual cardiac rehabilitation referral rates. Third, the measurement of cardiac rehabilitation knowledge and cardiac rehabilitation referral practice was based on self-designed questions instead of standard scales, and their reliability and validity warrant further testing in future research. Finally, the confounders included in this study may not be comprehensive enough, and in the future, we will target more potential confounders to control.

6. Conclusion

This study highlights a low cardiac rehabilitation referral rate among healthcare professionals, indicating much room for improvement. There was a significant and positive association between cardiac rehabilitation knowledge and cardiac rehabilitation referral practice, which was partially mediated by cardiac rehabilitation referral attitude. The mediation model suggests that enhancing cardiac rehabilitation knowledge and promoting positive attitudes through education and training and optimizing accessibility to cardiac rehabilitation services may effectively promote cardiac rehabilitation referral. Importantly, establishing an organized cardiac rehabilitation system. This could involve deploying dedicated cardiac rehabilitation nurses who can serve as knowledge ambassadors to both patients and staff, provide coordinated care pathways, and ensure continuity of service delivery through systematic follow-up protocols.

CRediT authorship contribution statement

Ziqiang Yao: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Ning Qin:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Shuangjiao Shi:** Writing – review & editing, Methodology, Investigation, Funding acquisition. **Yinglong Duan:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Shuhua Zhang:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Xiao Li:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Haoqi Liu:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Zhuqing Zhong:** Supervision, Project administration, Methodology, Conceptualization.

Patient consent statement

All participants provided electronic informed consent before completing the questionnaire that were anonymized to safeguard subjects privacy.

Ethics approval statement

This study was approved by the Institutional Review Board of the Third Xiangya Hospital, Central South University (IRB approval number: I 21090). All procedures were performed in compliance with relevant laws and institutional guidelines.

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Declaration of competing interest

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.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2025.103064.

Data availability

Data will be made available on request.

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