Development and Psychometrics Test of Home Blood Pressure Monitoring Perception Scale for Patients With Chronic Kidney Disease

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Research Article

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Abstract

Background: Home blood pressure monitoring (HBPM) has been proved to be beneficial to blood pressure control for both patients with hypertension and patients with chronic kidney disease (CKD). However, what are the psychodynamic predictors like perception for the establishment and persistence of HBPM have not been deeply explored, and there is a lack of instruments for assessing psychodynamic characteristics on HBPM from patients' perspectives, which has limited the in-depth understanding of HBPM behavior. The study aimed to develop an instrument for evaluating HBPM perception in patients with CKD, and to test the reliability and validity of the instrument.

Methods: The original item pool of the HBPM perception scale was developed according to the framework of the health promotion model and literature review. The psychometric characteristics of the instrument were examined with a sample of 436 CKD patients in China. Internal consistency reliability, split-half reliability, test-retest reliability and construct reliability were used to verify the reliability of the scale. And content validity, construct validity and criterion-related validity were used to test the validity of the scale.

Results: The expert consultation showed satisfactory content validity of the HBPM perception scale and produced a first draft of the survey with 43 items. By exploratory factor analysis and confirmatory factor analysis (CFA), we found evidence for the construct validity of the following factors: perceived benefits of HBPM, perceived barriers of HBPM, perceived self-efficacy of HBPM, situational influences and commitment to a plan of HBPM, and immediate competing demands and preferences. The finalized five-component HBPM perception scale has 27 items. CFA suggested the model fit the data well (χ^2=679.649, *df*=310, χ^2/*df*=2.192, root mean square error of approximation =0.074, confirmatory fit index=0.902). The HBPM perception scale was positively associated with the Self-Efficacy for Managing Chronic Disease 6-item Scale (r= 0.256, p<0.001). The Cronbach's α coefficient of all dimensions was above 0.750, the split-half reliability was above 0.624, and the test-retest reliability was above 0.749. The construct reliability of dimensions ranged from 0.749 to 0.951.

Conclusion Given reasonable psychometric properties, the HBPM perception scale is a valid and reliable instrument that can be used to assess the perception of HBPM.

Introduction

Chronic kidney disease (CKD), a group of diseases with chronic progressive deterioration of renal function and structure, with high morbidity, high mortality and high medical expenditure, has become a chronic non-communicable disease that seriously affects global public health. CKD has a high global prevalence of between 11–13%, with the majority stage 3[1]. The prevalence of CKD among Chinese adults is 10.8%, with an estimated 119.5 million CKD patients nationwide[2], and the prevalence of CKD in people over 45 years of age was 11.5%[3]. The results of the global burden of disease research program[4] showed that in 2013, 956,200 patients died of CKD worldwide, with a 1.34-fold increase since 1990. Cardiovascular events are the main cause of death of patients with CKD in the world, accounting for more than 60%[5]. Hypertension is the most common cardiovascular complication in patients with CKD. The prevalence of hypertension in patients with CKD in the United States was > 60%, and the prevalence of hypertension in patients with stage 3 and above was as high as 85.7% in the U.S.[6]. In China, the prevalence of hypertension in non-dialysis CKD patients is nearly 70%[7]. With the decline of renal function, the prevalence of hypertension in patients with CKD gradually increased, and was as high as 91% in CKD stage 5[7].

Hypertension is one of the major risk factors for the progression of CKD and cardiovascular disease. Blood pressure level and cardiovascular risk showed a continuous, independent and direct positive correlation[8]. Controlling blood pressure can reduce the risk of cardiovascular diseases such as atherosclerosis, heart failure, as well as cardiovascular events and vascular death [9]. Currently, patients' blood pressure is mainly controlled by medication treatment[10] and non-drug therapy [11] (such as no smoking, weight control, reduce mental stress). But blood pressure control in patients with CKD remains unsatisfactory. Literature reports that the control rate of hypertension in patients with CKD was 67.1% for the standard of blood pressure < 140/90mmHg, and 46.1% for the standard of blood pressure < 130/80mmHg in the U.S.[6]. In China, the control rate of blood pressure < 140/90mmHg in non-dialysis CKD patients was 33.1%, and the control rate of blood pressure < 130/80mmHg was only 14.1%[7]. In addition to antihypertensive drugs, how to help patients effectively establish the scientific lifestyle and related health promotion behaviors has become a key and urgent need to be addressed for non-drug therapy.

Blood pressure monitoring plays an essential role in the diagnosis, condition evaluation, curative effect evaluation and prognosis judgment of hypertension. Among them, home blood pressure monitoring (HBPM) has the advantages of strong practicability and maneuverability (simple operation, low cost, strong repeatability) [12,13], and its role in hypertension monitoring has been increasingly valued. At present, clinical practice guidelines in China[8], the United States[14], Japan[15], Europe[16] and other countries and regions recommend HBPM for hypertensive patients for efficacy evaluation of antihypertensive drugs. HBPM can effectively predict the risk of cardiovascular events, stroke and death in patients with hypertension[17]. Meanwhile, HBPM behavior can also be regarded as a health promotion behavior. Hypertensive patients with HBPM behavior have higher level of understanding of antihypertensive drugs, higher medication compliance, and more satisfactory blood pressure control[18,19].

Although HBPM has important value for CKD therapy, HBPM in patients with CKD has not been studied in-depth, and the subjects of the HBPM study are mainly hypertensive patients. In the hypertensive population, only about 50% had their blood pressure monitored at home[20]. Demographic factors, such as age, gender and education level have been identified associating with HBPM behavior of hypertensive patients in multiple studies[20–24]. From the patient's experiences, the main reasons for not measuring blood pressure at home include failing to recognize the benefits of HBPM[25], lacking skills to operate the device[25], having difficulty adhering to time limits for HBPM[26], and holding the belief that their blood pressure measured by themselves is not as accurate as the doctor's[27,28], which hinder patients to perform HBPM regularly. However, studies on the promotion and adherence of HBPM in CKD patients are not as rich as that in patients with hypertension. Therefore, it is very necessary to explore the psychodynamic mechanism and action process of HBPM in patients with CKD, so as to improve the adherence of HBPM for these patients. Moreover, studies have investigated patients' psychodynamic predictors to monitor home blood pressure mainly through single item questions[25,26,29], or interview patients for information[18,27,28,30]. The specific instruments to assess the psychodynamic predictors of patients' HBPM behavior is still lacking until now.

The health promotion model (HPM), as a comprehensive theoretical model, be able to identify complex biological, psychological and social processes associated with behavior change, and it can be used to explain various health promotion behaviors [31,32]. The model is composed of three groups of ten categories of factors that influence health behaviors, which includes personal characteristics and experiences (i.e., pre-related behaviors, personal factors), behavior-specific cognitions and affect (i.e., perceived benefits of action, perceived barriers of action, perceived self-efficacy, situational influences, interpersonal influences and activity-related affect), and desirable health promotion behavior (i.e., commitment to a plan of action and immediate competing demands and preferences)[32]. The health promotion model had been widely used to predict the establishment of behavioral predictors such as hearing protection[33], regular breakfast eating[34], and physical activity in adolescents[31] and patients with chronic disease like chronic kidney disease, diabetes and stroke [29,31,35]. And in previous studies, the health promotion model had demonstrated high levels of predictive power. Wu and Pender[36] studied the determinants of physical activity based on health promotion models, and the results showed that variables accounted for 30% of the variance in physical activity, and the perceived self-efficacy was the strongest predictor of physical activity among adolescents in Taiwan.

Since monitoring home blood pressure is a health promotion behavior, the intervention program based on the theory of health promotion behavior will be more targeted and systematic. This study assumes that the scale based on the health promotion model can effectively evaluate and predict HBPM behavior. The purpose of this study was to develop the home blood pressure monitoring perception scale and conduct reliability and validity tests so as to provide a reliable instrument for medical staff to assess the psychodynamic predictors of HBPM.

Methods

Participants

The convenience sample was selected from the department of nephrology of two tertiary hospitals in Guangdong province and collected data from March to October 2019. This study was approved by the ethics committee of the affiliated hospital of Sun Yat-sen University in accordance with the Declaration of Helsinki. Patients were included with the criteria: (1) diagnosed with CKD, the diagnostic criteria are derived from the Guidelines of Kidney Disease: Improving Global Outcomes; (2) diagnosed with hypertension according to the 2018 Chinese Guidelines for the Management of Hypertension: systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg without receiving antihypertensive medication; (3) at least 18 years old; (4) volunteer to join in this study,

and sign the informed consent. The exclusion criteria included: (1) dyskinesia of upper limbs; (2) upper-extremity amputations; (3) high anxiety or history of mental disorders; (4) cognitive impairments; and (5) people with severe visual or hearing impairments.

A total of 436 patients with CKD stage 1–5, aged 52.77 ± 14.45 years (range 20–87 years), completed the measures. CKD stage 1–4 patients were 17 (3.9%), 12 (2.8%), 21 (4.8%) and 9 (2.1%), respectively. There were 33 (7.6%) non-dialysis CKD-5 patients, 323 (74.1%) hemodialysis patients and 21 (4.8%) peritoneal dialysis patients. Among them, there were 284 males (65.1%) and 152 females (34.9%);114 (26.1%) had primary school or below,127 (29.1%) had completed junior high school, 111 (25.5%) had completed high school, and 84 (19.3%) had earned a university degree or above.

Of the 436 patients surveyed in this study, 89.91% (392) of patients had a blood pressure measuring device at home. Among these patients, electronic sphygmomanometer was the main type of blood pressure measuring device (97.45%, 382). Blood pressure was mainly measured in the upper arm (92.35%, 362). 65.83% (287) of patients had their blood pressure measured at least once a week. The mean office systolic blood pressure was 147.50 ± 21.19 mmHg, and the mean office diastolic blood pressure was 87.30 ± 14.22mmHg. There were 358 (82.1%) patients using at least one type of antihypertensive medication, and more than half of the patients (56.9%) took a combination of two or more antihypertensive drugs to control blood pressure. Specific participant characteristics were reported in the previous article[37].

Instruments

The questionnaire consisted of three parts, which were the home blood pressure monitoring perception scale, the Self-Efficacy for Managing Chronic Disease 6-item Scale and the characteristics questionnaires.

Home Blood Pressure Monitoring Perception Scale

This scale was developed through item pool formation, expert consultation and item selection. Based on the health promotion model, we generated the item pool for the HBPM perception scale after reviewing a large pool of literature and conducting research group discussions, which consisted of seven aspects and 58 items. The HBPM perception scale is a self-report scale.

A panel of eight experts was employed to conduct two rounds of reviews of the item pool of the HBPM perception scale. Experts had various academic backgrounds, including nephrology, cardiology, nursing, and education. They aged 24 ~ 54 (37.3 ± 9.1) years old and had clinical or academic experiences for 13.0 ± 11.2 years. There were two males and six females; three had doctoral degrees, one had master's degree; three of them hold associate senior titles and three hold intermediate titles. Experts were asked to evaluate the importance, relevance, and linguistic expression of each item, and were encouraged to add necessary items to the item pool. The importance and relevance were evaluated with a Likert 5-rating scale and a Likert 4-rating scale, respectively. The active coefficient of experts in the two rounds was 100%. The expert authority coefficient was 0.84, and the coordination coefficients of the two rounds of experts were 0.206 and 0.746, respectively. The full-score ratio ≥ 50%, with the average score of importance assignment ≥ 4.00, item-level content validity index (I-CVI) ≥ 0.78 was considered as the item selection standard [10]. After expert consultation and discussion by the research group, the draft of the HBPM perception scale was formed, including 43 items. Likert 5 rating was used in the scale, including "strongly disagree = 1, disagree = 2, neutrality = 3, agree = 4, strongly agree = 5".

Self-Efficacy for Managing Chronic Disease 6-item Scale

This scale has been used in chronic diseases to measure patients' self-efficacy[38]. The scale consists of 6 items with each item is scored on a scale of 1 to 10. The average score of the items represents the level of self-efficacy, and the higher the score, the better the self-efficacy. In this study, the scale was used to as a criterion, and criterion-related validity was calculated by analyzing its correlation with this developed scale.

Characteristics Questionnaire

The questionnaire was composed of demographic and sociological information of patients (gender, age, level of education), disease-related information such as office blood pressure and the use of antihypertensive drugs, etc.

Data Collection

Participants were asked to complete the questionnaires on the spot. The investigator explained the purpose, content and ethical issues of the study to patients. Patients participating in the study all signed informed consent forms. The patients completed the

questionnaire by themselves. A total of 436 questionnaires were issued, and 436 were effectively collected, with an effective collected rate of 100%. Thus, 436 valid respondents were included in the data analyses. Twenty participants completed the questionnaires again two weeks after the first survey.

Data Analysis

Data analyses were performed on the basis of three samples. First, the data collected from 436 participants were randomly split into two halves. The first half of the participants (sample 1) was used for item analysis and selection and exploratory factor analysis (EFA). Item frequency analysis[39], coefficient of variation (C.V.), critical ratio (C.R.), item-total correlation, corrected item-total correlation (CITC), internal consistency reliability coefficient, commonalities value and factor loading[40] were adopted to analyze and screen items, items that meet three or more standards were considered to be retained[41]. The standards for the above coefficients are shown in table 1. Sampling suitable for factor analysis was evaluated with the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity. Principal component analysis (PCA) and varimax rotation method were performed to decide the optimal number of components, and the number of extraction factors was determined by the eigenvalue (greater than 1) and scree plot. Items with factor loading values greater than 0.40 and no repeat load (the same item has a factor loading greater than 0.4 in 2 or more components) were kept.

Sample 2 included the other half of the participants, was used for validity and reliability test. Confirmatory factor analysis (CFA) was adopted to test the construct validity. Content validity and criterion-related validity were also analyzed to test the scale validity [40,42,43]. At the same time, the discriminability of the scale was verified in patients with different monitoring frequencies. Internal consistency reliability, split-half reliability, test-retest reliability and construct reliability were used to test the reliability of the scale [40,44]. Sample 3, which included 20 participants, was used to gauge test-retest reliability. SPSS 20.0 and Amos 23.0 were used for data analysis.

Results

Item Analysis and Selection

There was no item with more than 80% distribution on an option. The other analysis results of the items are shown in table 1. After analysis, item 23, 24, 34, 41, and 42 failed to meet the standard of 3 or more, therefore they were considered to delete.

Table 1

The analysis results of the items of the first draft with 43 items（n=218)

Item	$\bar{x}$	S	C.V.	C.R.	Item-total correlation	CITC	Cronbach's α if item deleted	Commonalities	Factor loading	Substandard quantity
1	3.88	0.806	0.208	10.431**	0.718**	0.700	0.937	0.554	0.744	0
2	3.82	0.906	0.237	14.449**	0.770**	0.753	0.937	0.654	0.809	0
3	3.80	0.914	0.241	11.814**	0.712**	0.691	0.937	0.560	0.748	0
4	3.49	1.026	0.294	12.393**	0.668**	0.641	0.937	0.481	0.694	0
5	3.78	0.911	0.241	12.800**	0.733**	0.714	0.937	0.604	0.777	0
6	3.61	0.925	0.256	14.527**	0.729**	0.708	0.937	0.599	0.774	0
7	3.72	0.950	0.255	11.726**	0.673**	0.649	0.937	0.524	0.724	0
8	4.13	0.683	0.165	5.295**	0.453**	0.429	0.939	0.182	0.426	2
9	3.91	0.854	0.218	6.630**	0.458**	0.428	0.939	0.185	0.431	2
10	3.83	0.889	0.232	4.371**	0.363**	0.328	0.940	0.115	0.339	4
11	3.28	1.163	0.355	11.645**	0.651**	0.620	0.937	0.437	0.661	0
12	3.85	0.873	0.227	7.402**	0.577**	0.551	0.938	0.312	0.559	0
13	3.47	1.087	0.313	9.382**	0.573**	0.539	0.938	0.289	0.537	0
14	3.56	0.997	0.280	6.050**	0.450**	0.413	0.939	0.188	0.433	2
15	3.20	1.122	0.351	6.388**	0.463**	0.422	0.939	0.170	0.413	2
16	3.63	1.009	0.278	9.348**	0.628**	0.600	0.938	0.345	0.587	0
17	3.97	0.811	0.204	4.368**	0.376**	0.344	0.939	0.118	0.343	4
18	3.89	0.830	0.213	7.223**	0.562**	0.535	0.938	0.302	0.549	0
19	3.53	1.039	0.294	11.631**	0.716**	0.692	0.937	0.510	0.714	0
20	3.60	1.017	0.283	12.130**	0.736**	0.714	0.937	0.553	0.744	0
21	3.44	1.034	0.301	12.887**	0.734**	0.711	0.937	0.555	0.745	0
22	3.50	1.013	0.289	12.379**	0.726**	0.703	0.937	0.564	0.751	0
23	3.76	0.858	0.228	-0.586	0.035	-0.003	0.942	0.003	-0.052	6
24	3.11	1.083	0.348	-0.760	0.015	-0.033	0.943	0.008	-0.091	6
25	3.69	0.892	0.242	4.477**	0.457**	0.425	0.939	0.172	0.415	2
26	3.83	0.818	0.214	5.856**	0.520**	0.493	0.938	0.217	0.466	0
27	4.03	0.692	0.172	6.186**	0.460**	0.435	0.939	0.217	0.466	0
28	3.61	1.078	0.299	14.314**	0.679**	0.652	0.937	0.500	0.707	0
29	3.23	1.074	0.333	12.290**	0.614**	0.583	0.938	0.415	0.644	0
30	3.44	0.964	0.280	6.389**	0.470**	0.436	0.939	0.213	0.461	0

31	2.80	1.114	0.398	9.683**	0.575**	0.541	0.938	0.364	0.603	0
32	3.44	1.115	0.324	7.813**	0.544**	0.507	0.938	0.291	0.539	0
33	2.78	1.154	0.415	9.296**	0.568**	0.532	0.938	0.354	0.595	0
34	3.64	1.008	0.277	1.651**	0.214**	0.171	0.941	0.017	0.130	6
35	3.96	0.811	0.205	9.109**	0.680**	0.660	0.937	0.471	0.686	0
36	3.23	1.122	0.347	10.193**	0.599**	0.566	0.938	0.386	0.621	0
37	4.04	0.816	0.202	7.393**	0.608**	0.584	0.938	0.372	0.610	0
38	3.24	1.176	0.363	12.124**	0.697**	0.669	0.937	0.509	0.713	0
39	2.83	1.124	0.397	9.549**	0.607**	0.574	0.938	0.414	0.643	0
40	2.66	1.062	0.399	7.306**	0.435**	0.396	0.939	0.207	0.455	0
41	2.97	1.177	0.396	2.196*	0.228**	0.178	0.941	0.026	0.162	6
42	3.49	0.956	0.274	2.197*	0.249**	0.208	0.940	0.022	0.150	5
43	3.80	0.881	0.232	3.549**	0.279**	0.242	0.940	0.075	0.274	4
Standard	-	-	≥0.15	≥3.00	≥0.40	≥0.40	0.94	≥0.20	≥0.45	-

Abbreviations: C.V., coefficient of variation; C.R., critical ratio; CITC, corrected item–total correlation.

*p 0.05; **p 0.001

Exploratory Factor Analysis

The KMO index was 0.903, and the Bartlett spherical test chi-square value reached statistical significance ($\chi^2 = 6050.194$, $p < 0.001$), indicating that it was suitable for factor analysis. There were 9 factors whose eigenvalue of initial load matrix was greater than 1, and the cumulative contribution rate of variance reached 72.669%.

According to the results, 5 items with factor loading less than 0.4 (item 25, 27, 30, 35, 43) were deleted. Items 22,26,29,37 with loads greater than 0.4 above two factors were deleted. Item 8,11 with loads more than 0.4 on at least two factors, but these two items played an important role in the HBPM behavior of patients during the investigation through communication with patients. Meanwhile, the study in patients with hypertension suggested that the price of the sphygmomanometer and the degree of mastery of HBPM methods are important factors affecting patients' HBPM behavior. Therefore, these two items were decided to keep after expert discussion. At the same time, item 28 has highly similar meaning with item 39 in the affiliation factor, so item 28 was deleted. Finally, there were 7 factors whose eigenvalues of the structural matrix are greater than 1, and the cumulative contribution rate of variance reaches 74.373% (Table 2). The factor loadings and structure were showed in Table 3.

Table 2
Total Variance Explained of 28 items(n = 218)

Dimension(component)	Initial Eigenvalues			Extracted Sum of Squared loadings		
	Total	Variance (%)	Cumulative(%)	Total	Variance (%)	Cumulative (%)
Perceived benefit of HBPM (F1)	10.993	39.260	39.260	5.679	20.283	20.283
Perceived self-efficacy of HBPM (F2)	2.359	8.425	47.686	3.406	12.163	32.447
Situational influences (F3)	2.203	7.866	55.552	2.605	9.304	41.751
Commitment to a plan of HBPM and immediate competing demands and preferences (F4)	1.791	6.396	61.948	2.550	9.108	50.859
Perceived barriers of HBPM (F5-F7)						
F5	1.352	4.829	66.777	2.541	9.076	59.935
F6	1.097	3.917	70.694	2.442	8.723	68.658
F7	1.030	3.679	74.373	1.600	5.715	74.373
Abbreviations: HBPM, home blood pressure monitoring.						

Table 3
Rotated Component Matrix of 28 items a (n = 218)

	Component						
	Perceived benefit of HBPM	Perceived self-efficacy of HBPM	Situational influences	Commitment to a plan of HBPM and immediate competing demands and preferences	Perceived barriers of HBPM		
	F1	F2	F3	F4	F5	F6	F7
5.HBPM helps control my disease (such as reducing my risk of coronary heart disease or stroke).	0.873	0.151	0.112	0.155	0.079	0.185	0.056
6.HBPM can improve my quality of life.	0.828	0.248	0.117	0.192	0.068	0.082	0.099
3.HBPM helps me take my medicine as directed.	0.810	0.104	0.180	0.113	0.241	0.098	0.058
2.HBPM helps me control blood pressure.	0.801	0.195	0.166	0.204	0.187	0.186	0.034
7.HBPM helps me adjust my lifestyle (diet, exercise, etc.).	0.773	0.241	0.182	0.112	-0.040	0.144	0.184
4.HBPM made me feel like I was working with my doctor to decide on a treatment.	0.761	0.167	0.087	0.229	0.176	-0.085	0.099
1.Home blood pressure monitoring is a good indicator of how my blood pressure fluctuates.	0.665	0.190	0.237	0.114	0.256	0.121	0.099
20.I am confident that I will be able to monitor my blood pressure at home for the long term.	0.344	0.852	0.171	0.134	0.177	0.041	0.003
19.I am confident that I can monitor my blood pressure at home regularly every day.	0.298	0.851	0.122	0.133	0.230	0.017	0.013
18.I am confident that I can monitor my blood pressure at home in the right way.	0.098	0.813	0.152	0.022	0.129	0.105	0.117
21.No matter what the situation, I can carefully monitor my blood pressure according to the HBPM plan.	0.353	0.765	0.150	0.226	0.242	0.041	-0.014
31.The media (Internet, books, magazines, T.V.) made me want to monitor my blood pressure at home.	0.226	0.162	0.819	0.182	0.046	0.074	0.088
33.The fellow patient's condition was controlled after monitoring blood pressure at home made me want to monitor my blood pressure at home.	0.247	0.080	0.797	0.315	0.033	0.044	0.066
32.The publicity from hospitals and community health services made me want to monitor my blood pressure at home.	0.172	0.260	0.706	0.115	0.133	0.033	0.027
40.I still monitor my blood pressure regularly when I'm away.	0.116	0.061	0.157	0.780	0.163	-0.090	0.072
38.I have made specific arrangements for the time and recording method of HBPM.	0.385	0.268	0.176	0.646	0.141	0.084	0.023

	Component						
	Perceived benefit of HBPM	Perceived self-efficacy of HBPM	Situational influences	Commitment to a plan of HBPM and immediate competing demands and preferences	Perceived barriers of HBPM		
	F1	F2	F3	F4	F5	F6	F7
36.In order to monitor blood pressure at home, I ask the medical staff for advice on how to measure blood pressure.	0.319	0.130	0.312	0.635	0.003	0.165	0.011
39.I plan to have family or friends (or fellow patients or colleagues) help remind me to monitor my blood pressure at home.	0.351	0.139	0.369	0.545	-0.035	0.063	0.251
13.I have trouble keeping my blood pressure monitored at a set time.	0.122	0.263	0.085	0.282	0.760	0.016	0.031
12.I don't have time to monitor my blood pressure at home.	0.286	0.126	0.134	0.063	0.751	0.067	0.144
16.HBPM is too frequently measured, I feel it troublesome.	0.124	0.357	0.073	0.097	0.711	0.214	0.148
17.I can't get my blood pressure measured by myself without the help of others.	0.114	0.068	-0.031	-0.093	0.540	0.342	0.094
9.I don't know how to measure blood pressure.	0.118	0.085	-0.002	0.137	0.134	0.846	0.132
10.The requirement of blood pressure measurement is too high for me (such as getting enough rest, measure posture, etc.).	0.166	0.040	-0.002	-0.019	0.070	0.781	0.073
8.I can't afford a blood pressure device financially.	0.037	0.026	0.422	-0.030	0.246	0.687	0.057
11.I don't know how to implement HBPM (e.g., frequency, time, recording, etc.).	0.471	0.070	-0.047	0.479	0.096	0.487	0.176
14.I think the blood pressure I measured at home was inaccuracy.	0.174	0.097	0.165	-0.004	0.077	0.153	0.850
15.I don't know how to explain the blood pressure.	0.156	-0.006	-0.007	0.218	0.271	0.139	0.776
Abbreviations: HBPM, home blood pressure monitoring; T.V., television. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization							
a. Rotation converged in 7 iterations.							

The first common factor, named perceived benefit of HBPM, included 7 items with the extracted sum of squared loadings was 5.679, and the variance was explained by 20.283%. It is used to investigate the perceived benefit of HBPM. The second common factor contained 4 items, the extracted sum of squared loadings was 3.406, which explained 12.163% of the variation. It was named perceived self-efficacy of HBPM and is used to evaluate the self-efficacy of patients for HBPM. The third common factor was named as situational influences. It contained 3 items, the extracted sum of squared loadings was 2.605, which accounted for 9.304% of the variation. It is mainly used to investigate the situational influences on HBPM. The fourth common factor extracted contained 4 items, with the extracted sum of squared loadings of 2.550, which explained for 9.108% of the variation. It was named as commitment to a

plan of HBPM and immediate competing demands and preferences. The fifth, sixth, seventh common factor extracted contained 4, 4, and 2 items, with a load of 2.541, 2.442, 1.600, which explained 9.076%, 8.723%, and 5.715% of the variation, respectively. Factors five, six and seven were related to barriers of HBPM behavior. Therefore, these 10 items were combined as one factor after expert consultation.

Confirmatory Factor Analysis

The construct validity of the scale was further verified by CFA. The fitting indexes of the model were as follows: χ^2 = 963.793,*df* = 340, χ^2/df = 2.835, RMSEA = 0.092, CFI = 0.842. The covariant relationships were established between the error values of item 1 and 2, item 6 and 7, item 9 and 10, as well as item 14 and 15, according to the meaning of these items and the modification index of the model. At the same time, the model fitting index suggested that the chi-square value can effectively reduce if the covariant relationship is established between item 13 and the perceived self-efficacy of HBPM dimension, and the research group agreed that the semantic of item 13 overlapped with the self-efficacy dimension, so item 13 was deleted. The modified model fitting indexes of the final scale were as follows: χ^2 = 679.649, *df* = 310, χ^2/df = 2.192, RMSEA = 0.074, CFI = 0.902.The model structure and the final 27-item scale were shown in Fig. 1 and Appendix.(Figure 1 Confirmatory Factor Analysis Model of HBPM perception scale. Abbreviations: HBPM, home blood pressure monitoring.)

Scale Reliability

Cronbach's α coefficient of the HBPM perception scale was 0.911. The split-half reliability of the HBPM perception scale was 0.896. The test-retest reliability coefficient of the HBPM perception scale was 0.908. The construct reliability of dimensions ranged from 0.749 to 0.951. The reliability coefficients of each dimension were shown in Table 4.

Table 4
The reliability coefficient of each dimension and total scale

Dimension	Cronbach's α coefficient	Split-half reliability	Test-retest reliability	Construct reliability
Perceived benefit of HBPM	0.952	0.963**	0.909**	0.951
Perceived self-efficacy of HBPM	0.816	0.862**	0.768**	0.811
Situational influence	0.898	0.919**	0.879**	0.907
Commitment to a plan of HBPM and immediate competing demands and preferences	0.797	0.624**	0.906**	0.825
Perceived barriers of HBPM	0.750	0.764**	0.829**	0.749
Total	0.911	0.896**	0.908**	-
Abbreviations: HBPM, home blood pressure monitoring.				
**$p < 0.001$				

Scale Validity

The I-CVI of 27 items in this study were 1.00, S-CVI /UA was 1.00, and S-CVI /AVE was 1.00. The correlation coefficient between the score of HBPM perception scale and Self-Efficacy for Managing Chronic Disease 6-item Scale was 0.256 (p<0.001). The square root of average variance extracted of dimensions between 0.571 and 0.858. The correlation coefficient of each dimension and the total score were shown in Table 5. Those who had their blood pressure measured at home at least once a week had higher scores on the perception scale than those who didn't (Table 6).

Table 5
Correlation analysis between dimensions and the total amount

Dimension	Perceived benefit of HBPM	Perceived self-efficacy of HBPM	Situational influences	Commitment to a plan of HBPM and immediate competing demands and preferences	Perceived barriers of HBPM	Square root of AVE
Perceived benefit of HBPM	1					0.858
Perceived self-efficacy of HBPM	0.298**	1				0.571
Situational influence	0.591**	0.328**	1			0.844
Commitment to a plan of HBPM and immediate competing demands and preferences	0.355**	0.095**	0.322**	1		0.792
Perceived barriers of HBPM	0.530**	0.223**	0.545**	0.549**	1	0.656
Total	0.814**	0.632**	0.767**	0.563**	0.746**	-
Abbreviations: HBPM, home blood pressure monitoring; AVE, average variance extracted.						
**$p < 0.001$						

Table 6

The difference of perception scale scores in patients with different frequency of HBPM

Variable	n	$\bar{x} \pm SD$	*t*	*p*
Measure blood pressure at home at least once a week			14.437	<0.001
Yes	287	103.51 ± 11.55		
No	149	85.11 ± 14.45		

Discussion

Home blood pressure monitoring has been shown to improve the accuracy of hypertension burden assessment in patients with CKD, improve the blood pressure management of these patients[18,19], and provide reliable data on the relationship between hypertension and prognosis[17], which has great clinical value in patients with CKD[8,14–16]. However, the cognitive and other psychological factors of HBPM are not well studied and there is a lack of specific instruments to explore the psychodynamic factors of home blood pressure monitoring behavior. In this study, we have developed a new valid and reliable scale to measure the perception of home blood pressure monitoring based on the health promotion model. The HBPM perception scale consists of 27 items covering five dimensions. It is evaluated on a Likert 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree), resulting in a final score in the range of 27 ~ 135.

Out of the 58 items in the item pool, 27 were retained in the finalized version. The justifications for reducing the item were as follows. First, there were 43 items retained after evaluated by experts for the relevance, importance and linguistic expression of the item. Second, based on findings from the item analysis, there were five items with 5 or more substandard indicators, which indicated that the sensitive, differentiated and representative of these items were poor, so these items were deleted. Third, based on findings from the EFA, ten items with factor loading less than 0.40 or had a factor loading greater than 0.4 in 2 or more components were omitted. Finally, the model fitting index suggested and research group discussion agreed that the semantic of item 13 overlaps with the perceived self-efficacy of HBPM dimension, so deleted this item. Based on the findings and the health promotion model, five domains were finally identified.

HBPM perception scale is a reliable and valid instrument to assess the perception of HBPM. Firstly, the data analysis results demonstrated it had reasonable reliability [40,44]. The Cronbach's α coefficient for total scale was 0.911 and ranged from 0.750 to 0.952. The split-half reliability was 0.896 for total scale and 0.624 ~ 0.963 for five dimensions. And the test-retest reliability for total scale was

0.908 ranged 0.829 ~ 0.909. The construct reliability of dimensions ranged from 0.749 to 0.951. Secondly, the results showed that the HBPM perception scale had reasonable validity [40,42,43]. The HBPM perception scale total score was positively correlated with the Self-Efficacy for Managing Chronic Disease 6-item Scale, suggesting that criterion-related validity was reasonable. Confirmatory factor analysis showed the model fit well: χ^2 = 679.649, *df* = 310, χ^2/df = 2.192, RMSEA = 0.074, CFI = 0.902. The I-CVI of 27 items in this study was 1.00, the scale-level content validity index (universal agreement) was 1.00, and the scale-level content validity index(average) was 1.00. The square root of average variance extracted of dimensions between 0.571 and 0.858. For patients who measured their blood pressure at home at least once a week or not, the scale could detect differences in scores, indicating that the scale can predict HBPM behavior well.

According to the analysis results, five domains were finally identified, and this factor structure derived from the health promotion model. The health promotion model puts forward ten categories of factors that influence health promotion behaviors. Our study demonstrates that the following five factors were predictors of HBPM behavior among CKD patients.

The dimension of perceived benefits of HBPM consists of 7 items. The perceived benefits of a certain behavior can directly promote an individual to adopt this behavior according to the health promotion model[34]. Data from 436 patients demonstrated this structure. And some results obtained in previous studies were retained. For example, the item "Home blood pressure is a good indicator of how my blood pressure fluctuates" was developed based on a study in Singapore[25]. These items are representative and can be used to assess the perceived benefit of HBPM behavior.

The perceived barriers of HBPM dimension contains 9 items. Individuals often avoid behaviors that they feel are more difficult to implement[34]. In terms of HBPM behavior, patients are more likely to avoid it because it involves barriers such as measurement equipment[25], time[26], and method[45]. Our study found that these barriers, which have been demonstrated in patients with hypertension, are also present in patients with CKD. For instance, items "I don't have time to monitor my blood pressure at home", "I don't know how to measure blood pressure" remained after data analysis. Attention should be paid in clinical practice to identify and help patients overcome the barriers of HBPM behavior.

The dimension of perceived self-efficacy of HBPM includes 4 items. Individuals with high self-efficacy are more likely to maintain healthy behaviors and engage in them frequently[36]. Two qualitative studies embedded within the randomized controlled trials in the U.K. have shown that patients undergoing HBPM are confident in self-monitoring blood pressure[27,28]. However, for HBPM, regularly, long-term, and accurately measure blood pressure is needed if its clinical value is to be brought into play. Therefore, this study developed items based on these three aspects, and data analysis also proved that perceived self-efficacy of HBPM plays an important role in HBPM behavior in patients with CKD. On the basis of previous studies and combined with the characteristics of HBPM, our study further refined the perceived self-efficacy of HBPM, so as to comprehensively reflect the self-efficacy of HBPM perceived by patients, and provide reference for clinical practice.

The situational influences dimension consists of 3 items. Individuals often want their behavior to be consistent with the behavior of others in a given situation[46]. One study showed that putting up posters about HBPM in health care facilities increased the use of HBPM for hypertension patients [47]. In this study, the items were developed mainly based on this result, and analysis of 436 cases of data also confirmed that situational influences are also important for HBPM behavior in patients with chronic kidney disease. The use of HBPM needs to be encouraged by setting up situations, such as health talks and more publicity.

The dimension of commitment to a plan of HBPM and immediate competing demands and preferences contains 4 items. A commitment to a plan of action is one's own plan to perform a certain behavior, and immediate competing demands and preferences are the various contingencies of a healthy behavior plan[46]. Making a plan is an important step before start acting. Individuals may have immediate competing demands and preferences before performing a planned health behavior, and the attraction or stress brought by such emergencies can affect individuals' health behavior[34]. Our study confirmed that this factor could affect the HBPM behavior in patients with CKD. It is necessary to help patients develop HBPM plan and adjust the plan flexibly for patients with special conditions.

HBPM perception scale is a reliable and sensitive quantitative instrument, which adopts the health promotion model as the cause pattern that can assist medical personnel in evaluating the determinants of HBPM behavior from the patient's perspective. For the patients who reluctant to perform HBPM according to recommendation, the scale can help clinical medical staff to find out the potential problems that patients will encounter during HBPM, so as to take preventive and targeted measures to help patients overcome the problems. In the case of patients with irregular monitoring, it can help to find the reasons for non-standard monitoring and then

develop personalized strategies, so as to improve the clinical work efficiency and reduce the workload of clinical medical staff. It can also be used in clinical studies to help to identify intervention targets and establish intervention strategies to improve the monitoring rate of patients' home blood pressure, and effectively predict the HBPM behavior and health outcome of HBPM intervention.

There are some limitations of this study. Although the patients with stage 1–5 CKD were investigated, the subjects were mainly hemodialysis patients. Future studies need to further explore the validity and reliability of the HBPM perception scale in non-dialysis patients and peritoneal dialysis patients. Meanwhile, the sample of this study was only recruited in two tertiary hospitals from Guangdong, China. This might limit the generalizability of the findings. Therefore, future studies need to assess the psychometrics features of the HBPM perception scale in different samples with different cultural and socio-economic status.

Conclusions

The HBPM perception scale provides a valid and reliable instrument for assessing the perception of HBPM. Besides, the items are straightforward and easy for users to understand and use. In addition to enriching our understanding of home blood pressure monitoring among patients, the HBPM perception scale is also useful in establishing a possible link between assessment and health education and helpful in developing appropriate training programs and evaluating the effectiveness of HBPM intervention program to improve blood pressure management in these patients and finally reduce the risk of cardiovascular events.

Abbreviations

HBPM: Home blood pressure monitoring

CKD: Chronic kidney disease

CFA: Confirmatory factor analysis

EFA: Exploratory factor analysis

HPM: Health promotion model

I-CVI: Item-level content validity index

C.V.: Coefficient of variation

C.R.: Critical ratio

CITC: Corrected item-total correlation

KMO: Kaiser–Meyer–Olkin

PCA: Principal component analysis

Declarations

Ethics approval

This study was performed in accordance with the Declaration of Helsinki and was approved by the ethics and academic committee of Sun Yat-sen University.

Consent for publication

Not applicable.

Availability of data

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare no conflicts of interest exist.

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Authorship

All authors contributed to the study design, or data collect, or data research and interpretation; and read and approved the content of the manuscript and take responsibility for all aspects of the work.

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Appendix

Appendix: Home Blood Pressure Monitoring Perception Scale

Item	1 Strongly disagree	2 Disagree	3 Neutrality	4 Agree	5 Strongly agree
Perceived benefit of HBPM					
1.Home blood pressure monitoring (HBPM) is a good indicator of how my blood pressure fluctuates.					
2.HBPM helps me control blood pressure.					
3.HBPM helps me take my medicine as directed.					
4.HBPM made me feel like I was working with my doctor to decide on a treatment.					
5.HBPM helps control my disease (such as reducing my risk of coronary heart disease or stroke).					
6.HBPM can improve my quality of life.					
7.HBPM helps me adjust my lifestyle (diet, exercise, etc.).					
Perceived barriers of HBPM					
8.I can't afford a blood pressure device financially.					
9.I don't know how to measure blood pressure.					
10.The requirement of blood pressure measurement is too high for me (such as getting enough rest, measure posture, etc.).					
11.I don't know how to implement HBPM (e.g., frequency, time, recording, etc.).					
12.I don't have time to monitor my blood pressure at home.					
13.I think the blood pressure I measured at home was inaccuracy.					
14.I don't know how to explain the blood pressure.					
15.HBPM is too frequently measured, I feel it troublesome.					
16..I can't get my blood pressure measured by myself without the help of others.					
Perceived self-efficacy of HBPM					
17.I am confident that I can monitor my blood pressure at home in the right way.					
18.I am confident that I can monitor my blood pressure at home regularly every day.					
19.I am confident that I will be able to monitor my blood pressure at home for the long term.					
20.No matter what the situation, I can carefully monitor my blood pressure according to the HBPM plan.					
Situational influences					
21.The media (Internet, books, magazines, T.V.) made me want to monitor my blood pressure at home.					
22.The publicity from hospitals and community health services made me want to monitor my blood pressure at home.					
23.The fellow patient's condition was controlled after monitoring blood pressure at home made me want to monitor my blood pressure at home.					
Commitment to a plan of HBPM and immediate competing demands and preferences					
24. In order to monitor blood pressure at home, I ask the medical staff for advice on how to measure blood pressure.					

25. I have made specific arrangements for the time and recording method of HBPM.
26. I plan to have family or friends (or fellow patients or colleagues) help remind me to monitor my blood pressure at home.
27.I still monitor my blood pressure regularly when I'm away.

Figures

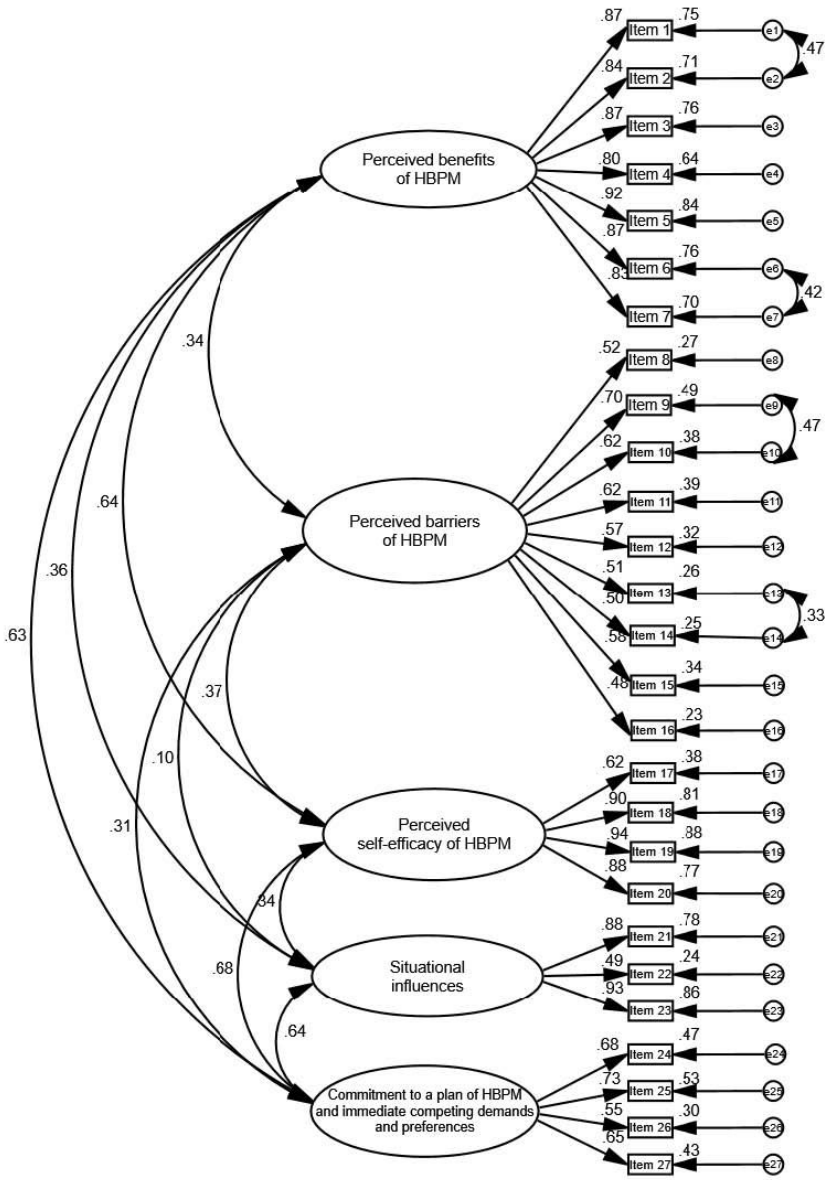

Figure 1

Confirmatory Factor Analysis Model of HBPM perception scale. Abbreviations: HBPM, home blood pressure monitoring.