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ORIGINAL RESEARCH

Chinese Healthcare Workers' Knowledge, Attitudes, and Practices in Diabetic Kidney Management: A Multi-Centered Cross-Sectional Study

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Background: Given the importance of diabetic kidney disease (DKD) management, this study aims to explore the knowledge, attitudes, and practices in disease management demonstrated by healthcare workers from the nephrology department.

Materials and Methods: This study is a multi-centered cross-sectional study, and adopts snowball sampling, with 530 healthcare workers being recruited to complete a questionnaire covering areas such as demographic characteristics, knowledge, attitude, and practices (KAP) of DKD management. This data was analyzed using descriptive statistics and binary logistics analysis.

Results: In this study, 530 healthcare workers were studied, including 94 doctors and 436 nurses. The participants were mainly from general tertiary hospitals in 14 provinces. For Chinese nurse, the results indicate that both poor knowledge level (Odds Ratio (OR) =0.63, 95% Confidence Interval (CI): 0.42–0.94) and having experience in further medical training in nephrology (OR=1.92, 95% CI: 1.20–3.08) are associated with the practice levels. For Chinese doctors, having not experience in further medical training in nephrology (OR=0.36, 95% CI: 0.15–0.83) are associated with their practice levels.

Conclusion: In summary, Chinese doctors and nurses in this study showed positive attitudes towards DKD management, but their knowledge and practical skills were lacking. This underscores a notable gap in achieving optimal DKD care. Notably, nurses' knowledge influenced their management practices, and additional nephrology training correlated with better engagement. To improve patient care, enhancing nephrology healthcare professional training and addressing knowledge-practice disparities are recommended.

Keywords: knowledge, attitude, practice, diabetic kidney disease

Introduction

Diabetic kidney disease (DKD), a manifestation of chronic kidney disease (CKD) instigated by diabetes mellitus, is delineated by escalating proteinuria and a decrement in glomerular filtration rate (GFR), culminating in end-stage renal disease (ESRD).[1] Reports indicate that DKD accounts for approximately 30–50% of ESRD cases globally.[2] Concurrently, the rising prevalence of diabetes annually positions DKD as a leading cause of CKD and ESRD in China.[3] Furthermore, DKD substantially heightens the risk for diabetic vascular complications, placing patients in an exceedingly high-risk category for cardiovascular morbidity and mortality.[4] Often presenting without early symptoms, many individuals with DKD are diagnosed at the proteinuria stage, when clinical symptoms become apparent. The failure to adequately manage DKD not only precipitates the progression to ESRD—necessitating dialysis or kidney transplantation for patient survival—but also amplifies the risk of cardiovascular complications, thereby exacerbating the overall burden of diabetes complications.[5] The progression from DKD to ESRD not only surges healthcare costs but also significantly impairs

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patient quality of life. This underscores the imperative for efficacious management strategies for DKD to mitigate these adverse outcomes.[6]

However, the early detection and initiation of interventions that effectively slow the progression of DKD are impeded by a multitude of factors. These include widespread lack of awareness about the health consequences of DKD, the complexity of the care required—including lifestyle changes, challenges in adhering to intricate medication regimens, and the tepid adoption and implementation of evidence-based management protocols.[7,8] Despite progress in the treatment of DKD patients, the advent of novel glucose-lowering agents marks a potential paradigm shift, promising to slow disease progression and enhance patient survival rates.[9] Yet, the integration and optimal application of these new therapies in clinical practice remain suboptimal. It is imperative, therefore, for the healthcare community, professional societies, and regulatory bodies to collaborate in developing and executing strategies to improve DKD awareness, detection, and treatment. This concerted effort is crucial to overcoming the entrenched challenges in managing this complex condition and to making substantive advances in patient care.[7]

Nevertheless, people's understanding of DKD is seriously deficient. A real-world study analyzed the electronic health record data of more than 6 million diabetic patients and found that even if there is laboratory evidence,[10] the diagnosis of DKD is often understandably delayed. In addition, many patients do not receive renal function examinations regularly, increasing the likelihood that they miss the opportunity for early diagnosis and treatment. According to a national survey based on the general population in China,[11] only 32.2% of diabetic patients have received diabetes treatment, and only 49.2% of patients have a glycosylated hemoglobin level that is < 7.0%. Hence, the diagnosis and treatment management of diabetic diseases in China urgently need to be improved. It can be inferred that the current situation of disease management for DKD patients is worrisome.

The KAP (Knowledge, Attitude, Practice) model, underpinning surveys on awareness of prevalent diseases,[12,13] aims to foster health-promoting behaviors by highlighting the relationship between knowledge, attitudes, and practices. This model is crucial in healthcare, particularly for disease prevention, screening, diagnosis, and awareness, with its application extending to various conditions including novel coronavirus pneumonia,[14] rheumatic heart disease,[15] dementia.[16] Healthcare professionals with a thorough understanding of disease management and practical experience are essential for delivering high-quality healthcare services and treatments.[17,18] However, in the context of DKD, limited research exists on KAP among nephrologists. A qualitative study found only 56% of healthcare workers perform kidney function assessments in Type 2 Diabetes patients, and merely 25% use urinary albumin for DKD monitoring and staging.[19] Similarly, a survey among Ethiopian healthcare professionals showed 91% recognized the link between diabetes, hypertension, and CKD development. However, knowledge gaps remain, as only 59% understood that evaluating enhanced GFR is more effective than using serum creatinine levels alone for assessing nephropathy severity.[20]

The KAP of healthcare workers regarding DKD can significantly impact the timely screening, diagnosis, and management of patients, potentially influencing the health-related outcomes of these patients.[10,21] However, there is a scarcity of comprehensive KAP studies on DKD conducted among healthcare workers. A comprehensive literature review further underscores the limited attention given to DKD-related KAP among healthcare workers and emphasizes the imperative for additional research in this domain.[18] Consequently, the research questions are: 1) What are the current levels of KAP among healthcare workers regarding DKD management? and 2) What factors influence these dimensions? Based on the KAP theory, this study surveys the awareness of healthcare workers regarding DKD management and seeks to understand their current KAP situation of DKD and its influencing factors, so as to provide the basis for future revisions of DKD-related training and effective implementations of early DKD screenings.

Materials and Methods

Subjects and Study Design

This study adopts a multi-center cross-sectional design, utilizing convenience and snowball sampling methods. It centers around an advanced training program on CKD management, specifically designed for nurses. This program was hosted in a major urban area within Sichuan Province, China. The majority of attendees were drawn from the nephrology departments of tertiary-level hospitals across various districts nationwide. To collect data, we developed an online survey

employing the Questionnaire Star platform. Participants were further encouraged to share this survey within their professional networks, aiming to maximize outreach and response rates.

Eligible participants for this study include doctors and nurses who possess professional qualification certificates and are currently active in clinical service. Participation is voluntary, with all participants required to provide informed consent prior to inclusion. Eligible individuals must be employed in departments such as nephrology or hemodialysis centres. Medical workers who are currently interns were excluded from the study to ensure the collected data reflects the insights of fully qualified healthcare professionals. Questionnaires completed too quickly and those with a continuous pattern of responses covering at least half the questionnaire length will be eliminated.[22] The study received approval from the Biomedical Ethics Review Committee of West China Hospital, Sichuan University (approval number: 2023(2054)).

Sample Size

Following the recommendations of Kotrlik et al,[23] the formula $n=Z^2p(1-p)/d^2$ is deemed more suitable for cross-sectional surveys. Given few studies on the KAP of DKD disease management, values of 50% for p, 95% (corresponding to a Z-value of 1.96) for the confidence level, and 5% for the margin of error were employed. Consequently, the minimum required sample size to be collected is 461.

Measurements

The first part of questionnaire was designed by the researchers according to the research purpose, requesting information such as the respondents' gender, age, marital status, occupation, department, professional title, working years, educational background, hospital level, and whether they had studied in the nephrology or diabetes department.

Validity and Reliability of the Tool

The second part of the questionnaire is the healthcare worker DKD management KAP questionnaire formulated by researchers after reviewing relevant literature. This is also with reference to the Chinese Guidelines for Diagnosis and Treatment of Diabetic Kidney Disease[1] and KDIGO 2022 Clinical Practice Guideline for Diabetes Management in Chronic Kidney Disease,[6] and based on the KAP theory model. After completing the original questionnaire, 6 experts (3 nursing experts and 3 doctors) were invited to form an external expert group to evaluate the content validity of the questionnaire. All of them had more than 10 years of experience in clinical nursing or diagnosis and treatment of nephropathy. Expert consultation was executed over Email or WeChat. According to the first consultation by external experts, the content validity index (CVI) of the 34-item doctor version questionnaire is 0.83–1.00, and the average item-CVI (I-CVI) of the scale is 0.98. The CVI of the 21-item nurse version questionnaire is 0.80–1.00, and the average item of the scale is 0.96. Scale-CVI/Average (S-CVI/Ave) and item-CVI exceeded the respective recommended levels of 0.80 and 0.78.[24] After creating the initial questionnaire, we conducted a pilot study involving 15 participants, including 7 doctors and 8 nurses, to assess its clarity, feasibility, and practicality.[25] The main goal was to gather participant feedback to ensure the questions were clear and not prone to misunderstanding. Based on the feedback received, we made slight modifications to the questionnaire. For evaluating the questionnaire's validity and reliability, we used Cronbach's α for internal consistency.[26] A Cronbach's $\alpha \geq 0.7$ was considered acceptable The questionnaire demonstrated strong reliability with Cronbach's α coefficients of 0.907, 0.973, and 0.918 for the knowledge, attitude, and practice sections, respectively.

The questionnaire is divided into a doctor version and nurse version, covering the following three dimensions: DKD-related knowledge, attitude, and practice of healthcare workers. ① The knowledge aspect encompasses various domains including the definition, diagnosis, risk factors, and common pharmacological treatments of DKD, featuring 13 items for doctors and 6 items for nurses. Specifically, 3 questions are designed for reverse scoring. The response options are "True", "False", and "Unknown". Correct answers are awarded one point, while incorrect answers or selections of "Unknown" receive no points. The total score is 0–13 points. Drawing upon previous studies,[17,27,28] individuals who achieved a score at or above the mean level in knowledge were regarded as possessing good knowledge. ② There are 6 items in the attitude dimension, including the willingness to learn DKD-related knowledge and the attitude towards DKD management. The three options which includes options of "Disagree", "Uncertain", and "Agree" are used for evaluation. The higher the score, the more positive the attitude towards DKD-related learning and disease management, with a total

score range of 6–18 points. Based on previous studies,[17,27,28] individuals who obtained a score above the mean level were categorized as exhibiting a positive attitude. ③ The practice dimension mainly includes DKD lifestyle management, referral suggestions, blood glucose management, and screening suggestions (15 items in the doctor version and 9 items in the nurse version). The Likert 5-level Scale which includes options of "Never", "Rarely", "Sometimes", "Often", and "Always" are used for evaluation. The practice level is proportional to the score. In accordance with prior research,[17,27,28] respondents were classified as demonstrating inadequate practices if their scores fell below the mean level.

Statistical Analysis

The data were analyzed by the software SPSS 23.0. Continuous variables that that do not conform to a normal distribution are represented by median (interquartile range, IQR). Categorical variables are represented by percentage (%). To find the factors that influenced the practice level of nurses or doctors, first, we ran univariate analysis considering practice level(good/poor) as a dependent variable. Variables with P<0.2 in the univariate analysis were then evaluated as independent variables in binary logistic regression analysis.[29] The logistic regression assessed the association between gender, marital status, age, professional title, educational level, working years, etc., and the KAP level. For binary logistic regression analysis, we calculated odds ratios (OR) and 95% Confidence interval (CI) for each independent variable. If $P < 0.05$, it indicates that the difference is statistically significant.

Results

Respondents' General Information

In this study, 530 healthcare workers were recruited, including 94 doctors and 436 nurses. Doctors were aged 26–56 (median: 37; IQR:33–42) and had worked for over 20 years (16.0%), of which 45.7% (n = 43) had further medical training in nephrology. Nurses were aged 22–58 (median: 33; IQR:28–37) and had worked for more than 20 years (12.9%). Ninety-eight nurses (22.5%) had further medical training in nephrology. The respondents are mainly from the tertiary (n=515) hospitals, secondary (n=15) hospitals in 14 Provinces, with women accounting for a large proportion of both groups of subjects (doctors 71.3%; nurses 94.5%). (See Tables 1 and 2)

Chinese Nurses' KAP of DKD Management

Knowledge Score

Participants scoring at or above the mean (≥ 60.3%) were classified as possessing proficient knowledge concerning DKD, as delineated in Supplementary Figure 1. The mean score on DKD management knowledge among Chinese nurses was recorded at 3.5, denoting a commendable level of expertise. It is of particular note that the lowest accuracy rates were observed in responses to items pertaining to the definition of DKD (9.8%) and the diagnostic criteria for DKD (7.3%). Conversely, the item concerning the importance of blood glucose regulation in DKD management garnered the highest accuracy, with an overwhelming majority of nurses (94.7%) acknowledging its criticality. (Refer to Figure 1).

Attitude Score

Respondents achieving a score at or above the mean (≥ 89.0%) are deemed to possess a positive attitude toward DKD management; otherwise, they are considered to hold a negative attitude. (See Supplementary Figure 1) This study shows that Chinese nurses hold a positive attitude towards DKD management, with a score of 17.3. The majority of nurses expressed a proactive attitude toward learning DKD knowledge (93.1%) and receiving relevant training (93.5%). 92.8% nurses should possess the ability to identify and diagnose DKD at an early stage. Similarly, a high proportion of nurses (92.2%) believed that DKD patients should be promptly referred to nephrology subspecialists for early intervention, and a substantial 94.2% advocated for comprehensive multidisciplinary diagnosis and treatment to assess potential DKD complications (see Figure 2).

Practice Score

Respondents with a score at or above the mean (≥ 53.4%) are considered to have good practice; otherwise, they are considered to have poor practice (see Supplementary Figure 1). The mean score of nurses' practice on DKD management

Table 1 The Scores of Nurses and Practice Score of DKD Disease Management Among Nurses with Different Characteristics (n=436)

Variable	N, Percentage (%)	Practice score Median (P_{25}, P_{75})
Gender		
Male	24(5.5)	32.5(27, 36)
Woman	412(94.5)	36(30, 41)
Marital status		
Married	314(72.0)	36(30, 41)
Unmarried	122(28.0)	35(29, 40)
Age		
18~29	132(30.3)	36(30, 41)
30~39	227(52.0)	36(30, 41)
≥40	77(17.7)	36(29, 41)
Professional title		
Primary	241(55.3)	35(29, 40)
Intermediate	157(36.0)	38(31, 42)
Vice-high and above	38(8.7)	36(30.50, 42.50)
Educational background		
College and below	36(8.3)	36.5(29.5, 41)
Bachelor	393(90.1)	36(30, 41)
Master and above	7(1.6)	31(29, 34)
Years of service		
≤ 5	103(23.6)	35(27.5, 40)
6~10	116(26.6)	35(29, 40)
11~20	161(36.9)	37(31, 42)
≥21	56(12.9)	38(31.50, 44)
Further medical training in Nephrology		
Yes	98(22.5)	39(32, 44)
No	338(77.5)	35.5(30, 40)
Departments		
Nephrology	355(81.4)	37.0(28.75, 42)
Hemodialysis center	81(18.6)	36.0(27.50, 40.25)
Type of hospitals		
Tertiary level hospital	427(97.9)	35.0(24.25, 42.50)
Secondary level hospital	9(2.1)	36.0(30, 41)
Knowledge level		
Good	263(60.3)	37.0(30, 42)
Poor	173(39.7)	35.0(39, 40)
Attitude level		
Positive	388(89.0)	36.0(30, 41)
Negative	48(11.0)	32.0(29, 40.75)

Note: P_{25}= 25% percentile; P_{75}=75% percentile.

was 35.1. A total of 74.4% of nurses often or always advised DKD patients to perform exercise according to their own conditions. In contrast, 18.9% of nurses seldom or never followed the individualized principle to hierarchically manage the target value of glycosylated hemoglobin of DKD patients, as shown in Figure 3.

Chinese Doctors' KAP Situation of DKD Management

Knowledge Score

Respondents achieving a score at or above the mean (≥ 59.6%) are regarded as having a good knowledge of DKD management; otherwise, they are considered to have mastered poor knowledge. (See Supplementary Figure 2) The mean

Table 2 The Scores of Practice of Doctors with Different Characteristics in DKD Disease Management (n=94)

Variables	N, Percentage (%)	Practice Score Median (P_{25}, P_{75})
Gender		
Male	27(28.7)	63(58.50, 65.50)
Woman	67(71.3)	61(57, 70)
Marital status		
Married	82(87.2)	61.5(57, 69)
Unmarried	12(12.8)	61.5(59, 67)
Age		
18~29	8(8.5)	61.5(59.25, 69.25)
30~39	52(55.3)	60(54.25, 65)
≥40	34(36.2)	63.5(60.50, 70.50)
Professional title		
Primary	16(17.0)	62(59.25, 69.50)
Intermediate	37(39.4)	60(53, 65.50)
Vice-high and above	41(43.6)	63(58.50, 71.50)
Educational background		
Bachelor	12(12.8)	62(56.50, 68.50)
Master	44(46.8)	61(57.50, 70)
Doctor	38(40.4)	63.5(57.25, 68)
Years of service		
≤ 5	19(20.2)	62(60, 74)
6~10	26(27.6)	59(53.75, 64)
11~20	34(36.2)	63(57.75, 70)
≥21	15(16.0)	64(61, 72)
Further medical training in Nephrology		
Yes	43(45.7)	63(60, 70)
No	51(54.3)	60(53, 68)
Departments		
Nephrology	84(89.4)	62.50(59.25, 68.75)
Hemodialysis center	10(10.6)	62.50(55.0, 67.50)
Type of hospitals		
Tertiary level hospital	88(93.6)	62.0(59.75, 69.25)
Secondary level hospital	6(6.4)	64.0(57, 68.75)
Knowledge level		
Good	56(59.6)	63.0(59.25, 7)
Poor	38(40.4)	60.0(53, 67.25)
Attitude level		
Positive	81(64.9)	61.0(56.50, 69)
Negative	13(35.1)	64.0(61, 71.50)

Note: P_{25}= 25% percentile; P_{75}=75% percentile.

score of knowledge among Chinese doctors was 8.7. The 12th item showed the highest accuracy, and most doctors (98.9%) knew the importance of self-monitoring of blood glucose for DKD management. The second most frequently items to be answered correctly were 6, 9 and 11, with 97.8% of doctors knowing that insulin is the most important drug for treating Type1 DKD (T1DKD), that ACEI/ARB drugs are the first choice for treating microalbuminuria in Type2 DKD (T2DKD), and the treatment scheme for generous proteinuria in DKD. In comparison to the nurse-oriented questionnaire, the accuracy rate for items associated with the definition of DKD (28.5%) and the diagnostic criteria (19.0%) exhibited a higher occurrence in the version tailored for doctors. A total of 24.4% of doctors put unknown for

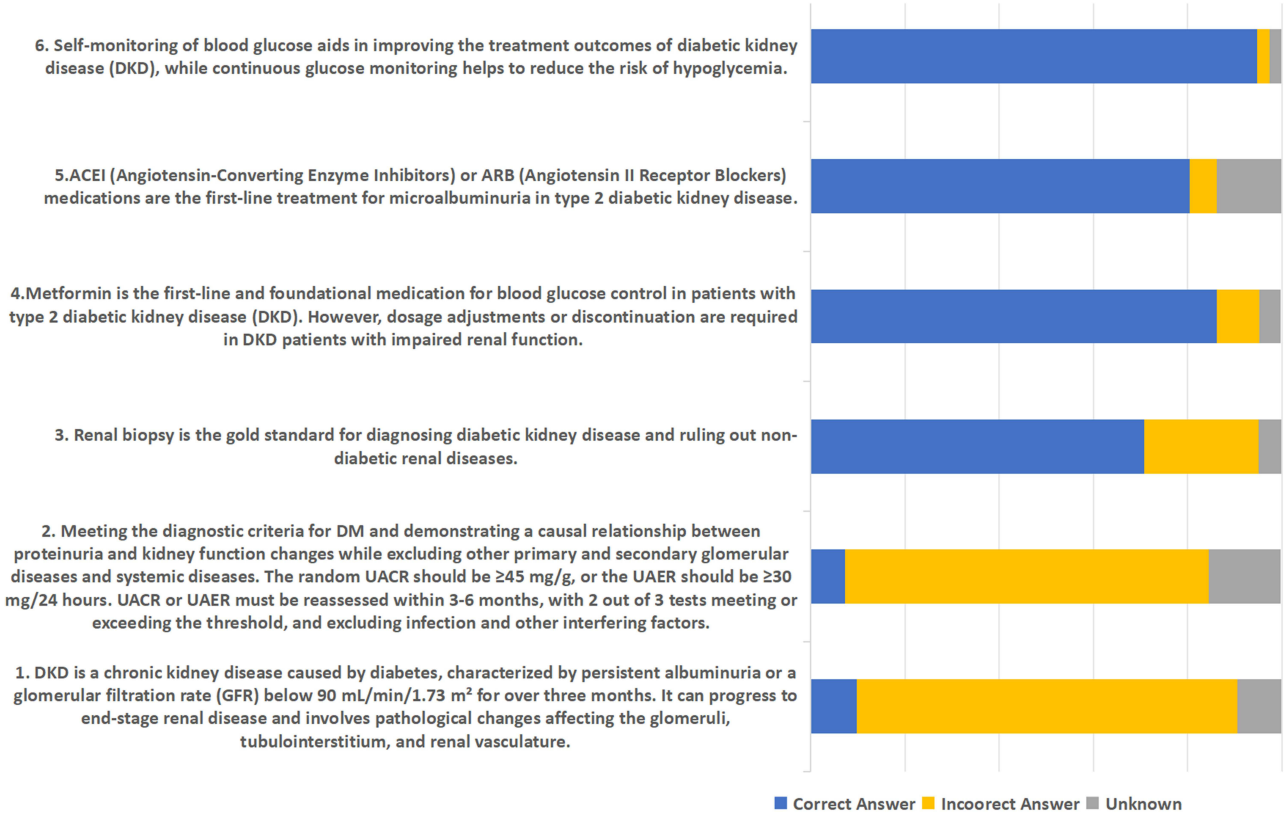

Figure 1 Scores of nurses' knowledge of DKD disease management. Presents the assessment of nurses' knowledge regarding the management of DKD, as indicated by their responses to a series of statements. Blue bars represent the percentage of correct answers ("True"), yellow bars indicate incorrect responses ("False"), and grey bars denote instances where participants selected "Do not Know". The statements cover various aspects of DKD, including clinical definitions, diagnostic criteria, treatment options, and monitoring practices. This visualization highlights areas where knowledge is strong as well as topics that may require further education and training within the nursing community.

the item "Blood uric acid level can be used as a predictor of renal function decline in patients with T2DKD" (see Figure 4).

Attitude Score

Respondents achieving a score at or above the mean (≥ 86.2%) are deemed to possess a positive attitude toward DKD management; otherwise, they are considered to hold a negative attitude. (See Supplementary Figure 2) This study shows that Chinese doctors hold a positive attitude towards DKD management, with a score of 16.8. A total of 93.5% of doctors agreed that "DKD is more likely to be complicated by diabetic vascular complications, making patients an extremely high-risk group for cardiovascular diseases and deaths". The overwhelming majority of doctors (91.3%) concurred that early referral to nephrology is imperative for DKD patients, while an even higher percentage (92.5%) emphasized the necessity of multidisciplinary diagnosis and treatment. (See Figure 5).

Practice Score

Respondents with a score at or above the mean (≥ 46.8%) are considered to have good practice; otherwise, they are considered to have poor practice (See Supplementary Figure 2). The mean score of doctors' practice on DKD management was 62.2, which is a high level. The scores of related items about DKD screening and referral suggestions were the highest, which shows that doctors have better practice behaviors in these two aspects. Regarding advice on dietary calorie intake, 11.6% of doctors said that they never or rarely provided advice to patients in this regard, indicating that their practical behavior was relatively insufficient, as shown in Figure 6.

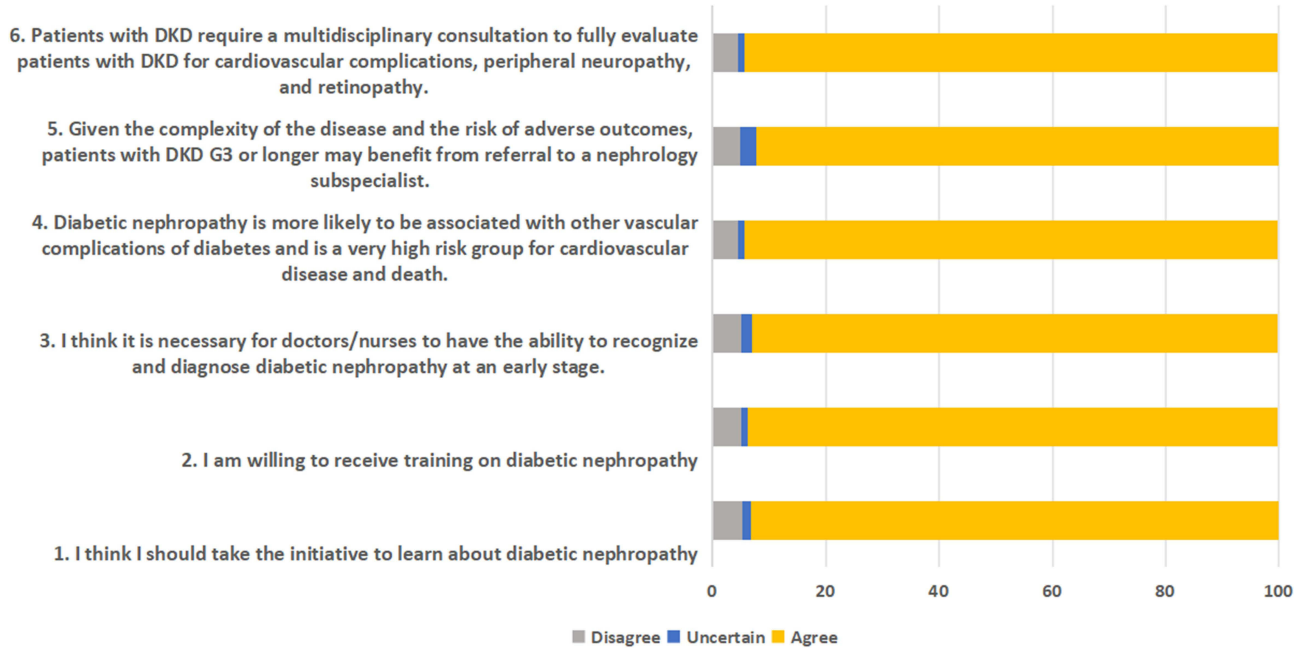

Figure 2 Scores of nurses' attitude of DKD disease management. Displays the scores reflecting nurses' attitudes towards the management of DKD. The bar graph quantifies the level of agreement (yellow bars), uncertainty (grey bars), and disagreement (blue bars) with a series of six statements concerning various aspects of DKD, from the need for multidisciplinary consultation to the willingness to receive and take initiative in training related to diabetic nephropathy. The percentage on the x-axis represents the proportion of respondents for each category, highlighting the overall positive attitude towards learning and managing DKD, as well as recognizing areas where there may be ambivalence or a need for increased awareness and education in the nursing profession.

The Practice Level and the Influencing Factors of Chinese Healthcare Workers

In this study, variables exhibiting a p-value of less than 0.2 in the univariate analysis were subsequently incorporated into the multivariable analysis. A binary logistic regression model was employed to delve into the associations between demographic factors and related variables, and the practice level of nurses and doctors in China. For Chinese nurse, the results indicate that both poor knowledge level (OR =0.63, 95% CI: 0.42–0.94) and having experience in further medical training in nephrology (OR=1.92, 95% CI: 1.20–3.08) are associated with the practice levels. For Chinese doctors, having not experience in further medical training in nephrology (OR=0.36, 95% CI: 0.15–0.83) are associated with their practice levels. The detailed results are shown in Tables 3 and 4.

Discussion

With the change in the disease spectrum, diabetes complicated by nephropathy or DKD has become the primary cause among hospitalized CKD patients in China.[30] For the ever-increasing large population of DKD patients, DKD will cause serious prognosis.[31,32] This underscores the urgent need for nephrology healthcare professionals to be well-versed in DKD management. Our study, the first of its kind in China, examines the KAP of nephrologists and nurses regarding DKD management.

Our findings reveal a significant knowledge gap in DKD management among healthcare professionals, with 60.3% of nurses and 53.6% of doctors demonstrating adequate knowledge. This aligns with Vigan et al's findings, which pointed out similar deficiencies in DKD understanding among general practitioners, particularly in defining and diagnosing DKD, as well as the importance of albuminuria in cardiovascular risk assessment and treatment modification for diabetic patients.[33] Albuminuria not only serves as a critical indicator for cardiovascular risk but also guides the necessity for customized anti-hyperglycemic therapy to prevent micro/macrovascular complications, underscoring its dual role in patient care and outcome improvement.[34]

The disparity in DKD diagnosis accuracy is alarming, as early and precise identification is crucial for effective intervention, key to managing disease progression and avoiding complications.[35] A comparative analysis revealed a discrepancy between laboratory-defined DKD prevalence and diagnoses recorded in electronic medical records,

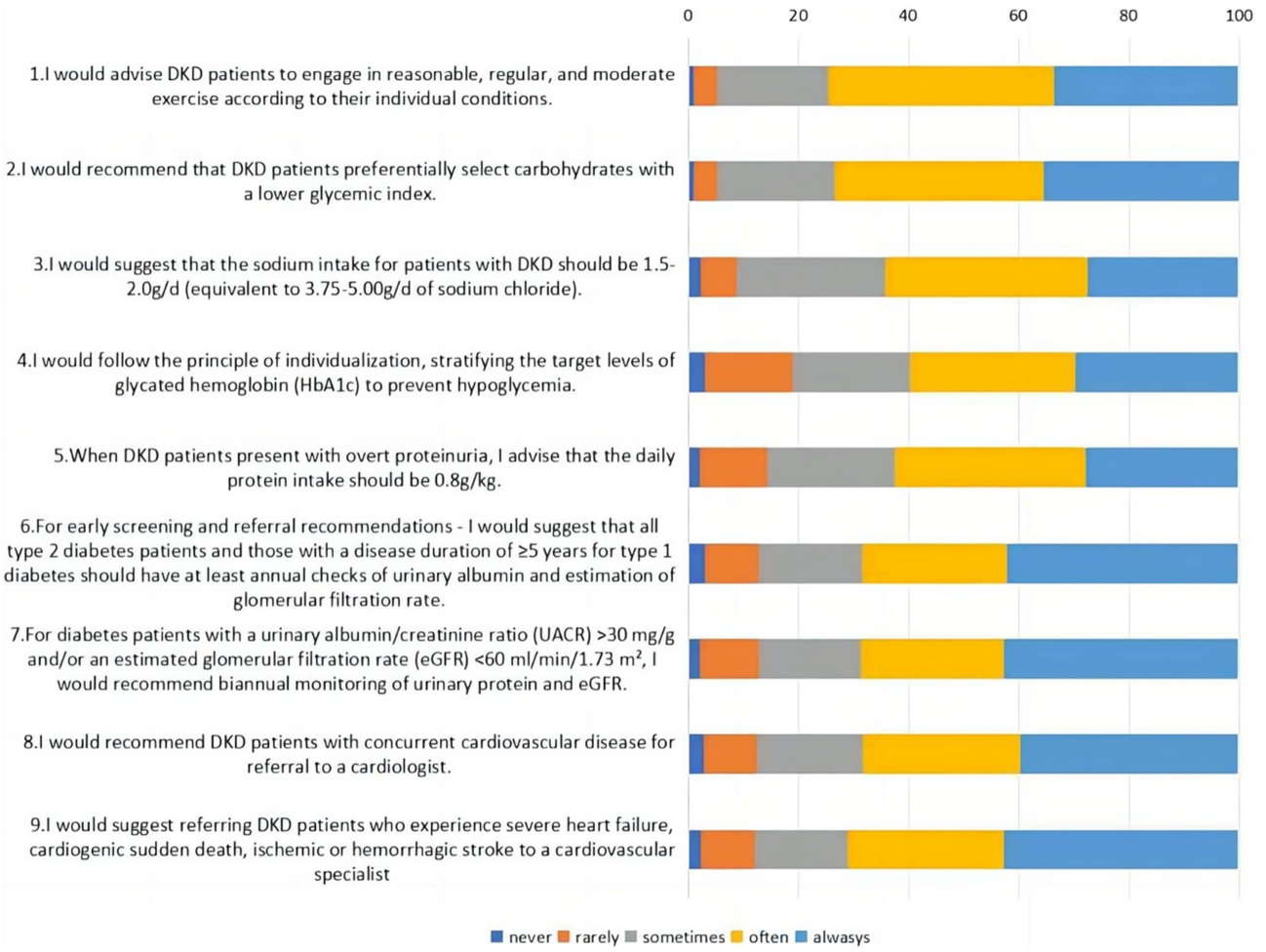

Figure 3 Scores of nurses' practice of DKD disease management. Illustrates the responses of nurses regarding their practices in managing DKD. The bar chart categorizes the frequency of certain practices, from "never" (dark blue) to "always" (Orange), based on a scale reflecting the regularity of specific management behaviors. These practices range from advising patients on exercise and dietary choices to following individualized principles for glycated hemoglobin levels and referring patients to a cardiologist for concurrent cardiovascular conditions. The chart provides insight into how often nurses implement various management strategies for DKD in their clinical routines, highlighting areas of strong adherence as well as potential gaps where practice may be improved.

highlighting a shortfall in healthcare providers' diagnostic capabilities.[36] The often asymptomatic nature of DKD until advanced stages necessitates routine screening for deteriorating kidney function and timely specialist referral. Emerging research on novel prognostic biomarkers offers hope for earlier identification of high-risk patients, potentially facilitating timely interventions to halt or slow DKD progression and its related complications.[37] Moreover, our study indicates a noticeable deficiency in physicians' proficiency regarding DKD pharmacological management, which could adversely affect treatment decisions. This observation echoes Hu et al's insights into the significant impact of nephrologists' knowledge on clinical decision-making, particularly concerning renal replacement therapies,[38] highlighting an urgent need for targeted educational programs to bridge these knowledge gaps and improve DKD management.

The KAP model underscores the link between comprehensive knowledge and the development of constructive attitudes and practices among healthcare professionals.[39] Continuous education in the most current clinical guidelines and treatments is crucial for equipping healthcare providers with the knowledge and skills necessary for effective DKD management. Prior research supports the significant influence of a positive attitude on the success of DKD treatment and overall healthcare delivery quality.[40,41] Our study highlights a notable discrepancy in attitudes towards DKD management between doctors and nurses, with nurses more uniformly agreeing on the importance of engaging in DKD education, the willingness to receive training, the necessity of collaborative care, the preventability of DKD with proper management, and the need for a comprehensive approach due to the disease's complexity.

Figure 4 Scores of doctors' knowledge of DKD disease management. Portrays the evaluation of doctors' knowledge pertaining to the management of DKD. The graph categorizes doctors' responses to a series of statements regarding DKD management practices into three responses: "True" (dark blue), "False" (yellow), and "Don"t Know' (light blue). The statements address various aspects of DKD, including clinical definition, diagnosis criteria, treatment options, and the significance of certain biomarkers in the management of the disease. The distribution of responses illustrates the level of awareness and understanding within the medical community about the best practices for managing DKD, highlighting the areas where knowledge is strong, as well as those where there may be some uncertainty or misinformation that needs to be addressed through further medical education and training.

Furthermore, this study sheds light on the distinct roles of nurses and doctors in DKD management. Nurses' direct patient care roles afford them practical DKD management knowledge through experiential learning, crucial for chronic disease management.[42] Conversely, the specialization of doctors might hinder their involvement in interdisciplinary efforts, particularly if their subspecialties do not align with DKD care, potentially affecting overall patient care quality.[43] The variance in disease management and patient education strategies between nurses and doctors is influenced by workload, institutional policies, and training level.[44] While nurses tend to support a holistic care model, doctors often focus on clinical decision-making. These observations underscore the necessity for improved interdisciplinary communication and collaboration, suggesting that better work conditions, reduced stress, and a supportive safety culture are key to aligning healthcare professionals' approaches for more effective patient care and disease management.[45,46]

In this study, over half of the nursing staff (53.4%) showed high proficiency in managing DKD, yet gaps were noted in lifestyle and dietary guidance, crucial for DKD care. This shortfall may stem from insufficient nutrition-focused education among nephrology professionals.[47] Integrating nutrition management into DKD training for nurses could significantly enhance patient care quality. Similarly, about 53.2% of physicians did not fully adhere to recommended pharmacotherapy guidelines, indicating a gap between practice and guidelines.[48,49] Improvements are needed in managing glycated hemoglobin and protein intake, areas vital for personalized home-based care. For physicians, enhancing skills in nutrition management, personalized treatment goals, and medication decisions is crucial. Incorporating these

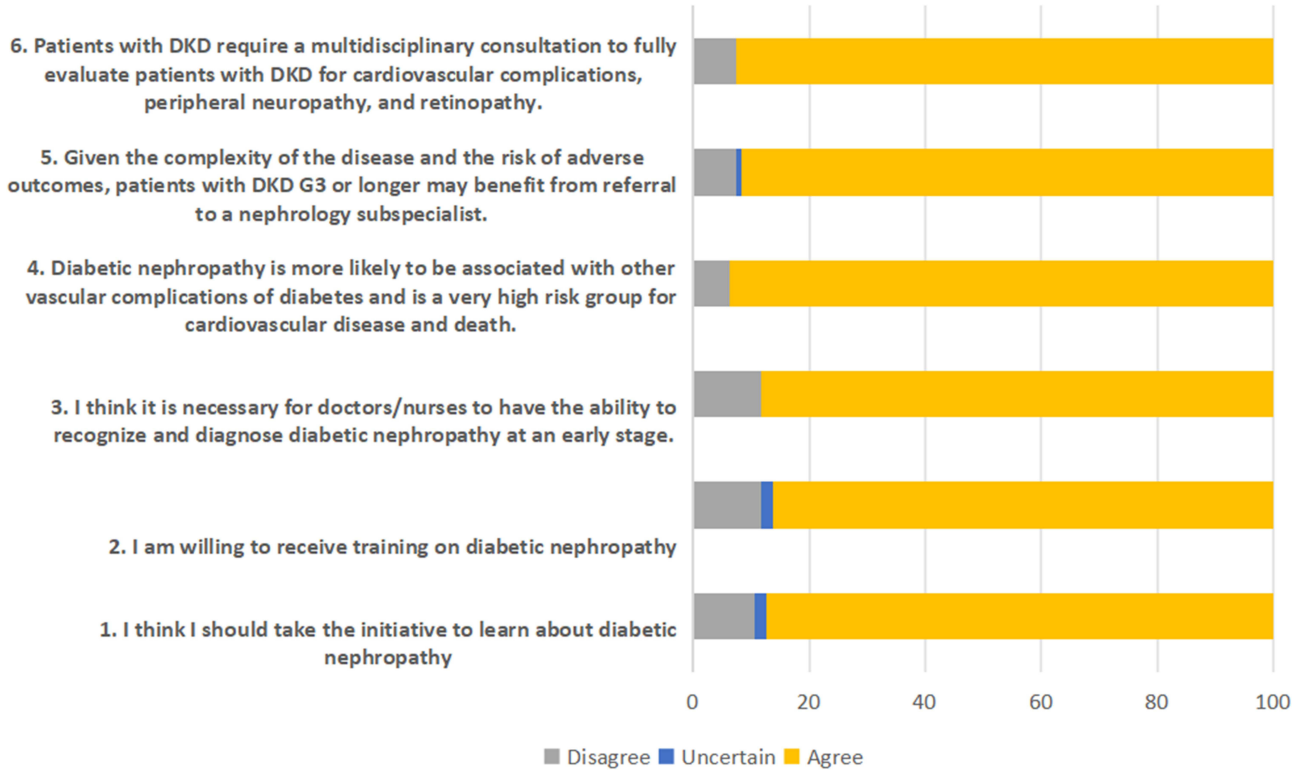

Figure 5 Scores of doctors' attitude of DKD disease management. Depicts the results of a survey evaluating doctors' attitudes toward the management of DKD. The horizontal bar graph represents doctors' levels of agreement (yellow bars), uncertainty (grey bars), and disagreement (blue bars) with a set of six statements concerning the necessity of multidisciplinary consultations, the importance of early diagnosis, the willingness to undergo training, and the perception of risk associated with diabetic nephropathy. The x-axis quantifies the percentage of responses, reflecting the medical professionals' consensus on each statement. This visualization offers insight into the medical community's readiness to engage with and address DKD, as well as the perceived value of specialized training and education in the effective management of this condition.

elements into educational programs for both nurses and physicians could strengthen their ability to provide evidence-based, guideline-aligned care.

In this study, nurses exhibit a correlation between practice levels and knowledge level, aligning with research findings by Hu and Muna et al[38,50] Educational interventions significantly boost nurses' knowledge and application, especially in evidence-based care and specific health domains.[51] This study's findings highlight a crucial link between nurses' understanding and their DKD management practices. Therefore, exploring workshops, seminars, online modules, e-learning, and clinical mentorship focused on DKD management as future research directions is essential.[52–54] These approaches could be key in elevating nurses' proficiency in DKD care. Ineffective dietary and exercise practices, conservative management strategies, limited resources, and inadequate healthcare systems contribute to the necessity for intensified treatment in DKD patients with comorbidities. Addressing these patients' complex health requirements demands a holistic approach, urging nephrology healthcare providers to improve practical skills and overcome therapeutic inertia.[5,42] Furthermore, binary logistic regression analysis reveals that both physicians and nurses with additional medical training in nephrology significantly associate with higher practice levels. However, in Chinese hospitals, access to advanced specialized training is often limited.[55] To overcome these challenges, healthcare institution managers should prioritize specialized training for medical personnel. Thus, the study highlights the need for an integrated approach that considers the unique perspectives and contributions of both doctors and nurses in the realm of DKD management, aiming to bridge the gap in clinical practice for optimized patient outcomes.

There are still some limitations in this study. First, since the respondents are mainly from the nephrology department of China's tertiary hospitals, the ability to generalize the conclusions is limited, especially for primary healthcare institutions. Secondly, the KAP questionnaire used in this study is self-reported and subjective, potentially susceptible to social desirability bias (the tendency of research subjects to provide socially desirable responses rather than genuine

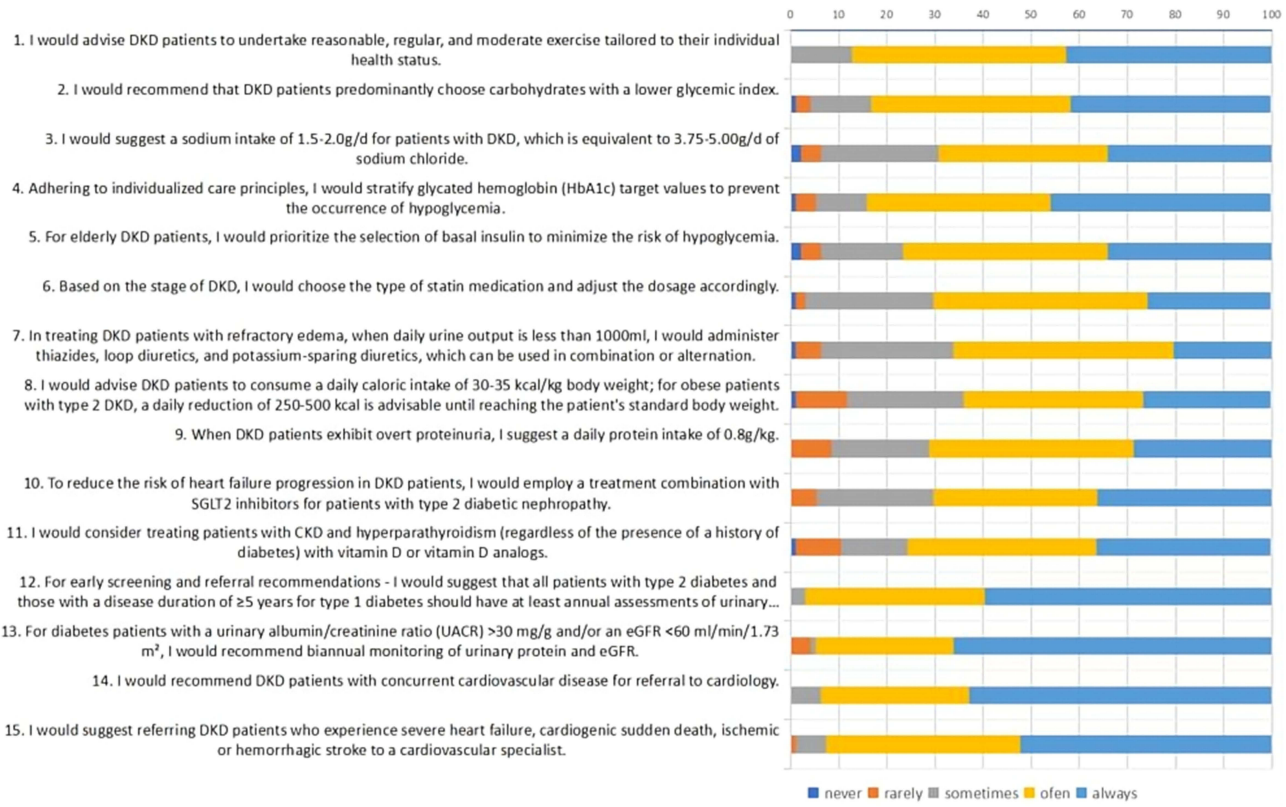

Figure 6 Scores of doctors' practice of DKD disease management. Presents a graphical representation of doctors' reported practices in the management of DKD, as outlined in a survey of various clinical approaches. The bar graph delineates the frequency at which doctors engage in specific management strategies, ranging from "never" (dark blue) to "always" (Orange). The survey covers recommendations on exercise, diet, medication adjustments based on DKD stage, treatments for complications, and referral practices to specialists. Responses to these statements are quantified on the x-axis, demonstrating the prevalence of these practices among doctors and providing insights into how current guidelines are being applied in the clinical setting for the management of DKD.

ones).[56] Finally, the sampling of this study is not randomized and most were from Central-Western China, which leads to the possibility that some eligible subjects may not have been able to participate, thus limiting the general applicability of the research results.

In conclusion, Chinese doctors and nurses in this study generally held positive attitudes towards DKD management, but their knowledge and practical application levels were relatively low. This highlights a significant gap in achieving ideal DKD management among the respondents. Notably, nurses' knowledge levels influenced their DKD management practices. Additionally, healthcare providers with extra nephrology training demonstrated higher levels of engagement in DKD management. To enhance patient care, it is recommended to provide additional training for nephrology healthcare professionals and address any knowledge and practice disparities.

Table 3 The Associations Between Influencing Factors and Practice Level of Chinese Nurses in DKD Disease Management (n=436)

	p	OR	95% CI	
			Lower	Upper
Knowledge level	Reference			
Knowledge level (poor)	0.02	0.63	0.426	0.93
Have any experience in further medical training in nephrology (No)	Reference			
Have any experience in further medical training in nephrology (Yes)	0.01	1.922	1.20	3.079
Constant	0.18	1.198		

Abbreviations: OR, odds radio; CI, confidence interval.

Table 4 The Associations Between Influencing Factors and Practice Level of Chinese Doctors in DKD Disease Management(n=94)

	p	OR	95% CI	
			Lower	Upper
Have any experience in further medical training in nephrology (Yes)	Reference			
Have any experience in further medical training in nephrology (No)	0.02	0.36	0.15	0.83
Constant	0.04	4.23		

Abbreviations: OR, odds radio; CI, confidence interval.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics and Consent Statement

Approval of the research protocol: The study was approved by the Biomedical Ethics Review Committee of West China Hospital, Sichuan University (protocol code 2023(2054)).

Informed Consent: Written informed consent was obtained from all participants.

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Disclosure

The authors declare no conflicts of interest in this work.

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