

# BMJ Open Knowledge, attitudes and practices among patients with end-stage kidney disease towards hyperkalaemia management in Shenzhen, China: a cross-sectional study

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## ABSTRACT

**Objectives** To investigate the knowledge, attitudes and practices (KAP) among patients with end-stage kidney disease (ESKD) towards hyperkalaemia.

**Design** A cross-sectional study.

**Setting** This study was conducted between September and November 2023 at the Department of Nephrology, Shenzhen Third People's Hospital and the Second Affiliated Hospital of Southern University of Science and Technology.

**Participants** The study included 568 patients with ESKD who were undergoing haemodialysis, peritoneal dialysis or both, recruited through convenience sampling.

**Primary and secondary outcome measures** This study was conducted using a self-administered questionnaire, which assessed participants' KAP towards hyperkalaemia management. The questionnaire comprised four sections: demographic information, knowledge (13 items), attitudes (9 items) and practices (9 items), with responses evaluated using a 5-point Likert scale. A cut-off value of 70% of the total score was applied, with thresholds for sufficient knowledge, favourable attitudes and proactive practices set at 6.3, 31.5 and 31.5 points, respectively. The higher the KAP scores, the better the levels of knowledge, attitude and practice. A structural equation model (SEM) was constructed to analyse the effects of demographic characteristics on KAP dimensions. Path coefficients (standardised estimates) were used to assess the strength of relationships between variables, with coefficients >0.2 generally considered moderate effects and >0.5 strong effects.

**Results** A total of 568 participants were enrolled in this study, including 369 (64.69%) males, and 249 (43.84%) have been diagnosed with ESKD for more than 5 years. The median (IQR) KAP scores of the participants were 9 (3–9) (possible range: 0–9), 34 (24–45) (possible range: 9–45) and 32 (10–45) (possible range: 9–45), respectively. SEM demonstrated that the frequency of dialysis had direct effects on knowledge (coefficient=0.113,  $p=0.039$ ), education had direct effects on attitudes (coefficient=0.257,  $p<0.001$ ), knowledge had direct effects on practices (coefficient=−0.130,  $p=0.016$ ), attitudes had direct effects on practices (coefficient=0.549,  $p<0.001$ )

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The study's sample size is relatively small due to constraints related to time and other factors.
- ⇒ The research was carried out at a hospital located in Shenzhen, an area renowned for its advanced economy and high-quality healthcare services. As a result, caution must be exercised when generalising these findings to populations residing in less economically developed or medically underserved areas.
- ⇒ The use of trap questions (K3, K11, K6 and K12) served as a quality control mechanism to ensure the accuracy and completeness of the questionnaire responses.
- ⇒ The rigorous development process ensures that the questionnaire accurately measures the intended constructs.
- ⇒ The implementation of an online questionnaire with IP restrictions helped prevent duplicate submissions and ensured that each participant completed the survey only once. This approach, combined with the dissemination strategy using QR codes and WeChat platforms, facilitated efficient and broad data collection while maintaining data integrity.

and education had direct effects on practices (coefficient=0.112,  $p=0.007$ ).

**Conclusion** Patients with ESKD enrolled in this study have sufficient knowledge, favourable attitudes and proactive practices towards the hyperkalaemia. Nevertheless, it is still recommended to enhance clinical practice in hyperkalaemia management among patients with ESKD by tailoring education for those with lower education levels, emphasising the importance of regular dialysis and implementing strategies to bridge the knowledge-practice gap.

## INTRODUCTION

End-stage kidney disease (ESKD) is the advanced stage of chronic kidney disease (CKD), typically resulting from a variety of

kidney disorders.<sup>1</sup> The optimal management of ESKD entails kidney replacement therapy (KRT), with kidney transplantation emerging as the preferred treatment option.<sup>2,3</sup> Hyperkalaemia, a frequent electrolyte disturbance in CKD and ESKD, is exacerbated by impaired kidney function, resulting in reduced potassium excretion,<sup>4</sup> and often referred to as 'high blood potassium' in clinical practice.<sup>5</sup> Hyperkalaemia is a common and dangerous condition in patients with CKD and ESKD, particularly in those undergoing dialysis, as it can cause serious complications, including life-threatening arrhythmia.<sup>6,7</sup> The prevalence of hyperkalaemia in the general population is estimated to range between 2% and 3%.<sup>8</sup> However, as the estimated glomerular filtration rate declines from 60 to 90 mL/min/1.73 m<sup>2</sup> to below 20 mL/min/1.73 m<sup>2</sup>, the prevalence of hyperkalaemia (defined as >5 mEq/L) increases significantly, rising from 2% to 42%, and reaching 56.7% among patients with CKD stage 5.<sup>9</sup>

The global incidence of ESKD is steadily rising with the ageing population, imposing a significant burden on affected individuals, their families and public healthcare systems.<sup>10,11</sup> Despite recent advancements in ESKD management, mortality rates among patients with ESKD remain stubbornly high.<sup>12</sup> The high prevalence and potential dangers of hyperkalaemia in patients with ESKD further emphasise its clinical significance, making effective management and prevention crucial to reducing mortality and improving quality of life. The presence of hyperkalaemia also adds complexity to the already intricate care required for these patients, placing further strain on healthcare resources. However, there remains a significant gap in patients' understanding and management of hyperkalaemia, which is often due to inadequate awareness and education. Existing research indicates that many patients may not fully comprehend the inherent risks associated with their condition, highlighting a lack of awareness regarding its severity. This lack of awareness can lead to adverse clinical events, emphasising the need for improved patient education and engagement in ESKD care.<sup>13–15</sup>

A knowledge, attitudes and practices (KAP) survey is a research methodology employed to evaluate the collective understanding, beliefs and behaviours of a particular group concerning a specific subject.<sup>16–18</sup> In accordance with the KAP model, individual practices or behaviours are shaped by the combination of one's knowledge and attitude towards the subject at hand. This model finds substantial application in the realm of health education and promotion, operating on the fundamental premise that knowledge serves as a catalyst, positively impacting one's attitude, which subsequently shapes their practices and behaviours.<sup>19,20</sup>

Given the critical role of hyperkalaemia management in ESKD care, identifying knowledge gaps and misconceptions through a KAP survey can provide targeted interventions to enhance patient outcomes and reduce the risks associated with this condition. Therefore, this

study aimed to investigate the KAP among patients with ESKD towards hyperkalaemia management. Via a detailed analysis of patients' levels of knowledge, attitudes and self-care behaviours germane to hyperkalaemia, this study endeavours to unveil contributory factors contributing to suboptimal awareness and management of hyperkalaemia within the scope of ESKD.

## METHODS

### Study design and participants

This cross-sectional survey was conducted between September and November 2023 at the Department of Nephrology, Shenzhen Third People's Hospital and the Second Affiliated Hospital of Southern University of Science and Technology. This study used convenience sampling to recruit patients with ESKD. The inclusion criteria of this study encompassed patients with ESKD undergoing haemodialysis, peritoneal dialysis or a combination of both. Exclusion criteria were patients with ESKD who had received kidney transplants or those not undergoing any form of KRT. A total of 815 cases were collected, including 419 electronic questionnaires and 396 paper questionnaires. Participants completing the electronic survey provided electronic consent by acknowledging a consent form prior to beginning the questionnaire, while those completing the paper survey provided written consent by signing a consent form attached to the questionnaire. Both methods ensured that participants were fully informed about the study purpose, procedures and their rights to withdraw at any time without consequences.

### Questionnaire

The questionnaire was developed with guidance from the Executive Summary of the Kidney Disease: Improving Global Outcomes 2021 Clinical Practice Guideline for the Management of Blood Pressure in Chronic Kidney Disease, and relevant literature on hyperkalaemia management.<sup>21–23</sup> The original questionnaire was designed and administered in Chinese as the study participants were native Chinese speakers. To ensure clarity and accuracy, the questionnaire was translated into English (online supplemental file 1). A translation and back-translation process were employed, involving bilingual nephrology experts, to maintain the consistency and validity of the content across both language versions. The initial draft underwent revisions based on feedback from two senior experts specialising in nephrology and haemoperfusion, both holding the title of chief physician. Subsequently, a pilot test was conducted (n=30), resulting in a Cronbach's alpha coefficient value of 0.763, indicating good internal consistency.

The final questionnaire was administered in Chinese and encompassed four distinct dimensions: demographic information, knowledge, attitudes and practices. This questionnaire assesses the KAP of patients with ESKD regarding hyperkalaemia. It consists of four

sections: demographic information, knowledge (13 items), attitudes (9 items) and practices (9 items). The questions cover patients' understanding, perceptions and management behaviours related to hyperkalaemia, with responses measured using a Likert scale. The demographic section included 15 items, whereas the KAP dimensions comprised 13, 9 and 9 items, respectively. In the knowledge dimension, questions K3 and K11 were intentionally crafted as trap questions, each representing precisely contradictory concepts. Patients who chose 'correct' or 'incorrect' for both questions were identified as experiencing logical conflicts and consequently were excluded from the survey. Similarly, questions K6 and K12 were constructed as trap questions, conveying identical meanings. Respondents whose questionnaires featured discrepant responses to both questions would be disqualified. These four aforementioned questions serve as instruments for ensuring the quality control of the questionnaire, which do not form part of the statistical analysis in this study but are solely employed to illustrate the accuracy rates of the respective questions. Thus, knowledge items were scored with 1 point awarded for correct responses and 0 point for incorrect answers, yielding a possible score range of 0–9. The items related to attitudes and practices are presented in the form of a 5-point Likert scale, where positive statements (denoted as 'P') are scored from 5 to 1, and negative statements (denoted as 'N') are reverse-scored. Positive statements (denoted as 'P') are assigned values from 'a' to 'e' corresponding to scores from 5 to 1. Negative statements (denoted as 'N') are reverse-scored. The total score range for both of these dimensions is between 9 and 45 points.

The survey was distributed through two main methods: manual collection and a WeChat QR code. For manual collection, paper questionnaires were handed out at several haemodialysis centres, with a section where respondents could voluntarily provide their phone numbers for follow-up contact if necessary. Alternatively, participants could complete the survey by scanning a WeChat QR code hosted on Sojump (<http://www.sojump.com>). These QR codes were prominently displayed in key areas of the dialysis centres, such as reception rooms, waiting areas, nephrology department bulletin boards and at the nurses' stations. Employing face-to-face training for four research assistants, this study effectively managed the process of distributing, retrieving and ensuring the quality control of the questionnaires.

### Sample size calculation

Sample size was calculated using the formula for cross-sectional studies:  $\alpha=0.05$ ,  $n = \left( \frac{Z_{1-\alpha/2}}{\delta} \right)^2 \times p \times (1 - p)$ , where  $Z_{1-\alpha/2}=1.96$  when  $\alpha=0.05$ , the assumed degree of variability of  $p=0.5$  maximises the required sample size and  $\delta$  is admissible error (which was 5% here). The

theoretical sample size was 480, which includes an extra 20% to allow for subjects lost during the study.

### Statistical analysis

STATA 17.0 (Stata Corporation, College Station, Texas, USA) was used for statistical analysis. For data conforming to a normal distribution, continuous variables are presented as mean $\pm$ SD, while categorical variables are expressed in terms of frequency and percentage (n (%)). Group differences for these variables were assessed using the t-test (for two independent samples) or analysis of variance (for three or more independent samples). In the case of data that do not follow a normal distribution, continuous variables are represented by the median (IQR). To compare differences between groups in this context, the Mann-Whitney U test (for two samples) or the Kruskal-Wallis H test (for multiple samples) was employed.

In this study, 70% of the total score was used as the cut-off value,<sup>24 25</sup> which means the threshold for sufficient knowledge, favourable attitudes and proactive practices were 6.3, 31.5 and 31.5 points, respectively. Pearson correlation was used to analyse the correlation between knowledge, attitudes and practices. Variables with  $p<0.05$  in the single-factor logistic regression analysis are included in the multivariate logistic regression analysis. A structural equation model (SEM) of KAP among patients with ESKD towards hyperkalaemia management was constructed with AMOS 24.0 (IBM, New York, USA). SEM tested the following main hypotheses: (1) education had direct effects on the frequency of dialysis; (2) frequency of dialysis had direct effects on knowledge; (3) knowledge had direct effects on attitudes; (4) education had direct effects on attitudes; (5) knowledge had direct effects on practices; (6) attitudes had direct effects on practices and (7) education had direct effects on practices. The model fitting was evaluated using the following indices:  $\chi^2$  fit statistics/degree of freedom (CMIN/DF), root mean square error of approximation (RMSEA), incremental fit index (IFI), Tucker-Lewis index (TLI) and comparative fit index (CFI). Path coefficients (standardised estimates) were used to assess the strength of relationships between variables, with coefficients $>0.2$  generally considered moderate effects and  $>0.5$  strong effects.

### PATIENT AND PUBLIC INVOLVEMENT STATEMENT

This study used convenience sampling to recruit ESKD patients. Investigators explained the survey's purpose to participants, who volunteered without intervention. They could withdraw anytime. Besides questionnaires and necessary guidance, no other interventions were carried out, ensuring data collection respected patients' rights.



## RESULTS

### Demographic characteristics and KAP scores

The initial survey included 827 collected questionnaires, comprising both electronic and paper-based responses. During the data cleaning process, a series of quality control measures were applied to ensure the validity of responses. First, two responses with an answer time of less than 60s were excluded. Additionally, one questionnaire containing an implausible age value ('3843.5') was removed. Two cases were excluded due to missing body mass index (BMI) values, while another two were eliminated because of an abnormal history of kidney removal. Furthermore, two responses with abnormal dialysis methods and one with abnormal dialysis frequency were excluded. Logical inconsistencies in the knowledge section led to the removal of two additional questionnaires. Finally, 247 cases were excluded due to inconsistent or conflicting answers to trap questions designed to assess response reliability. After applying these criteria, a total of 568 valid questionnaires were included in the final analysis. Among the participants, the majority of participants were male (369, 64.96%), aged 50 or above (288, 50.70%), with normal BMI (160, 28.17%), residing in urban areas (455, 80.11%) and having education levels of junior high school or below (52.99%). Additionally, most participants have been diagnosed with ESKD more than 5 years (249, 43.84%) and have been on dialysis for 1–5 years (247, 43.49%), with frequency of three times a week for 4 hours per session (455, 80.11%) (table 1).

The median (IQR) KAP scores of the participants were 9 (3–9) (possible range: 0–9), 34 (24–45) (possible range: 9–45) and 32 (10–45) (possible range: 9–45), respectively. Participants aged 50 or above demonstrated significantly better attitudes (median: 34; IQR: 24–45;  $p<0.001$ ) and practices (median: 33; IQR: 10–45;  $p<0.001$ ) compared with those under 50. Urban residents exhibited significantly higher knowledge scores (median: 9; IQR: 4–9;  $p=0.007$ ) but lower practice scores (median: 32; IQR: 10–45;  $p=0.010$ ) than their rural counterparts. The education level was significantly associated across all domains as participants with a college degree or higher scored significantly higher in knowledge (median: 9; IQR: 7–9;  $p=0.006$ ), attitude (median: 35; IQR: 28–45;  $p<0.001$ ) and practice (median: 33; IQR: 20–45;  $p<0.001$ ). Occupational status also influenced attitude (median: 34; IQR: 24–45;  $p=0.001$ ) and practice (median: 33; IQR: 18–45;  $p=0.007$ ), with employed or self-employed participants displaying more positive attitudes and practices. Monthly per capita income affected practice (median: 34; IQR: 22–45;  $p=0.008$ ), particularly for participants earning over 10 000 yuan, who exhibited higher practice scores. Participants who underwent peritoneal dialysis scored significantly higher in attitude (median: 35; IQR: 28–40;  $p<0.001$ ) and practice (median: 35; IQR: 25–45;  $p<0.001$ ) compared with those on haemodialysis. Finally, participants who experienced hyperkalaemia after ESKD diagnosis had significantly higher knowledge scores (median: 9; IQR: 4–9;  $p=0.008$ ) (table 1).

### Knowledge dimension

The three knowledge items with the highest correctness rates were as follows: "People with kidney failure should not eat foods that have a lot of potassium, like dried seafood, and should watch their diet closely" (K9), with a correctness rate of 99.65%, "Doctors check blood potassium levels to see if someone has high blood potassium" (K6), with a correctness rate of 99.30%, "High blood potassium is found by testing the potassium in the blood" (K12), also with a correctness rate of 99.30%. In addition to the extremely high correctness rate of the above questions, the other questions also showed a high correctness rate of more than 90%, with the exception of one question, "Not all kidney failure patients need drugs for treatment" (K7), only with a correctness rate of 60.39% (online supplemental table S1).

### Attitudes dimension

Regarding attitudes, a notable majority of patients (93.13%) strongly agree or agreed that possessing adequate knowledge about high blood potassium is of paramount significance (A1). Similarly, a high percentage (72.89%) acknowledged the pivotal role of regular check-ups in preventive management (A2). Only 1.94% of patients disagree to follow the prescribed medication regimen (A4) as a preventive measure against high blood potassium. However, some of the patients with ESKD (40.49%) believed that disease prevention primarily rests with medical professionals rather than at the patient level (A6). Interestingly, a substantial portion (81.69% totally) expressed unwavering confidence in their ability to prevent high blood potassium (A7), while a majority (89.97% totally) indicated complete trust in the therapeutic strategies recommended by their attending physicians (A8). Lastly, a noteworthy proportion (85.57%) concurred on the necessity of a holistic intervention encompassing various facets for addressing high blood potassium in patients with ESKD (A9) (online supplemental table S1).

### Practices dimension

In the practice dimension, 55.46% of respondents (very consistent: 14.44%; somewhat consistent: 41.02%) reported favourably seeking knowledge through sources like literature and educational materials (P1). Similarly, when it came to following medication guidelines, 60.03% of participants (very consistent: 21.83%; somewhat consistent: 38.20%) showed commitment (P2). Moreover, in terms of adhering to medical recommendations and scheduled check-ups, 82.22% of respondents (very consistent: 28.35%; somewhat consistent: 53.87%) displayed a strong practice (P3). Seeking psychological support and using social networks to cope with the emotional impact of the ailment was observed in 42.61% of participants (very consistent: 8.63%; somewhat consistent: 33.98%) (P8). Lastly, employing healthful routines and physical activity to prevent ESKD complications, including high blood potassium, was practised by 59.86% of respondents

**Table 1** Demographic characteristics and knowledge, attitudes and practices scores

Variables	n (%)	Knowledge, median (IQR)	P value	Attitude, median (IQR)	P value	Practice, median (IQR)	P value
Total	568	9 (3–9)		34 (24–45)		32 (10–45)	
Gender			0.309		0.327		0.322
Male	369 (64.96)	8 (3–9)		33 (25–43)		32 (17–45)	
Female	199 (35.04)	9 (4–9)		34 (24–45)		33 (10–45)	
Age (years)			0.330		<0.001		<0.001
<50	280 (49.30)	9 (5–9)		33 (25–41)		31 (18–45)	
≥50	288 (50.70)	8 (3–9)		34 (24–45)		33 (10–45)	
Body mass index (kg/m <sup>2</sup> )			0.011		0.237		0.284
<18.5 (underweight)	49 (8.63)	8 (6–9)		32 (24–42)		32 (10–45)	
18.5–23.9 (normal)	160 (28.17)	8 (3–9)		34 (25–45)		32 (18–45)	
24–27.9 (overweight)	54 (9.51)	9 (4–9)		34 (25–43)		32 (20–45)	
>28 (obese)	17 (2.99)	8 (5–9)		34 (27–40)		32 (17–45)	
Residence			0.007		0.767		0.010
Rural	113 (19.89)	8 (3–9)		33 (27–39)		33 (23–45)	
Urban	455 (80.11)	9 (4–9)		34 (24–45)		32 (10–45)	
Education			0.006		<0.001		<0.001
Junior high school or below	301 (52.99)	9 (4–9)		32 (24–42)		31 (10–45)	
High school and technical secondary school	175 (30.81)	8 (3–9)		34 (27–43)		33 (17–45)	
College or above	92 (16.20)	9 (7–9)		35 (28–45)		33 (20–45)	
Occupation			0.209		0.001		0.007
Employed/self-employed	199 (35.04)	8 (3–9)		34 (24–45)		33 (18–45)	
Unemployed	120 (21.13)	9 (4–9)		33.5 (27–39)		32 (17–45)	
Retired	152 (26.76)	9 (5–9)		32 (25–41)		31 (18–45)	
Other	97 (17.08)	8 (6–9)		33 (27–43)		33 (10–45)	
Marital status			0.592		0.122		0.303
Unmarried	52 (9.15)	9 (6–9)		34.5 (24–42)		33 (25–45)	
Married	500 (88.03)	9 (3–9)		34 (25–45)		32 (10–45)	
Other	16 (2.82)	8 (7–9)		32.5 (25–39)		32 (25–45)	
Monthly per capita income (CNY)			0.004		0.032		0.008
<2000	157 (27.64)	9 (5–9)		34 (27–40)		32 (18–45)	
2000–5000	221 (38.91)	8 (3–9)		33 (25–43)		32 (10–45)	
5000–10 000	142 (25.00)	8 (4–9)		32 (24–40)		33 (17–45)	
>10 000	48 (8.45)	9 (4–9)		34 (25–45)		34 (22–45)	
Medical insurance			0.021		0.865		0.109
No insurance	32 (5.63)	9 (7–9)		33.5 (28–37)		29.5 (19–45)	
Basic medical insurance only	477 (83.98)	8 (3–9)		34 (24–45)		32 (10–45)	
Basic medical as well as commercial insurance	59 (10.39)	9 (4–9)		33 (30–41)		32 (25–45)	
Time since ESKD diagnosis			0.751		0.011		0.020
Within 1 year	79 (13.91)	9 (5–9)		34 (28–41)		33 (19–45)	
1–3 years (including 1 year)	127 (22.36)	8 (4–9)		33 (25–40)		33 (17–45)	
3–5 years (including 3 years)	113 (19.89)	9 (4–9)		32 (27–42)		31 (10–45)	
>5 years	249 (43.84)	8 (3–9)		34 (24–45)		32 (18–45)	
History of kidney removal			0.243		0.131		0.822
Yes	18 (3.17)	8 (8–9)		32 (27–38)		33 (24–44)	

Continued

**Table 1** Continued

Variables	n (%)	Knowledge, median (IQR)	P value	Attitude, median (IQR)	P value	Practice, median (IQR)	P value
No	550 (96.83)	9 (3–9)		34 (24–45)		32 (10–45)	
Dialysis method in the last six months			0.054		<0.001		0.001
Haemodialysis	512 (90.14)	9 (3–9)		34 (25–45)		32 (10–45)	
Peritoneal dialysis	39 (6.87)	8 (5–9)		35 (28–40)		35 (25–45)	
Both	17 (2.99)	9 (5–9)		31 (24–39)		32 (25–34)	
Dialysis duration			0.863		0.276		0.186
<1 year	90 (15.85)	9 (5–9)		34 (28–41)		33 (19–45)	
1–5 years (including 5 years)	247 (43.49)	9 (4–9)		33 (24–42)		32 (17–45)	
5–10 years (including 10 years)	147 (25.88)	8 (3–9)		34 (25–42)		32 (10–44)	
>10 years	84 (14.79)	8 (5–9)		33 (28–45)		32 (21–45)	
Dialysis frequency			0.073		0.135		0.001
Daily, 4 hours per session	38 (6.69)	8 (5–9)		34 (29–40)		34 (25–45)	
Every other day, 5 hours per session	9 (1.58)	8 (8–9)		32 (27–37)		34 (27–45)	
Two times per week, 4 hours per session	52 (9.15)	8 (4–9)		33 (27–40)		32 (19–45)	
Three times per week, 4 hours per session	455 (80.11)	9 (3–9)		33 (24–45)		32 (10–45)	
Other	14 (2.47)	8 (7–9)		35 (25–40)		35.5 (19–44)	
Hyperkalaemia after ESKD diagnosis			0.008		0.685		0.423
Yes	262 (46.13)	9 (4–9)		33 (25–41)		32 (10–45)	
No	306 (53.87)	8 (3–9)		34 (24–45)		32 (17–45)	

ESKD, end-stage kidney disease.

(very consistent: 16.73%; somewhat consistent: 43.13%) (P9) (online supplemental table S1).

### Pearson's analysis

Pearson's analysis was performed to assess the relationship between knowledge, attitudes and practices. It was shown that the knowledge and the attitudes were positively correlated ( $r=0.165$ ,  $p<0.001$ ), and attitudes and practices were also positively correlated ( $r=0.316$ ,  $p<0.001$ ) (table 2).

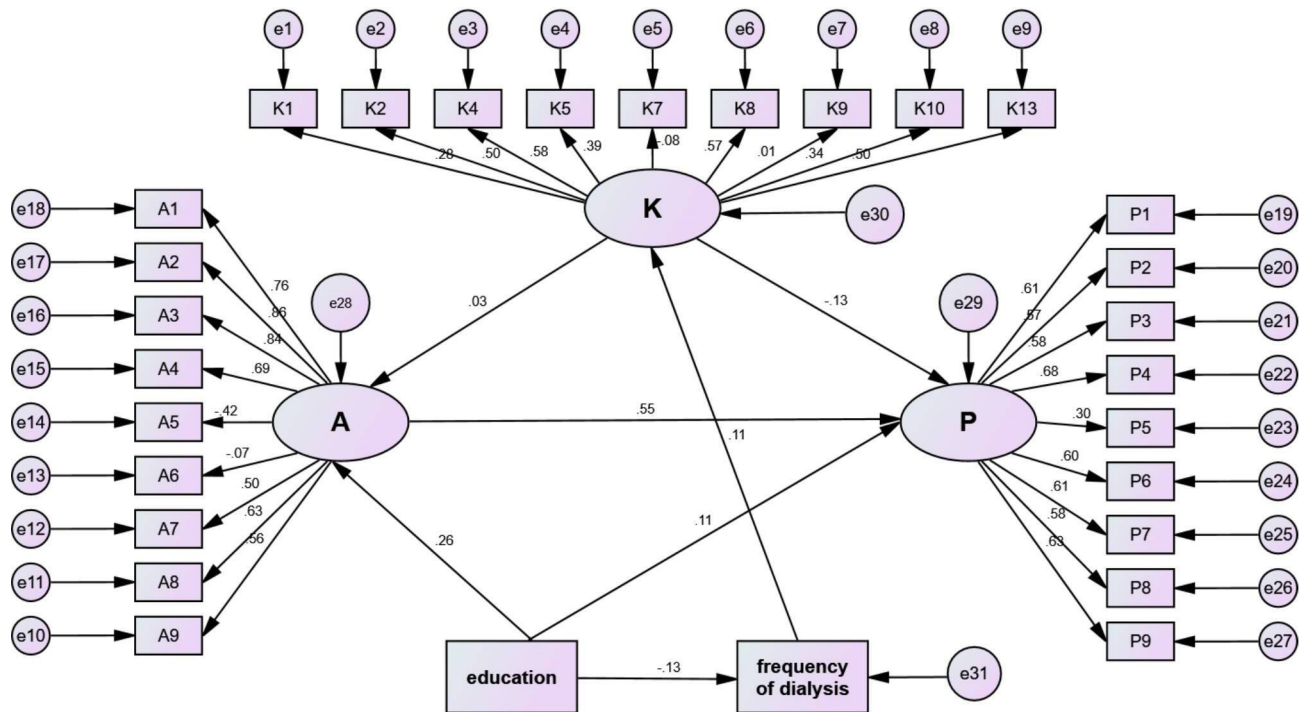
### Multivariate analyses

Multivariate analysis revealed that being overweight (OR=2.230, 95% CI: 1.212 to 4.103,  $p=0.010$ ), residing in rural areas (OR=0.566, 95% CI: 0.361 to 0.888,  $p=0.013$ ), having a monthly per capita income between 2000 and 5000 yuan (OR=0.456, 95% CI: 0.283 to 0.735,  $p=0.001$ ) or between 5000 and 10000 yuan (OR=0.454, 95% CI: 0.268

to 0.771,  $p=0.003$ ) and experiencing high blood potassium after an ESKD diagnosis (OR=1.478, 95% CI: 1.040 to 2.099,  $p=0.029$ ) were independently associated with sufficient knowledge. Sufficient knowledge (OR=1.449, 95% CI: 1.116 to 1.880,  $p=0.005$ ), BMI categories of 24–27.9 (OR=1.997, 95% CI: 1.053 to 3.788,  $p=0.034$ ) and >28 (OR=2.752, 95% CI: 1.123 to 6.744,  $p=0.027$ ), having a college education or above (OR=4.028, 95% CI: 2.136 to 7.596,  $p<0.001$ ) and a monthly per capita income between 2000 and 5000 yuan (OR=0.381, 95% CI: 0.231 to 0.628,  $p<0.001$ ) or between 5000 and 10000 yuan (OR=0.299, 95% CI: 0.172 to 0.519,  $p<0.001$ ), as well as individuals undergoing both haemodialysis and peritoneal dialysis (OR=0.106, 95% CI: 0.027 to 0.421,  $p=0.001$ ) were independently associated with favourable attitudes. Sufficient knowledge (OR=0.743, 95% CI: 0.578 to 0.955,  $p=0.020$ ), favourable attitudes (OR=1.184, 95% CI: 1.103 to 1.271,

**Table 2** Pearson's analysis

	Knowledge	Attitudes	Practices
Knowledge	1		
Attitudes	0.165 ( $p<0.001$ )	1	
Practices	−0.099 ( $p=0.018$ )	0.316 ( $p<0.001$ )	1



**Figure 1** Structural equation model.

$p < 0.001$ ), being below 50 years of age (OR=0.582, 95% CI: 0.374 to 0.906,  $p=0.017$ ) and having a high school or technical secondary school education (OR=1.712, 95% CI: 1.134 to 2.585,  $p=0.011$ ) were independently associated with proactive practices (online supplemental table S2).

### Structural equation model

SEM was established to further investigate the possible effects between knowledge, attitudes and practices of patients with ESKD and their education and frequency of dialysis. The fitting index of the structural model (CMIN/DF=3.191; RMSEA=0.062; IFI=0.813; TLI=0.778; CFI=0.810) outperformed the respective threshold value, signifying that the data satisfactorily fit the structural model (online supplemental table S3).

SEM demonstrated that the frequency of dialysis had direct effects on knowledge (coefficient=0.113,  $p=0.039$ ), education had direct effects on attitudes (coefficient=0.257,  $p < 0.001$ ), knowledge had direct effects on practices (coefficient=-0.130,  $p=0.016$ ), attitudes had direct effects on practices (coefficient=0.549,  $p < 0.001$ )

and education had direct effects on practices (coefficient=0.112,  $p=0.007$ ). Among these, the path coefficient between attitudes and practices (0.549) represents a strong effect, indicating that attitudes significantly influence practices in this patient population (figure 1, table 3).

### DISCUSSION

Patients with ESKD have sufficient knowledge, favourable attitude and proactive practice towards the hyperkalaemia. This conclusion is based on the thresholds of sufficient knowledge, favourable attitudes and proactive practices, which were defined as 6.3, 31.5 and 31.5 points, respectively, representing 70% of the total score for each domain. Nevertheless, it is still recommended to develop targeted interventions, such as nutrition education, medication adherence programmes and regular monitoring of potassium levels, to effectively enhance knowledge and bridge the knowledge-practice gap.

**Table 3** Test results of the hypothesis

Hypothesised paths	Estimate	Standardised estimate	SE	CR	P value
Frequency of dialysis <--- Education	-0.165	-0.133	0.051	-3.208	0.001
Knowledge <--- Frequency of dialysis	0.005	0.113	0.002	2.064	0.039
Attitudes <--- Knowledge	0.262	0.029	0.467	0.561	0.575
Attitudes <--- Education	0.113	0.257	0.020	5.601	<0.001
Practices <--- Knowledge	-2.041	-0.130	0.847	-2.409	0.016
Practices <--- Attitudes	0.972	0.549	0.113	8.575	<0.001
Practices <--- Education	0.087	0.112	0.032	2.691	0.007



In comparison with previous research, targeted interventions like nutrition education and medication adherence programmes have been shown to significantly improve patient outcomes in hyperkalaemia management.<sup>26 27</sup> This study found age-based disparities in hyperkalaemia management attitudes and practices, revealing that individuals aged 50 and above demonstrated significantly better attitudes and practices compared with those under 50. To address this, age-specific educational programmes and support systems should be implemented to improve younger patients' adherence to hyperkalaemia management guidelines.<sup>28</sup> Other studies also reported that older patients often adhere better to management guidelines, suggesting that age-specific interventions are necessary.<sup>29–31</sup> Education level significantly impacts KAP, emphasising the importance of patient education, especially for those with lower educational backgrounds. Occupational status influences attitude and practice, with employed or self-employed individuals exhibiting more positive attitudes and practices. Higher income levels correlate with better practices, highlighting the role of socio-economic factors in patient engagement. Monthly per capita income significantly affects practice, underscoring the need for affordable and accessible interventions. Healthcare providers should consider these findings when developing strategies to enhance patient education and adherence in hyperkalaemia management.<sup>32 33</sup> The study also found that patients' illness experiences significantly influence their KAP related to dialysis. Interventions that incorporate patient education, peer support groups and motivational counselling have been shown to improve patient engagement in dialysis care and should be considered for ESKD management.<sup>34 35</sup>

High correctness rates in most knowledge items indicate a robust foundational understanding of hyperkalaemia among patients. However, the lower correctness rate regarding medication underscores the necessity of addressing misconceptions and providing accurate information.<sup>36</sup> Notably, an item stating 'medication is unnecessary for patients with ESKD' displayed a relatively low correctness rate, diverging from expectations and hinting at potential misconceptions. This discrepancy may arise from differences in patient education programmes or healthcare systems, affecting the emphasis on medication in ESKD management.<sup>37–39</sup>

In terms of attitudes, the study revealed that patients generally acknowledged the significance of knowledge, regular check-ups and medication adherence in preventing hyperkalaemia, aligning with the existing literature emphasising the crucial role of patient attitudes in effective disease management.<sup>40–42</sup> Nevertheless, it is noteworthy that a substantial proportion believed that the responsibility for disease prevention primarily lies with medical professionals rather than patients themselves. This perspective contradicts the prevailing healthcare narrative, which emphasises patient empowerment and favourable involvement in self-management.<sup>43–45</sup> This disparity may stem from cultural or healthcare system

variations, underscoring the necessity for culturally sensitive interventions that promote a collaborative partnership between patients and healthcare providers.

In the practice dimension, the study revealed that a majority of participants consistently engaged in practices such as seeking knowledge, adhering to medication guidelines, following medical recommendations and using psychological support and physical activity. These commendable practices align with the ideal standards of ESKD management and should be favourably promoted and integrated into routine care plans to enhance disease management and overall patient outcomes.<sup>46 47</sup>

Previous research has similarly shown that increased knowledge positively impacts patient attitudes, supporting the results of this study.<sup>19 48</sup> The negative correlation between knowledge and practices suggests that while knowledge is important, it does not always translate into optimal practices.<sup>49</sup> This highlights the need for targeted interventions that bridge the gap between knowledge acquisition and practical application.

The SEM employed in this study offers valuable insights into the intricate relationships among knowledge, attitudes, practices, education and the frequency of dialysis. It sheds light on the direct negative effect of education on the frequency of dialysis, implying that patients with higher educational levels may require less frequent dialysis, a departure from conventional expectations. Additionally, the analysis underscores the pivotal role of knowledge in shaping patient practices, underscoring the importance of targeted educational programmes.<sup>50</sup> While some findings align with prior research, such as the positive influence of knowledge on attitudes, there are unique aspects to consider. The observed negative direct effect of 'education' on the 'frequency of dialysis' is a particularly noteworthy departure from expectations, emphasising the necessity for personalised treatment plans that account for patients' educational backgrounds. This finding may also suggest that well-educated patients exhibit greater capacity for independent disease management.<sup>51 52</sup>

This study had several limitations. The cross-sectional design, relying on anonymous questionnaire responses, posed challenges in tracing the prevalence of hyperkalaemia within the population. Furthermore, certain indicators in the KAP correlation analysis and SEM yielded non-significant or negative results, which may reflect underlying population characteristics or unmeasured confounding factors. Moreover, the research was carried out at a hospital located in Shenzhen, an area renowned for its advanced economy and high-quality healthcare services. Additionally, the exclusion of a significant number of respondents due to trap question failures, while necessary to ensure data quality, may limit the generalisability of our findings to the broader population. Future studies should validate these findings in diverse populations.

This study breaks new ground by focusing on the KAP of patients with ESKD regarding hyperkalaemia, an area



that has not been comprehensively investigated before. Furthermore, the findings of this investigation suggest the necessity of implementing measures aimed at narrowing the gap between knowledge and practice. Such measures encompass continuous patient support and the reinforcement of pivotal concepts to augment the pragmatic utilisation of knowledge in the management of hyperkalaemia among patients with ESKD.

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