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Study on the status and countermeasures of disease self-management ability in chronic kidney disease patients in cold regions

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Abstract

Objective: Effective Chronic Kidney Disease (CKD) management is particularly important in cold regions of China, where climate and lifestyle factors play significant roles. However, there is a lack of relevant studies in this area. Therefore, the purpose of this study was: (1) to assess the status of self-management capacity in individuals with CKD in cold regions of China and analyze the factors influencing it; (2) to identify strategies to improve CKD management in primary care settings in these regions; and (3) to understand patients' attitudes toward eHealth services. **Methods:** This was a regional, cross-sectional observational study. A questionnaire measuring CKD patients' self-management abilities was derived from the Perceived Kidney Disease Self-Management Scale, the Kidney Disease Behavioral Inventory (KDBI), and the Health Literacy Questionnaire. Data were collected from hospitalized CKD patients in Heilongjiang Province and analyzed using One-Way Analysis of Variance (ANOVA), Hierarchical Regression Analysis, and K-prototype cluster analysis. **Results:** A total of 957 participants were tested. Of these, 70.64% had less than a bachelor's degree, and 56.27% had been diagnosed with hypertensive or diabetic nephropathy. The KDBI scale showed a lower overall score compared to the PKDSMS. Factors such as CKD stage 4 (F = 2.367, P = 0.042), last year's medical expenses (F = 3.974, P = 0.004), and poor self-rated health (F = 33.352, P < 0.01) were found to influence scores on both scales. The health literacy questionnaire revealed significant differences (P < 0.01) in health knowledge, except by sex. Additionally, healthcare expenditures and poor self-rated health were negatively associated with self-management capacity. **Conclusion:** This study provides valuable insights into the self-management challenges faced by CKD patients in cold regions of China. Despite some difficulties in improving self-management, patients showed positive attitudes toward enhancing CKD management services in primary care and developing digital management tools. These findings offer useful references and recommendations for future clinical practice and research in this field.

Keywords

chronic kidney disease; self-management capacity; cross-sectional observational research; frigid regions

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1 Introduction

Chronic kidney disease (CKD), defined as persistent abnormalities in kidney structure or function for more than 3 months, with implications for health[1], affects more than 10% of the global population[2]. The diagnosis of CKD is based on the chronicity criterion, and the majority of cases are irreversible. As CKD progresses, the risk of comorbidities (*e.g.*, hypertension, diabetes, cardiovascular disease[3]) increases, alongside the potential for evolving into end-stage kidney disease (ESKD). This ultimately leads to a reduced quality of life[4], a higher economic burden, and potentially a threat to patients' lives. By 2040, CKD is predicted to be the fifth leading global cause of death[5]. In China, although the prevalence of CKD in adults decreased from 10.8% in 2009 to 8.2%[6], the country remains

one of two where nearly one-third of the world's CKD patients reside[7] (the other country is India).

A growing body of evidence suggests that efficient self-management of chronic diseases is directly associated with the reduction of unnecessary healthcare expenditures and the improvement of health outcomes[8]. The American Journal of Kidney Diseases identified the self-management of CKD as a priority research topic over the past decade[9]. Despite multiple studies and targeted efforts, self-management among CKD patients remains suboptimal[10]. In China, the awareness rate of CKD is less than 10%[6]. "Self-management" is a multifaceted concept, defined as a range of behaviors through which patients manage the development of their illness[11]. Patients' capacity for CKD self-management is closely linked to their beliefs about managing the condition, their ability to access health information and make informed decisions, and ultimately, their ability to implement these management techniques.

In addition to patients' inherent factors, environmental factors play a significant role in CKD self-management. The frigid zone encompasses approximately 43.5% of China's geographical area[12]. In 2019, China accounted for the highest number of CKD-related deaths due to hypothermia worldwide[13]. Furthermore, previous research has shown a correlation between CKD progression and factors such as diet, alcohol use, cigarette smoking, air pollution, and other elements in cold regions[14]. Unfortunately, patients in cold regions have not received sufficient attention regarding how to manage these variables, which contribute to the development of CKD. The lack of relevant data has hindered the provision of therapy and support for CKD patients.

Social support can address the practical requirements of individuals with CKD[15]. However, studies commonly emphasized the contributions of emotional support from family and friends or medical assistance from nephrologists, while the role of general practitioners as first responders to health support appears to have been overlooked. The advancement of digital health technology warrants further exploration of the potential benefits of integrating electronic health (eHealth) with primary health care to improve CKD management[16]. This study aimed to (1) investigate the current state of self-management behaviors among individuals with CKD in cold regions of China and explore the influence of various factors; (2) identify key areas for primary health care services in cold regions to enhance CKD management; and (3) recognize patients' attitudes toward eHealth services, thereby providing support and direction for the digital management of CKD in cold regions.

2 Materials and Methods

2.1 Study design and data source

This study was a cross-sectional survey, and both the survey process and result reporting strictly adhered to the guidelines for observational studies in enhanced epidemiology (Appendix 1)[17]. Study participants were recruited in December 2024 from 49 hospitals across Heilongjiang Province. These hospitals were located in regions covering most of central, northern, and eastern Heilongjiang, including five principal cities and their subordinate counties: Harbin (the provincial capital in the central region), Qiqihar (in the northwest), Daqing (in the central north), Mudanjiang (in the southeast), and Jiamusi (in the east).

The inclusion criteria were: (1) patients with CKD who had received a physician-confirmed diagnosis at least one month prior, (2) aged 18 years or older, and (3) able to understand and acknowledge their condition. Exclusion criteria included patients with significant restrictions in daily mobility who were unable to care for themselves, as well as those with impaired comprehension, psychiatric symptoms, altered consciousness, communication disorders, or uremic encephalopathy.

Patients were invited to participate in the survey by scanning a QR code provided by their attending physician during their hospital visit. The questionnaire was hosted on "Wenjuanxing", and patients could only proceed after reviewing the study's objectives and methodology and clicking "Agree". Patients were encouraged to ask their healthcare providers any questions about their condition during the process to ensure accurate completion of the questionnaire.

2.2 Data collection instrument

The questionnaire for this study consisted of five sections (Appendix 2). It included 10 socio-demographic items and 31 questions related to CKD self-management. The socio-demographic section collected basic information, including age, sex, education level, disease severity (CKD stage and type), and self-evaluation of health status.

Perceived competence was assessed using the Perceived Kidney Disease Self-Management Scale (PKDSMS), a validated 8-item instrument rated on a scale from 1 to 5[18]. The Cronbach's α for the PKDSMS in CKD patients was 0.83. The Brief Health Literacy Scale (BHLS)[19], which uses a 5-point response format, consisted of three items. To gain further insights into patients' health literacy, we adapted the original scale into a multiple-choice questionnaire and added an item: "Before being diagnosed with chronic kidney disease, had you heard of this condition?"

The Kidney Disease Behaviors Inventory (KDBI) is a 16-item instrument derived from the Summary of Diabetes Self-Care Activities. It evaluates self-care activities such as health record maintenance, adherence to healthcare protocols, and life planning, on a scale from 1 to 5. The Cronbach's α for the KDBI scale in CKD patients was 0.69[20]. Given that the climate in cold regions (*e.g.*, increased occurrences of low temperatures, fine particulate matter [PM2.5], *etc.*) affects the health of CKD patients[21], we added "I pay attention to weather changes every day" as one of the self-care criteria.

Lastly, we included three multiple-choice questions to assess CKD patients' acceptance of regular CKD management in primary care and their willingness to use a smartphone app for disease management.

2.3 Statistical Analysis

Statistical analysis was performed using SPSS (Statistics 27, IBM Corporation, Armonk, United States) and R (4.4.1, R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were used to summarize the data: variables with a normal distribution were expressed as mean ± standard deviation, while categorical variables were represented by frequency and percentage. Skewness and kurtosis tests were applied to verify the normal distribution of the data. Independent samples *t*-tests or one-way ANOVA[22] were used to analyze differences in socio-demographic data when assumptions of normality and homogeneity of variance were met. In cases where these assumptions were violated, Welch ANOVA was used, and differences in categorical data were assessed using the chi-square test[23], with $P < 0.05$ considered statistically significant. Hierarchical regression analysis and multinomial logistic regression were used to identify factors influencing patient self-management. The Patient Self-Management Scale and Question 3 of the Health Literacy Questionnaire were analyzed using cluster analysis. Cross-covariance was used to investigate the need for primary care services and mobile app usage across different patient groups.

3 Results

3.1 Characteristics

A total of 1791 individuals were invited to participate in the survey, of whom 1785 accepted the invitation and 6 declined. To minimize data bias resulting from careless or incomplete responses and to enhance sample representativeness, we excluded questionnaires with response times of less than 300 seconds. The remaining 957 questionnaires were included in the analysis, yielding an inclusion rate of 53.61%. Table 1 presents the demographic characteristics of the sample. Of the participants, 55.07% were male, and 70.64% had an education level below college. More than 50% of the participants were diagnosed with hypertensive nephropathy or diabetic nephropathy, as shown in the table. Additionally, 51.62% of patients rated their health status as "very good" or "good" in the self-assessment of health.

3.2 Self-management of CKD patients

Table 2, 3 and 4 presents the detailed scores for self-management behaviors among patients with CKD. The first subscale, the Perceived Kidney Disease Self-Management Scale (PKDSMS), had a Cronbach's alpha of 0.662 and a Kaiser-Meyer-Olkin (KMO) value of 0.819, indicating good reliability. The kurtosis (0.787) and skewness (0.670) of the data suggest an approximately normal distribution. The statement "I am actively involved in my CKD (dialysis) management and have achieved some results" had the highest mean score (4.097 ± 1.029) after reverse scoring. In contrast, the statement "No matter how hard I try, it seems difficult to control my CKD (dialysis) as I would like" had the lowest mean score.

In the health literacy questionnaire, 37.62% of respondents reported a high response rate, while 54.75% indicated that the hospital's materials contained too many professional terms that were difficult to understand. Since their CKD diagnosis, 68.97% of patients showed a high motivation to seek health information, but only 26.33% felt confident in assessing whether the information was relevant to their condition. Furthermore, 337 participants (35.21%) reported that they had never heard of CKD before their diagnosis.

The final section of the scale, the Kidney Disease Behaviors Inventory (KDBI), also demonstrated good reliability and a normal distribution. The highest score was for the item "I miss dialysis treatments" (4.613 ± 0.741), reflecting better performance on this aspect after reverse scoring. Conversely, patients scored relatively poorly on exercise-related behaviors (3.259 ± 1.294). There remains significant room for improvement in areas such as dietary management, weather awareness, weight monitoring, and medication adherence.

3.3 Differences in demographic profiles of self-management in patients with CKD

The results from Table 5 and 6 suggest that patients with CKD stage 4 ($F = 2.367$, $P = 0.042$), healthcare costs ranging from RMB 10,000 to RMB 30,000 in the past year ($F = 3.974$, $P = 0.004$), poor or very poor self-assessed health ($F = 33.352$, $P < 0.01$), and those with diabetic nephropathy ($F = 10.141$, $P < 0.01$) demonstrated poorer perceived disease self-management. Patients who were unaware of their CKD stage ($F = 2.622$, $P = 0.023$) and those with

Table 1 Demographic characteristics and clinical characteristics of the study samples

Characteristic	Number (*N*)	Percent (%)	Characteristic	Number (*N*)	Percent (%)
Sex			CKD Cost, RMB		
Male	527	55.07	≤ 5000	131	13.69
Female	430	44.93	5000-9000	151	15.78
Education background			10,000-29,999	298	31.14
Junior high school or below	378	39.50	30,000-49,999	139	14.52
High school or vocational school	298	31.14	≥ 50,000	238	24.87
Bachelor's degree or associate degree	268	28.00	Basic health insurance type		
Master's degree or above	13	1.36	Urban employee basic medical insurance	584	61.02
CKD stage			Urban and rural resident basic medical insurance	205	21.42
1 (eGFR > 90mL/[min·1.73m^2])	72	7.52	New rural cooperative medical insurance	128	13.38
2 (eGFR 60-89mL/[min·1.73m^2])	51	5.33	Other	40	4.18
3 (eGFR = 30–60 mL/[min·1.73m^2])	59	6.17	Self-Rated Health		
4 (eGFR < 30 mL/[min·1.73m^2])	38	3.97	Very good	208	21.73
5 (eGFR < 15mL/[min·1.73m^2])/(Uremic stage)	631	65.94	Good	286	29.89
Uncertain	106	11.08	Fair	305	31.87
CKD duration, years			Poor	130	13.58
< 1	144	15.05	Very poor	28	2.93
1-3 (Including 1)	242	25.29	CKD type		
3-5 (Including 3)	175	18.29	Diabetic Nephropathy	238	24.87
5-10 (Including 5)	193	20.17	Hypertensive Nephropathy	266	27.80
≥ 10	203	21.21	Glomerulonephritis	187	19.54
Kidney replacement therapy duration (dialysis or transplant), years			Tubulointerstitial Disease	20	2.09
No replacement treatment	272	28.42	Hereditary kidney Disease	48	5.02
< 1	151	15.78	Renal Vascular Disease	4	0.42
1-3 (Including 1)	238	24.87	Autoimmune Disease-related Kidney Disease	20	2.09
3-5 (Including 3)	104	10.87	Infectious Kidney Disease	9	0.94
5-10 (Including 5)	136	14.21	Tumor-related Kidney Disease	12	1.25
≥ 10	56	5.85	Other	153	15.99

Table 2 Scores for each questionnaire on self-management in CKD patients

PKDSMS Item	M	SD
*It is difficult for me to find effective solutions for problems that occur with my kidney disease (dialysis).	2.550	1.436
*I find efforts to change things I donn't like about my kidney disease (dialysis) are ineffective.	2.652	1.442
I handle myself well with respect to my kidney disease (dialysis).	3.955	1.101
I am able to manage things related to my kidney disease (dialysis) as well as most other people.	4.086	1.051
I succeed in the projects I undertake to manage my kidney disease (dialysis).	4.097	1.029
*Typically, my plans for managing my kidney disease (dialysis) don't work out well.	2.683	1.349
*No matter how hard I try, managing my kidney disease (dialysis) doesn't turn out the way I would like.	2.735	1.403
I am generally able to accomplish my goals with respect to managing my kidney disease (dialysis).	3.811	1.147

* = Item reverse-scored. Cronbach's α = 0.062, KMO = 0.819.

Table 3 The health literacy questionnaire score

Health literacy questionnaire Item (Multiple Choice Question)	Response		Prevalence Rate (%)
	Number (*N*)	Response Rate (%)	
1. When reading written materials such as health manuals and drug instructions related to chronic kidney disease provided by hospitals or pharmacies, have you encountered the following situations?			
I found the text too small and it was very difficult to read.	489	35.10	51.10
I felt that there were too many professional terms and the content was complicated and difficult to understand.	524	37.62	54.75
I needed someone to help me read or interpret the content.	380	27.28	39.71

Continued

Table 3 Continued

Health literacy questionnaire Item (Multiple Choice Question)	Response		Prevalence Rate (%)
	Number (*N*)	Response Rate (%)	
I was able to extract the content I needed from the information I collected.	501	20.59	52.35
I understood the CKD information I obtained.	221	9.08	23.09
I have conveyed my views and understanding of chronic kidney disease to others (doctors, patients, relatives and friends).	448	18.41	46.81
I applied the information about chronic kidney disease (life, diet, etc.) I obtained to my daily life.	603	24.78	63.01

Table 4 The status of self-management behaviors among CKD patients

KDBI Item	M	SD
Checked your blood pressure at home	4.051	0.973
Checked your weight changes	4.175	0.943
Monitored weather changes	4.069	1.002
Kept track of laboratory results related to your kidney disease	4.186	0.957
Kept track of symptoms related to your kidney disease	4.083	1.015
Kept track of thoughts and feelings about your health	3.524	1.205
Taken medications as prescribed	4.575	0.719
*Taken a medication in different ways than prescribed	3.664	1.337
*Not taken a prescribed medication	3.841	0.976
Taken herbs, non-prescribed vitamins, or other natural remedies	1.964	1.169
Followed your kidney diet plan	3.962	0.970
Chosen healthier food to eat	4.109	0.974
Exercised for more than 60 minutes each week	3.259	1.294
Taken time to unwind and feel better	3.340	1.213
*Missed dialysis treatments	4.613	0.741
*Missed visits with your doctor	4.391	0.911

* = Item reverse-scored, Cronbach's α = 0.786, KMO = 0.839.

Table 5 Analysis of variation between participant characteristics and PKDSMS

Item	M ± SD	t/F	*P*
Sex		-1.443	0.149
Male (*N* = 527)	3.29 ± 0.68		
Female (*N* = 430)	3.36 ± 0.69		
Education background		2.001	0.112
Junior high school or below (*N* = 378)	3.27 ± 0.66		
High school or vocational school (*N* = 298)	3.30 ± 0.68		
Bachelor's degree or associate degree (*N* = 268)	3.40 ± 0.72		
Master's degree or above (*N* = 13)	3.41 ± 0.57		
CKD stage		2.367	0.042
1 (eGFR > 90mL/[min·1.73m^2]) (*N* = 72)	3.38 ± 0.76		
2 (eGFR = 60-89mL/[min·1.73m^2]) (*N* = 51)	3.46 ± 0.78		
3 (eGFR = 30-60 mL/[min·1.73m^2]) (*N* = 59)	3.25 ± 0.63		
4 (eGFR < 30 mL/[min·1.73m^2]) (*N* = 38)	3.05 ± 0.55		
5 (eGFR < 15mL/[min·1.73m^2])/(Uremic stage) (*N* = 631)	3.33 ± 0.69		
Uncertain (v106)	3.33 ± 0.62		
CKD duration, years		2.179	0.069
< 1 (*N* = 144)	3.35 ± 0.59		
1-3 (Including 1) (*N* = 242)	3.28 ± 0.71		
3-5 (Including 3) (*N* = 175)	3.26 ± 0.70		
5-10 (Including 5) (*N* = 193)	3.29 ± 0.70		
≥ 10 (*N* = 203)	3.44 ± 0.68		

Continued

Table 5 Continued

Item	M ± SD	t/F	*P*
Kidney replacement therapy duration (dialysis or transplant), years		0.899	0.481
No replacement treatment (*N* = 272)	3.30 ± 0.67		
< 1 (*N* = 151)	3.30 ± 0.67		
1-3 (Including 1) (*N* = 238)	3.31 ± 0.69		
3-5 (Including 3) (*N* = 104)	3.31 ± 0.69		
5-10 (Including 5) (*N* = 136)	3.33 ± 0.72		
≥ 10 (*N* = 56)	3.50 ± 0.67		
CKD Cost, RMB		3.974	0.004
≤ 5000 (*N* = 131)	3.48 ± 0.69		
500-9000 (*N* = 151)	3.43 ± 0.73		
10,000-29,999 (*N* = 298)	3.24 ± 0.64		
30,000-49,999 (*N* = 139)	3.29 ± 0.71		
≥ 50,000 (*N* = 238)	3.28 ± 0.68		
Basic health insurance type		2.328	0.077
Urban employee basic medical insurance (*N* = 584)	3.35 ± 0.71		
Urban and rural resident basic medical insurance (*N* = 205)	3.33 ± 0.66		
New rural cooperative medical insurance (*N* = 128)	3.20 ± 0.63		
Other (*N* = 40)	3.22 ± 0.58		
Self-Rated Health		33.352	< 0.010
Very good (*N* = 208)	3.59 ± 0.75		
Good (*N* = 286)	3.49 ± 0.65		
Fair (*N* = 305)	3.18 ± 0.58		
Poor (*N* = 130)	2.93 ± 0.55		
Very poor (*N* = 28)	2.92 ± 0.74		
CKD type		10.141	< 0.010
Diabetic Nephropathy (*N* = 238)	3.21 ± 0.66		
Hypertensive Nephropathy (*N* = 266)	3.33 ± 0.6		
Glomerulonephritis (*N* = 187)	3.33 ± 0.73		
Tubulointerstitial Disease (*N* = 20)	3.26 ± 0.64		
Hereditary kidney Disease (*N* = 48)	3.46 ± 0.63		
Renal Vascular Disease (*N* = 4)	2.97 ± 0.06		
Autoimmune Disease-related Kidney Disease (*N* = 20)	3.29 ± 0.90		
Infectious Kidney Disease (*N* = 9)	3.24 ± 0.55		
Tumor-related Kidney Disease (*N* = 12)	3.29 ± 0.37		
Other (*N* = 153)	3.45 ± 0.73		

$^{*}P < 0.05$, $^{**}P < 0.01$.

poorer self-assessed health ($F = 8.203$, $P < 0.01$) also had lower kidney disease behavior ratings. Health literacy scores showed significant differences across all demographic characteristics, except for sex (the text does not include results for this variable).

3.4 Determinants of self-management behavior in chronic kidney disease patients

Stratified regression analysis and categorical logistic regression (Table 7 and 8, details in Appendix 3) were used to examine the relationships among demographics, self-reported health status, illness categorization, disease duration, and self-management behavior. The results indicated that total medical costs in the previous year related to CKD and self-reported health status were major factors influencing health literacy (Multinomial Logistic Regression results not shown in the text). Medical costs had a negative effect on PKDSMS ($B = -0.045$), meaning that higher medical costs were associated with lower PKDSMS scores ($\Delta R^2 = 0.019$). Additionally, patients' self-evaluation of their health status (average $B = -0.244$, poor $B = -0.314$, extremely poor $B = -0.243$) had a substantial impact on KDBI ($\Delta R^2 = 0.042$), while other variables showed negligible effects.

3.5 Examination of the demand for primary care and digital devices among patients with two classifications of CKD self-management levels

The KDBI and PKDSMS scores, along with the question "Before

Table 6 Analysis of variation between participant characteristics and KDBI

Item	M ± SD	t/F	*P*
Sex		-0.690	0.491
Male (*N* = 527)	3.85 ± 0.49		
Female (*N* = 430)	3.88 ± 0.53		
Education background		0.075	0.974
Junior high school or below (*N* = 378)	3.86 ± 0.51		
High school or vocational school (*N* = 298)	3.86 ± 0.53		
Bachelor's degree or associate degree (*N* = 268)	3.87 ± 0.49		
Master's degree or above (*N* = 13)	3.82 ± 0.29		
CKD stage		2.622	0.023*
1 (eGFR > 90mL/[min·1.73m^2]) (*N* = 72)	3.86 ± 0.48		
2 (eGFR = 60-89mL/[min·1.73m^2]) (*N* = 51)	3.93 ± 0.44		
3 (eGFR = 30–60 mL/[min·1.73m^2]) (*N* = 59)	3.96 ± 0.45		
4 (eGFR< 30 mL/[min·1.73m^2]) (*N* = 38)	3.79 ± 0.44		
5 (eGFR< 15mL/[min·1.73m^2])/(Uremic stage) (*N* = 631)	3.88 ± 0.50		
Uncertain (*N* = 106)	3.72 ± 0.60		
CKD duration, years		0.880	0.475
< 1 (*N* = 144)	3.82 ± 0.55		
1-3 (Including 1) (*N* = 242)	3.88 ± 0.50		
3-5 (Including 3) (*N* = 175)	3.88 ± 0.52		
5-10 (Including 5) (*N* = 193)	3.90 ± 0.48		
≥ 10 (*N* = 203)	3.82 ± 0.49		
Kidney replacement therapy duration (dialysis or transplant), years		1.554	0.170
No replacement treatment (*N* = 272)	3.83 ± 0.53		
< 1 (*N* = 151)	3.81 ± 0.48		
1-3 (Including 1) (*N* = 238)	3.93 ± 0.50		
3-5 (Including 3) (*N* = 104)	3.88 ± 0.46		
5-10 (Including 5) (*N* = 136)	3.89 ± 0.49		
≥ 10 (*N* = 56)	3.80 ± 0.59		
CKD Cost, RMB		0.204	0.936
≤ 5000 (*N* = 131)	3.84 ± 0.59		
5000-9000 (*N* = 151)	3.87 ± 0.51		
10,000-29,999 (*N* = 298)	3.85 ± 0.51		
30,000-49,999 (*N* = 139)	3.88 ± 0.47		
≥ 50,000 (*N* = 238)	3.88 ± 0.48		
Basic health insurance type		2.565	0.053
Urban employee basic medical insurance (*N* = 584)	3.89 ± 0.49		
Urban and rural resident basic medical insurance (*N* = 205)	3.85 ± 0.46		
New rural cooperative medical insurance (*N* = 128)	3.83 ± 0.56		
Other (*N* = 40)	3.67 ± 0.67		
Self-Rated Health		8.203	0**
Very good (*N* = 208)	3.98 ± 0.52		
Good (*N* = 286)	3.93 ± 0.49		
Fair (*N* = 305)	3.79 ± 0.50		
Poor (*N* = 130)	3.73 ± 0.47		
Very poor (*N* = 28)	3.80 ± 0.55		
CKD type		0.837	0.582
Diabetic Nephropathy (*N* = 238)	3.85 ± 0.50		
Hypertensive Nephropathy (*N* = 266)	3.88 ± 0.51		
Glomerulonephritis (*N* = 187)	3.85 ± 0.48		
Tubulointerstitial Disease (*N* = 20)	3.85 ± 0.49		
Hereditary kidney Disease (*N* = 48)	3.96 ± 0.35		
Renal Vascular Disease (*N* = 4)	3.63 ± 0.34		
Autoimmune Disease-related Kidney Disease (*N* = 20)	3.82 ± 0.64		
Infectious Kidney Disease (*N* = 9)	3.88 ± 0.32		
Tumor-related Kidney Disease (*N* = 12)	4.10 ± 0.48		
Other (*N* = 153)	3.82 ± 0.57		

*$P < 0.05$, **$P < 0.01$.

Table 7 Stratified regression analysis of factors influencing self-management on PKDSMS

Characteristics	Layer 1	Layer 2	Layer 3	Layer 4
	P	*P*	*P*	*P*
Sex	0.006			
Education Background				
CKD Cost, RMB				
Basic health insurance type				
CKD duration, years				
Kidney replacement therapy duration(dialysis or transplant), years				
Self-Rated Health				
CKD stage				
CKD type				
$\triangle R^2$	0.019	0.012	0.114	0.013

Different colours represent the layering of different items. For details, refer to Appendix 3.

Table 8 Stratified regression analysis of factors influencing self-management on KDBI

Characteristics	Layer 1	Layer 2	Layer 3	Layer 4
	P	*P*	*P*	*P*
Sex				
Education Background				
CKD Cost, RMB				
Basic health insurance type				
CKD duration, years				
Kidney replacement therapy duration (dialysis or transplant), years				
Self-Rated Health			*P* < 0.01	
CKD stage				
CKD type				
$\triangle R^2$	0.007	0.009	0.042	0.021

Different colours represent the layering of different items. For details, refer to Appendix 3.

being diagnosed with chronic kidney disease, had you heard of this condition?" were used as clustering variables. The optimal K value of 2 for clustering was determined based on the interpretability of the clusters, practical significance, and expert recommendations. Subsequently, K-prototype cluster analysis was performed, resulting in two clusters: one representing higher-level self-management and the other representing lower-level self-management, as shown in Fig. 1, Table 9, 10 and 11.

4 Discussion

This study provides significant evidence on the current state of self-management among CKD patients in cold areas, addressing the data gap for this specific demographic. We explored how demographic factors correlated with three self-management status questionnaires: the PKDSMS, health literacy, and KDBI. Additionally, we assessed the willingness of individuals with varying self-management levels to utilize regular CKD management services and mobile care options from primary care providers. The response rate of 99.67% not only reflects the representativeness of the sample but also underscores the positive attitudes of CKD patients towards this survey.

The statistical findings indicated that the male-to-female ratio of the survey sample closely mirrored that of the province, which enhancing the representativeness of the sample. Over 70% of the patients had not attained a college degree, validating the prior observation that "lower education is associated with a higher prevalence of CKD[6]". This may be attributed to individuals with higher educational attainment often having superior access to and comprehension of health information, hence increasing their likelihood of adopting healthy lifestyles to avoid CKD[24]. Although we did not observe significant differences in PKDSMS and KDBI scores based on education level, our findings reconfirm that patients with greater educational

Table 9 PKDSMS and KDBI Mean Scores in different clusters of patients

Clusters of patients	KDBI	PKDSMS
Higher level (*N* = 498)	4.20 ± 0.31	3.68 ± 0.68
Lower level (*N* = 459)	3.50 ± 0.42	2.93 ± 0.42
F	875.812	411.771
P	*P* < 0.01	*P* < 0.01

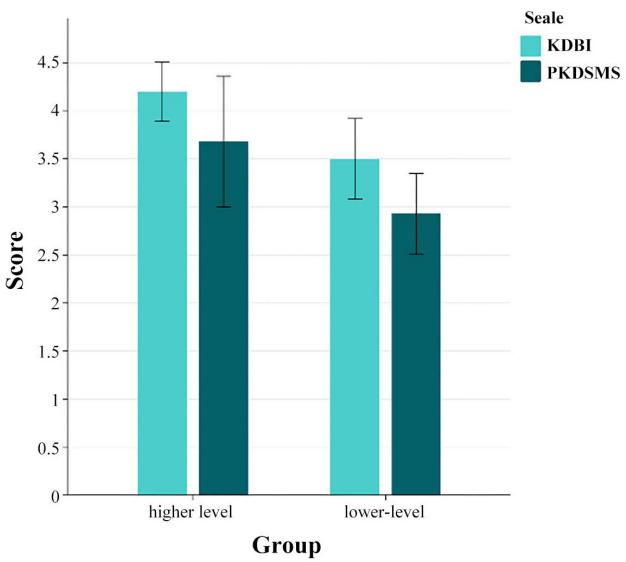

Fig. 1 PKDSMS and KDBI Mean Scores in different clusters of patients

attainment exhibited elevated health literacy in health literacy assessments. According to the 2023 Heilongjiang Provincial Statistical Bulletin on National Economic and Social Development, the per capita disposable income of permanent residents in the province was RMB 29,694. Although 61.02% of patients in our sample were covered by urban workers' basic health insurance, which offers higher reimbursement rates compared to other insurance types, 40% of patients reported

Table 10 Cross-covariance analysis for different clusters

Item	Higher Level	Lower Level	Total	χ^2	*P*
Willingness to receive CKD diagnosis and treatment at primary health care institutions				25.378	< 0.01
Very willing	181 (36.35)	113 (24.62)	294 (30.72)		
Willing	95 (19.08)	133 (28.98)	228 (23.82)		
Uncertain	88 (17.67)	105 (22.88)	193 (20.17)		
Unwilling	83 (16.67)	72 (15.69)	155 (16.20)		
Very unwilling	51 (10.24)	36 (7.84)	87 (9.09)		
Willingness to download and install a mobile health management application				36.942	< 0.01
Very willing	273 (54.82)	164 (35.73)	437 (45.66)		
Willing	131 (26.31)	167 (36.38)	298 (31.14)		
Uncertain	58 (11.65)	89 (19.39)	147 (15.36)		
Unwilling	16 (3.21)	15 (3.27)	31 (3.24)		
Very unwilling	20 (4.02)	24 (5.23)	44 (4.60)		

Table 11 Attitude of using smart device among CKD patients in frigid zone

Item	Response		Prevalence Rate (%)
	Number (*N*)	Response Rate (%)	
If you are willing to use the app, which features would you prioritize? (Multiple Choice question)			
Disease monitoring and alerting	702	25.25	73.35%
Health consultation and lifestyle guidance	674	24.24	70.43%
Medication reminders and management	565	20.32	59.04%
Appointment scheduling and queue management	461	16.58	48.17%
Education and training resources	295	10.61	30.83%
Other	83	2.99	8.67%
Total	2780	100	290.49%

that their healthcare expenditures for CKD in the previous year exceeded their disposable income. CKD patients in this region continue to endure a significant burden from the disease; thus, enhanced efforts are required to decelerate its progression and alleviate this burden. These findings also underscore the necessity for improvements within the healthcare insurance system. In cold regions, diabetic nephropathy and hypertensive nephropathy continue to represent a substantial segment of the population, consistent with prior findings[25]. The elevated prevalence rates correlate with dietary practices, lifestyle choices, environmental influences, and the quality of medical care in the area[26]. Therefore, interventions targeting these pertinent influencing factors should be prioritized in CKD management. The statistical findings revealed that the male-to-female ratio of the survey sample closely matched that of the province, enhancing the sample's representativeness. Over 70% of the patients had not attained a college degree, supporting previous observations that "lower education is associated with a higher prevalence of CKD[6]". This may be because individuals with higher education levels typically have better access to and comprehension of health information, which increases their likelihood of adopting healthier lifestyles to avoid CKD[24]. Although we did not observe significant differences in PKDSMS and KDBI scores based on education level, our findings reconfirm that patients with higher educational attainment demonstrated better health literacy.

According to the 2023 Heilongjiang Provincial Statistical Bulletin on National Economic and Social Development, the per capita disposable income of permanent residents in the province was RMB 29,694. Despite 61.02% of our patients being covered by urban workers' basic health insurance, which offers higher reimbursement rates, 40% of patients reported that their healthcare expenditures for CKD in the past year exceeded their disposable income. CKD patients in this region continue to bear a significant burden from the disease, highlighting the need for enhanced efforts to slow its progression and alleviate the economic strain. These findings also emphasize the importance of improving the healthcare insurance system. In cold regions, diabetic nephropathy and hypertensive nephropathy remain prevalent, consistent with prior studies[25]. The higher prevalence rates are influenced by dietary practices, lifestyle choices, environmental factors, and the quality of medical care in these areas[26]. Therefore, interventions targeting these key factors should be prioritized in CKD management.

PKDSMS helps assess patients' confidence in managing their disease and is a suitable instrument for evaluating self-efficacy in CKD patients. The overall rating for PKDSMS in our sample was relatively high, surpassing findings from a study conducted in Rawalpindi[27]. The majority of CKD patients in cold regions exhibited high confidence in managing their disease, though some

expressed frustration about their inability to effectively manage it. Patients with medical expenses between 10,000 RMB and 30,000 RMB in the past year and those with CKD stage 4 scored significantly lower on PKDSMS. This likely reflects diminished confidence due to the prolonged illness, its complexity, and financial strain. Stratified regression analysis also showed that healthcare costs directly influenced PKDSMS scores. Patients who rated their health as poor or very poor had lower PKDSMS scores, reflecting the physical and psychological limitations associated with poor self-rated health, which impair self-management abilities[28]. Progress is needed to restore CKD patients' confidence and improve their self-efficacy. Social support, including guidance from healthcare providers and encouragement from family, could improve self-care confidence[29].

Health literacy questionnaires effectively evaluate patients' ability to obtain, comprehend, and use health-related information[19]. Our study found that healthcare documents are often difficult for non-medical personnel to understand. This issue is likely to worsen as the population ages in Heilongjiang Province, a typical cold-region province[30]. Innovations in health science communication may improve this situation[31]. Despite a relatively low percentage of patients with favorable educational backgrounds able to independently collect health information and make decisions, most still rely on specialist guidance. However, when CKD patients are concentrated in tertiary hospitals, healthcare providers face tremendous pressure to meet patient needs. Thus, improving regular health management services in primary care settings is essential. It is also concerning that over one-third of patients were unaware of CKD prior to diagnosis. This highlights a significant gap in health education and CKD awareness in cold regions, suggesting that primary healthcare providers must implement innovative educational strategies to raise awareness of prevention and screening[32].

While CKD patients in cold regions scored "often" on the item "I pay attention to weather changes", their ratings for exercise and dietary programs were low. Reduced exercise may stem from the need to protect dialysis access sites in later-stage CKD or from adverse weather and hazardous road conditions typical of cold regions. Research shows that rehabilitative exercises[33] and low-sodium, low-protein diets[34] improve quality of life and reduce disability and mortality in CKD patients. However, managing these behaviors is more challenging in cold regions due to weather and lifestyle factors. Web-based and mobile technology, incorporating scheduling and reminders, may effectively increase participation in self-management[35]. Our findings indicated that patients with poor self-rated health had lower KDBI scores, and these scores were significantly impacted. When patients were grouped based on PKDSMS and KDBI scores, the total score for PKDSMS was much higher than for KDBI, even within the same group. From a cognitive-behavioral change perspective, much work remains to transition from improving CKD patients' management confidence to enabling them to apply their knowledge and actively manage their condition in cold regions.

Notably, while the group with superior self-management capacity showed more positivity towards primary care CKD management services and mobile app development, the group with inferior self-management capacity did not significantly reject these services. This aligns with findings from Kalaitzaki *et al.*[36]. Both groups emphasized condition monitoring and health counseling in the mobile app design[37]. These results are promising for future studies on optimizing CKD management services in primary care and app development. However, the difficulty older adults face in accessing primary care and using mobile phones presents a barrier to equitable healthcare access. Therefore, the development of effective monitoring and reminder devices for the elderly, particularly in the increasingly aging cold regions of China, requires further attention[38].

5 Limitations

This study provides a comprehensive analysis of the self-management capabilities of CKD patients in cold regions, exemplified by Heilongjiang Province. It offers valuable data and subsequent optimization strategies for the care of CKD patients in cold climates worldwide. However, certain limitations must be acknowledged. Firstly, despite efforts to increase the sample size, the findings derived from inpatient convenience sampling may be influenced by factors such as admission rate bias[39]. Future research should explore and compare data from various perspectives, including outpatient and community surveys, to validate and improve the reliability of the inpatient survey results. Additionally, the data were cross-sectional, preventing the determination of causality or directionality. Lastly, the assessment of self-management relied on patient self-reporting, which may lead to either an overestimation or underestimation of actual self-management capabilities[40].

6 Conclusions

This study provides an efficient method for gathering data on CKD self-management practices in cold regions. It also includes a comprehensive assessment of local patient approval of smart health management tools. Given that the disease burden of CKD in cold areas is exacerbated by the combined effects of environmental stressors and lifestyle factors, it is crucial for primary care providers to empower patients by rebuilding their confidence in health management through structured guidance and ongoing monitoring of self-care behaviors. With the innovation of health promotion strategies and the development of intelligent management and monitoring tools, we look forward to the imple-

mentation of more targeted, in-depth self-management interventions that address the specific influencing factors of CKD in cold regions. These efforts will bring hope to more CKD patients in high-latitude areas.

Acknowledgment

Not applicable.

Research ethics

This study was approved by the ethics committee of Second Affiliated Hospital, Harbin Medical University (approval code: KY2024-298).

Informed consent

All participants provided informed consent prior to inclusion in the study.

Author contributions

All authors read and approved the manuscript. Conception and design: Wei X R, Wang Y C. Questionnaire design and distribution: Wei X R, Li C L, Xu L L, Meng S W, Xing C. Data collection and analysis: Wei X R, Li C L, Yu H M. Article writing, literature review: Wei X R, Li C L. Article supervising: Wang Y C, Chang G M, Gao Q.

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None declared.

Conflict of interest

Wang Y C is an Editorial Board Member of Frigid Zone Medicine. The article was subject to the journal's standard procedures, with peer review handled independently of this Member and his research groups.

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Data availability

The datasets used and/or analyzed in the current study are available from the corresponding author upon reasonable request.

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