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Development and validation of a rating scale for barriers to and facilitators of nurses' participation intentions in "Internet + Nursing Service"

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Abstract

Background Given increases in China's aging population, the growing demand for public health services and the shortage of human resources among nurses have become more prominent. Under such a background, "Internet + Nursing Services" have received more attention. Thus, exploring the barriers to and facilitators of nurses' willingness to participate in "Internet + Nursing Services" and utilizing internet technology to increase the supply of nursing services has become a key issue.

Objective This study aimed to develop a scale for assessing the barriers to and facilitators of nurses' willingness to participate in "Internet + Nursing Services" and to test the validity and reliability of the scale.

Methods A preliminary scale was developed based on a literature review, theoretical research, semistructured qualitative interviews, and two rounds of Delphi expert inquiry. A convenient sampling method was used for the questionnaire survey. A 5-point Likert scale was used to evaluate the importance of the items. The survey data of 659 clinical nurses obtained from February to March 2023 were used for item analysis, exploratory factor analysis (EFA), and reliability and validity tests of the scale. The survey data of 538 clinical nurses obtained in April 2023 were used for confirmatory factor analysis (CFA) of the final scale.

Results The final scale consists of 25 items and 4 dimensions (performance expectations, perceived risk, need for professional knowledge training, and nonprofessional knowledge training). The scale showed good structural validity and content validity: the Cronbach's α coefficient of the scale was 0.955, the split-half reliability was 0.778, the test-retest reliability was 0.944, the kaiser-meyer-olkin(KMO) value was 0.960, and the cumulative variance contribution

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rate of the 4 common factors was 83.147%. The scale content validity index(S-CVI) was 0.914. The confirmatory factor analysis model had favorable fit indices: $\chi^2/df = 4.234$, RMSEA = 0.078, NFI = 0.940, IFI = 0.953, TLI = 0.947, and CFI = 0.953.

Conclusion The scale for assessing the barriers to and facilitators of nurses' willingness to participate in "Internet + Nursing Services" has good reliability and validity, and provides a reference for evaluating nurses' willingness to participate in "Internet + Nursing Services".

Keywords Internet+nursing services, Nurses, Scale, Exploratory factor analysis, Confirmatory factor analysis

Background

The aging population of China continues to rise. As of 2021, the population over 60 years old was more than 264 million, and 85% of elderly individuals have varying degrees of home care needs. In addition, 44 million disabled or semidisabled elderly individuals have an increasing demand for home care services [1]. The number of registered nurses per thousand people in China is only 3.18 [2]. The imbalance between the supply and demand of medical resources has made home-visiting nursing services an inevitable trend in Chinese health care reform [3]. With the emergence of the "Internet +" era, information technology provides a new perspective for health care reform [4]. "Internet+Nursing Services" is a type of nursing mode that combines the nursing profession and internet information technology, which is characterized as "application online, service offline". Patients can communicate with nurses online in the form of pictures, text, voice messages or videos using mobile terminals to overcome the restrictions of time and space and help nurses provide professional and convenient home-visit nursing care for discharged, elderly and end-stage patients, satisfying their diverse and multilevel health needs [5–7]. In 2020, the National Health Commission of China issued the "Notice on Further Promoting the Pilot Work of "Internet+Nursing Services", which further expanded the scope of the pilot work of "Internet+Nursing Services" [8]. With the development of "Internet+Nursing Services", as direct participants and implementers, the willingness and behavior of nurses seriously affect the quality of nursing services and the development of this industry [9]. "Internet+Nursing Services", as an innovative and particular form of nursing service, requires nurses to have strong professional knowledge and skills and possess the ability to identify and respond to possible risks, particularly the workplace and the unpredictability of the service object. Therefore, administrators should look deeply into the willingness, attitudes, and influencing factors of nurses to participate in "Internet+Nursing Services" to identify the factors that promote and hinder their participation and seek appropriate improvement strategies. However, tools to assess barriers to and facilitators of nurses' willingness to participate in "Internet+Nursing Services" remain lacking.

Ajzen et al. suggested that, to some extent, the willingness to adopt is an important indicator of the user's acceptance and use decision [10]. In their study, the authors defined the subjective probability as the participation intention of nurses' willingness to adapt and use "Internet+Nursing Services". To date, many studies have focused on the acceptance and utilization of information technology. In the field of medicine and health care, studies on the adoption and utilization of new techniques are mainly based on several models, such as the theory of reasoned action (TRA), the theory of planned behavior (TPB), and the technology acceptance model (TAM), and each model is composed of different variables [11]. By integrating the TRA, TPB and TAM, Venkatesh et al. proposed the unified theory of acceptance and use of technology (UTAUT) model from the perspective of social cognitive theory. The UTAUT model regards performance expectations (PEs), effort expectations (EEs), facilitating conditions (FCs), and social influence (SI) as the core variables that determine the behavioral intentions (BIs) of individuals [12, 13]. The UTAUT model has been widely used in fields such as computer science, business economics, library and information science, psychology, health care services, management science, and medical informatics. In this study, we developed a rating scale to assess the barriers to and facilitators of nurses' willingness to participate in "Internet+Nursing Services". This study provides a tool for hospital managers to evaluate this issue and offers a reference for improving the management scheme of "Internet+nursing services".

Research methods

The process of developing the scale for evaluating the barriers to and facilitators of nurses' participation in "Internet+Nursing Services" included three phases (Fig. 1).

Research team

The research team consisted of seven members, including one director of the nursing department in a general hospital; two head nurses from the internal medicine and surgery departments, separately; and two postgraduate nursing students. The main tasks of the team included performing a literature review, interviewing, forming the initial item pool, creating expert inquiry forms, revising

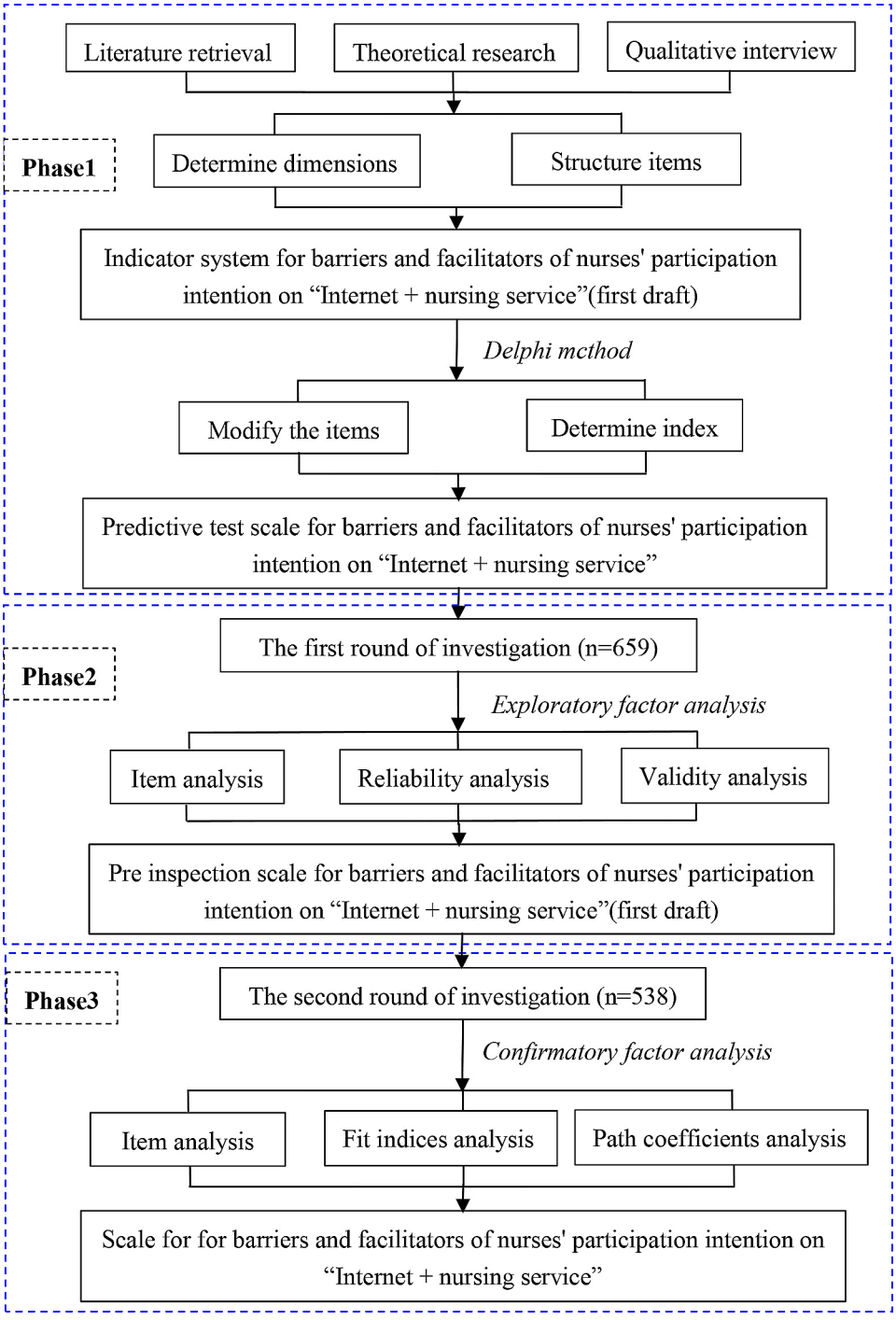

Fig. 1 Process of developing the scale for evaluating the barriers to and facilitators of nurses' participation in "Internet + Nursing Services"

and reviewing items in each round of inquiry to form a preliminary scale, distributing and collecting the scale, and finally conducting reliability and validity tests of the scale.

Development of the item pool

This study used UTAUT as the theoretical framework and combined it with literature analysis [14–19]. We also conducted semistructured interviews with specialists and nurses and extracted and summarized the data using the Colaizzi analysis method [20]. By sorting out the existing theoretical model information and the feature "Internet + Nursing Services", we establish 6 variables: (1) Performance expectation: the benefits that nurses believe that participating in "Internet + Nursing Services" can bring; (2) Perceived risk: Nurses' subjective

judgment and prediction of possible risks in participating in the "Internet+Nursing Services"; (3) Knowledge needs: the demand that "Internet+Nursing Services" imposes on nurses to utilize new information and technology; (4) Professional knowledge needs: the demand that "Internet+Nursing Services" imposes on nurses to be equipped with professional knowledge and skills. (5) External knowledge needs: the demand that "Internet+Nursing Services" imposes on nurses to have diverse knowledge and interdisciplinary ability. (6) Behavioral intention: the extent to which nurses actually accept and use "Internet+Nursing Services". On the basis of the above 6 items, a hypothetical model of the willingness of nurses to participate in "Internet+Nursing Services" was constructed. The following hypotheses were proposed: H1: Performance expectations positively influence nurses' behavioral intentions to engage in "Internet+Nursing Services"; H2: Perceived risk negatively influences nurses' behavioral intentions to engage in "Internet+Nursing Services"; H3: Knowledge needs negatively influence nurses' behavioral intentions to engage in "Internet+Nursing Services"; H4: Professional knowledge needs positively influence nurses' knowledge needs in "Internet+Nursing Services"; H5: External knowledge needs positively influence nurses' knowledge needs in "Internet+Nursing Services"; H6: There is a mutual influence and correlation between professional knowledge needs and external knowledge needs. A hypothetical model of barriers and facilitators for nurses to participate in "Internet+Nursing Services" was then constructed, and the hypotheses were integrated into 4 dimensions: performance expectations, perceived risk, professional knowledge needs, and external knowledge needs (Fig. 2). Finally, a preliminary list of barriers to and facilitators of nurses' willingness to participate in "Internet+Nursing Service" was developed via the item pool.

Item construction and assessment

Through a literature review, theoretical analysis and qualitative interviews, we constructed a preliminary draft composed of 4 dimensions and 45 indicators to evaluate barriers to and facilitators of nurses' willingness to participate in "Internet+Nursing Services", and the draft was evaluated using a 5-point Likert scale. We subsequently conducted interviews with specialists in the field of nursing using the Delphi method. The inclusion criteria for the experts were as follows: (1) engaged in clinical nursing management, internal medicine nursing, surgical nursing, cancer nursing, critical care nursing, outpatient nursing and other specialized work; (2) had a bachelor's degree or above; (3) had 10 years or more of working experience in the nursing field; (4) had a medium-grade or above professional title; and (5) participated in the study voluntarily and answered the questionnaire actively. The principles of item selection were as follows: the mean value of the item ≥ 3.5 with a variable coefficient ≤ 0.25 [21] combined with the comments of the specialists. The interval between the two rounds of expert consultation was 15 days to avoid memory bias.

Scale pretesting

To ensure that the descriptions of the scale items are accurate and easy to understand, convenience sampling was used to select 30 clinical nurses from a tertiary grade hospital and a secondary hospital in Yichang for a presurvey. The inclusion criteria were as follows: (1) held a nurse practicing a certificate; (2) had engaged in clinical nursing work for more than 3 years; and (3) provided informed consent and voluntary participation in this survey. The exclusion criterion was nurses who were on further education or internships. The initial draft of the scale was revised on the basis of the survey results.

Scale formal testing

On the basis of the sample-to-item ratio of 1:5 to 1:10 suggested by Wu et al. [22], the initial draft of the scale in this study contained 37 items, requiring a sample size of 185 to 370; however, considering a 20% loss of samples, the final required sample size was 232 to 463. Convenience sampling was chosen to select nurses from

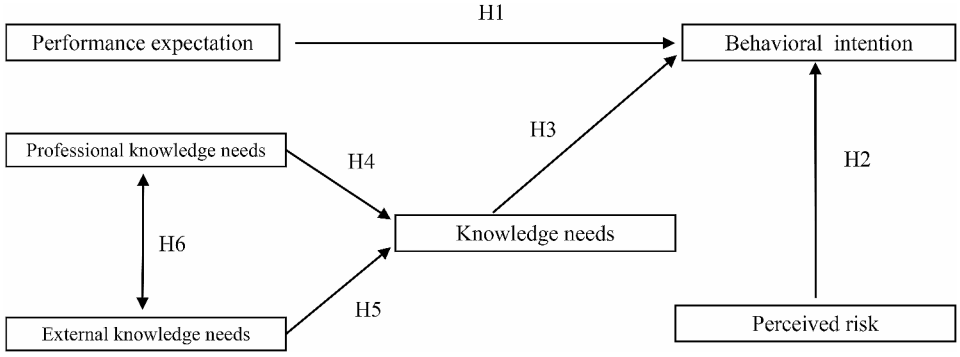

Fig. 2 Hypothetical model of the effects of barriers to and facilitators of nurses' participation intentions in "Internet+Nursing Services"

8 tertiary hospitals, 12 secondary hospitals, and several community health care institutions in Hunan, Hubei, Anhui, and Zhejiang Provinces. An anonymous questionnaire survey was conducted by sending a questionnaire link using a mobile application. The inclusion criteria for participants were as follows: (1) were aged over 18 years; (2) were nursing professionals with qualifications; (3) had 3 years or more of nursing experience; and (4) provided informed consent and were willing to participate in this research survey. The exclusion criteria were as follows: (1) nursing personnel not in clinical positions, such as those in medical examinations or departments of disinfection and supplementation; (2) nursing personnel who are undergoing regular training, advanced studies, or internships. To prevent duplication of entries, only one submission was allowed per IP address, and incomplete questionnaires were not accepted to ensure data completeness.

Scale evaluation

Project analysis

Three methods were used to screen the items in the scale: (1) Critical ratio method: items with a total score in the bottom 27% and top 27% that did not reach significance ($P>0.05$) or with a t value less than 3.000 are removed. (2) Correlation coefficient method: items with a total correlation coefficient less than 0.400 are removed. (3) Internal consistency coefficient method: items that, after removal, significantly increase the Cronbach's alpha coefficient of the scale are removed.

Reliability analysis

The internal consistency was assessed by calculating Cronbach's α coefficient and split-half reliability for both the overall scale and each dimension. To test the external stability of the scale, a random sample of 30 participants was selected for retesting after 30 days, and the test–retest reliability was calculated. A significance level of $P<0.05$ was used to determine the statistical significance of differences in the study.

Validity analysis

(1) Content validity: The content validity index of the scale was calculated using the overall content validity index and expert ratings of the importance of each item in the scale. (2) Structural validity: After item analysis, exploratory factor analysis was conducted using SPSS 21.0 software to evaluate the structural validity of the scale.

Bartlett's sphericity test and the (KMO) test were used to evaluate the suitability of the factor analysis, and principal component analysis and varimax rotation were used to extract the factors. Specifically, (1) four common factors were extracted using the fixed-factor extraction method; (2) each factor contained at least three items, with each item having a loading value>0.5 on one of the factors; and (3) the factor structure was consistent with the scree plot test principle and was easy to name. Confirmatory factor analysis was conducted using AMOS 23.0 to further evaluate the structural validity and degree of fit.

Methods of statistical analysis

Data processing and analysis were conducted using SPSS 21.0 and AMOS 23.0 software. Normally distributed continuous variables were described as the means±standard deviations (x±s), whereas independent samples t tests were reported as variables with equal variances. Counts and percentages (%) were used to describe categorical variables, and group comparisons were performed via chi-square tests. The authority coefficient (Cr) of the experts was calculated as the average of their judgment coefficient and familiarity coefficient. Here, the judgment coefficient refers to the basis for the experts' assessment of the importance of each item, and the familiarity coefficient refers to the experts' familiarity with the item content. The degree of agreement among the experts was measured using Kendall's W coefficient. Content validity was assessed by calculating the item content validity index on the basis of the overall content validity index and expert ratings of the importance of each item. Structural validity was assessed using exploratory factor analysis via SPSS 21.0, with evaluation on the basis of the suitability of Bartlett's sphericity test and the KMO measure of sampling adequacy. Factors were extracted using principal component analysis with varimax rotation, with four common factors retained such that each contained at least three items and its loadings were greater than 0.5. Convergent validity was assessed via confirmatory factor analysis with AMOS 23.0. Internal consistency reliability was assessed via Cronbach's alpha coefficient, and test–retest reliability was assessed using the intraclass correlation coefficient.

Ethical approval

The study was approved by the Ethics Committee of Yichang Central People's Hospital (Approval number: No. 2023-038-01). All participants in the study provided informed consent and were free to withdraw from the study at any time for any reason. Additionally, they were assured that the survey questionnaire would only be used for research purposes.

Results

Results of expert inquiries

The response rates for the two rounds of expert questionnaires were 100% and 93.33%, separately. The authority coefficients of the experts were 0.837 and 0.887, and

the item coefficient of variation ranged from 0.06 to 0.18. After two rounds of expert inquiry, according to expert opinions and discussions among the research team, six items were deleted; for example, "Your understanding of the concept of Internet+nursing services" was deleted, as experts thought it was unnecessary. The four items were merged with "Do you think nurses involved in "Internet+Nursing Service" need to undergo knowledge and ability assessments?", as the experts thought that both theoretical assessment and operational assessment belong to the scope of ability assessment. Two items were added, as the experts thought that the legality concerns nurses engaging in "Internet+Nursing Services" without prescribing authority. This resulted in a preliminary version of the Nurse "Internet+Nursing Services" Participation Willingness Obstacle and Facilitation Factor Rating Scale, which consists of 4 dimensions and 37 items.

Findings of the pilot study

In accordance with the feedback from the presurvey, the order, wording, and phrasing of the questionnaire items were further adjusted and improved to ensure that each item was expressed clearly and in a common and easy-to-understand manner. The overall form of the questionnaire was not modified, and no dimensions or items were added or deleted. In addition, on the basis of the results of the presurvey, the average time for completing the questionnaire was 348.10±92.413 s, with a minimum value of 174 s and a maximum value of 535 s. Thus, to ensure the quality and validity of the questionnaire results, by combining the pilot study findings and team discussion, we excluded the results from the questionnaires for which the completion time was less than 180 s.

Characteristics of the participants

From February to March 2022, the first round of the questionnaire survey yielded a total of 808 completed questionnaires, with 695 valid questionnaires and an effective response rate of 86.01%, and these responses were subject to exploratory factor analysis. From March to April 2023, the second round of the questionnaire survey yielded a total of 639 questionnaires, with 538 valid questionnaires and an effective rate of 84.19%, and these responses underwent confirmatory factor analysis. There were no statistically significant differences in sex, age, hospital level, or other factors among the participants in the EFA and CFA (all $P>0.05$) (Table 1).

Item analysis

The 695 valid questionnaires from the first round of the survey were subjected to item analysis. Five items with a Cronbach's α coefficient that significantly increased after deletion were removed, and seven items with a total correlation coefficient that was less than 0.400 were deleted. The extreme group comparison method revealed statistically significant differences ($P<0.05$ and t value>3.000) between the high- and low-score groups for each item. Finally, 25 items with good discrimination ability were retained for factor analysis, including nine items for performance expectations, five items for perceived risk, seven items for professional knowledge training requirements, and four items for nonprofessional knowledge training requirement. These items were used to form the initial draft of the Nurse Participation Willingness Obstacle and Promotion Factors Assessment Scale for "Internet+Nursing Services", which consists of four dimensions and 25 items.

Reliability analysis

The scale and its four dimensions have ideal internal consistency and split-half reliability, with internal consistency values ranging from 0.902 to 0.978 for each dimension and a total internal consistency of 0.955. The split-half reliability for each dimension ranges from 0.897 to 0.973, and the total split-half reliability is 0.778. In addition, 30 survey participants were randomly selected for retesting after 30 days, and the test–retest reliability for each dimension ranged from 0.609 to 0.768, with a total test-retest reliability of 0.944 (all $P<0.001$) (Table 2).

Validity analysis

Content validity

Twenty experts from 12 hospitals in 6 different provinces and cities in China were invited to evaluate the content validity of the scale. The results revealed that the content validity index of the scale (S-CVI) was 0.914, and the content validity index of the items (I-CVI) ranged from 0.776 to 1.000.

Structural validity

The results of the exploratory factor analysis revealed that the KMO value was 0.960, and the test value χ^2 of Bartlett's test of sphericity was 22558.002 ($P<0.001$). The percentage of the explanatory variance of the four extracted common factors was 83.147%, indicating that the scale had good construct validity. The loading values of the items on each corresponding factor ranged from 0.542 to 0.901. Items 22, 23, 24, and 25 had loading values greater than 0.4 for two factors but with a difference of less than 0.2, so they were retained and tentatively assigned to the "additional knowledge requirements" dimension on the basis of the previous hypothesis and professional context (Table 3). Finally, we extracted four factors, each containing at least three items, and the scree plot showed a flat slope after the fifth factor (Fig. 3).

Table 1 General demographic characteristics (EFA, $n=695$; CFA, $n=538$)

Category	Group		Statistic (*P* value)
	EFA (number/percent)	CFA (number/percent)	
Age (years)	34.74 ± 7.832	34.36 ± 7.780	$t=0.858$ (0.391)
Gender			$\chi^2=1.365$ (0.243)
Female	37 (5.3)	21 (3.9)	
Male	658 (94.7)	517 (96.1)	
Professional title			$\chi^2=2.731$ (0.255)
Primary	289 (41.6)	249 (46.3)	
Intermediate	346 (49.8)	247 (45.9)	
Advanced	60 (8.6)	42 (7.8)	
Position			$\chi^2=1.115$ (0.291)
Nurse	612 (88.1)	484 (90.0)	
Head nurse or above	83 (11.9)	54 (10.0)	
Working years			$\chi^2=2.776$ (0.427)
$0<Y<5$	102 (14.7)	93 (17.3)	
$5\le Y<10$	201 (28.9)	152 (28.3)	
$10\le Y<15$	196 (28.2)	159 (29.5)	
$15\le Y$	196 (28.2)	134 (24.9)	
Marital status			$\chi^2=1.111$ (0.574)
Unmarried	98 (14.1)	82 (15.2)	
Married	577 (83.0)	445 (82.7)	
Divorce or bereavement	20 (2.9)	11 (2.1)	
Educational background			$\chi^2=2.243$ (0.134)
Undergraduate or below	148 (21.3)	134 (24.9)	
Bachelor degree or above	547 (78.7)	404 (75.1)	
Specialist nurse			$\chi^2=0.001$ (0.971)
Yes	219 (31.5)	169 (31.4)	
No	476 (68.5)	369 (68.6)	
Children's situation			$\chi^2=3.235$(0.198)
Childless	147 (21.2)	133 (24.7)	
1 child	449 (64.6)	342 (63.6)	
2 or more	99 (14.2)	63 (11.7)	
Hospital grade			$\chi^2=2.224$(0.329)
Tertiary hospital	278 (40.0)	195 (36.2)	
Secondary hospital	339 (48.8)	285 (53.0)	
Primary hospital	78 (11.2)	58 (10.8)	

Note: EFA = Exploratory factor analysis; CFA = Confirmatory factor analysis

Table 2 Reliability analysis results of the barriers and facilitators scale for nurses' participation intention "Internet + Nursing Services" ($n=695$)

Dimension	Reliability coefficient		
	Cronbach's α coefficient	Split-half reliability	Test–retest reliability
Performance expectation	0.969	0.958	0.768**
Perceived risk	0.902	0.897	0.652**
Professional knowledge needs	0.978	0.965	0.609**
External knowledge needs	0.974	0.973	0.762**
Total scale	0.955	0.778	0.944**

Note: $^{**}P<0.01$

Confirmatory factor analysis

Between March and April 2023, five additional hospitals in Hubei Province were surveyed, and a total of 538 valid questionnaires were collected. Confirmatory factor analysis was conducted using maximum likelihood estimation. The results revealed that the 3-factor model did not meet the reference standard for several indicators and that the 4-factor model performed better than the 3-factor model for all indicators, but the RMSEA and AGFI indicators did not reach the ideal values. Therefore,

Table 3 Exploratory factor analysis results of the barriers and facilitators scale for nurses' participation intention for "Internet + Nursing Services" ($n = 695$)

Items	Factor				Commonality
	Professional knowledge needs	Performance expectation	Perceived risk	External knowledge needs	
1. You think that "Internet + Nursing Services" can optimize the allocation of nursing resources	0.224	**0.852**	0.031	0.081	0.784
2. You think that "Internet + Nursing Services" can reflect the value of nursing services and improve personal income	0.259	**0.849**	0.019	0.028	0.788
3. You think that "Internet + Nursing Services" can broaden the practice development path and promote the development of the nursing discipline	0.283	**0.860**	0.013	0.087	0.828
4. You think that "Internet + Nursing Services" can enhance the influence of hospitals and alleviate the demand for medical treatment	0.274	**0.858**	0.037	0.155	0.837
5. You think that "Internet + Nursing Services" can improve the utilization rate of medical resources and alleviate nursing staff shortages	0.214	**0.881**	-0.016	0.010	0.822
6. You think that "Internet + Nursing Services" can improve the quality of nursing services	0.280	**0.887**	0.013	0.124	0.881
7. You think that "Internet + Nursing Services" can facilitate patients and provide nursing services to more home patients	0.319	**0.800**	0.068	0.164	0.774
8. You think that the home care environment of "Internet + Nursing Services" is better	0.241	**0.835**	-0.022	0.053	0.759
9. You think that "Internet + Nursing Services" can improve your life satisfaction and happiness	0.225	**0.856**	-0.064	0.017	0.788
10. You think that "Internet + Nursing Services" will increase medical risks and disputes	0.110	-0.090	**0.832**	0.033	0.713
11. You think that there is a lack of personal safety guarantees for corresponding laws and regulations and supporting management systems when there is a dispute in "Internet + Nursing Services"	0.106	0.002	**0.852**	0.070	0.742
12. You are concerned about the legitimacy of nurses having no rights to engage in "Internet + Nursing Services"	0.082	0.024	**0.879**	0.004	0.779
13. You are concerned about residents' acceptance of "Internet + Nursing Services"	0.105	0.088	**0.786**	0.008	0.637
14. You worry about the traffic problems of "Internet + Nursing Services"	0.106	-0.016	**0.851**	0.070	0.740
15. You think it is necessary to perform theoretical and operational training for "Internet + Nursing Services" nurses	**0.883**	0.273	0.113	0.047	0.870
16. You think it is necessary to perform specialized training for "Internet + Nursing Services" nurses	**0.901**	0.293	0.106	0.048	0.910
17. You think it is necessary to perform general training for "Internet + Nursing Services" nurses	**0.881**	0.278	0.097	-0.001	0.864
18. You think it is necessary to perform workflow training for "Internet + Nursing Services" nurses	**0.891**	0.302	0.113	0.076	0.904
19. You think it is necessary to perform professional qualification training for "Internet + Nursing Services" nurses	**0.889**	0.309	0.102	0.063	0.901
20. You think it is necessary to assess the knowledge and ability of "Internet + Nursing Services" nurses	**0.871**	0.314	0.095	0.100	0.877
21. You think it is necessary to perform prejob training and mid-term training for "Internet + Nursing Services" nurses	**0.875**	0.296	0.102	0.154	0.888
22. You think it is necessary to perform language and behavior training for "Internet + Nursing Services" nurses	**0.721**	0.277	0.123	**0.542**	0.905
23. You think it is necessary to perform psychological nursing training for "Internet + Nursing Services" nurses	**0.718**	0.265	0.150	**0.567**	0.929

Table 3 (continued)

Items	Factor				Commonality
	Professional knowledge needs	Performance expectation	Perceived risk	External knowledge needs	
24. You think it is necessary to train the nurses of "Internet + Nursing Services" in nurse–patient communication skills	**0.704**	0.267	0.157	**0.602**	0.954
25. You think it is necessary to perform professional etiquette and ethical training for "Internet + Nursing Services" nurses	**0.697**	0.271	0.131	**0.581**	0.914
Eigenvalue	13.215	4.117	2.698	0.757	
Variance interpretation rate %	52.860%	16.469%	10.791%	3.027%	
Cumulative variance contribution rate (%)	52.860%	69.329%	80.120%	83.147%	
KMO value	0.960				
Bartlett's sphericity test value	22558.002				
df	300				
P value	0.000				

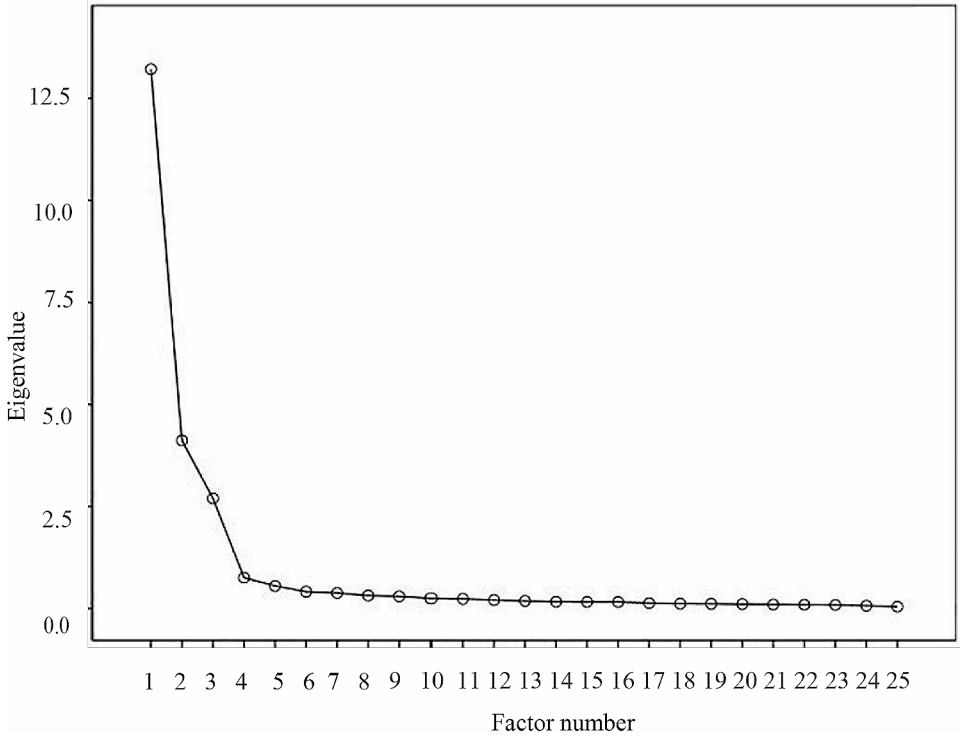

Fig. 3 Flat slope of EFA for the scale of nurses' participation intention for "Internet + Nursing Services"

further modifications were made to the various factor models. After multiple revisions, the 3-factor model did not meet the standards unless the "extra knowledge requirement" item was completely deleted. This finding indicated that the two cannot be attributed to the same factor dimension. The initial results of the 4-factor model revealed that the modification indices (MIs) between e1 and e2 and between e10 and e11 were relatively large. Considering that the two sets of items measured similar traits, there may be some degree of correlation in the measurement error of the measurement indicators. Thus, a covariation relationship was established between e1 and e2 as well as between e10 and e11 to correct the model. On the basis of the reference standards for evaluating model fit indicators [23], the final 4-factor revised model was well adapted and had good construct validity (Table 4; Fig. 4). The average variance extraction (AVE) values of the four dimensions of performance expectations, risk perception, professional knowledge requirements, and extra knowledge requirements were 0.789, 0.658, 0.871, and 0.907, respectively, all of which were greater than 0.5. The composite reliability (CR) values

Table 4 Results of the confirmatory factor analysis model fit indices ($n = 538$)

Verify indicators		Absolute fit measures							Relative fit measures			
		CMIN	df	CMIN/df	RMSEA	RMR	GFI	AGFI	CFI	TLI	NFI	IFI
Reference standard				< 5.00	< 0.08	< 0.05	> 0.80	> 0.80	> 0.90	> 0.90	> 0.90	> 0.90
Monitor value	3-factor model	2302.662	272	8.466	0.118	0.031	0.703	0.645	0.890	0.878	0.877	0.890
	4-factor initial model	1307.312	269	4.860	0.085	0.028	0.829	0.793	0.944	0.937	0.930	0.944
	4-factor modified model	1130.435	267	4.234	0.078	0.026	0.848	0.815	0.953	0.947	0.940	0.953

Note: CMIN = minimum value of the discrepancy C; df = degrees of freedom; RMSEA = root mean square error of approximation; RMR = root mean square residual; NFI = normed fit index; RFI = relative fit index; IFI = incremental fit index; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; PCFI = parsimony fit index; PNFI = parsimony normed fit index; CFI = comparative fit index; TLI = Tucker–Lewis index

were 0.971, 0.905, 0.979, and 0.975, respectively. All of these values were greater than 0.7, indicating that the questionnaire had good convergent validity. The correlation coefficients between the four dimensions ranged from 0.253 to 0.888. The square root of the AVE of performance expectations was 0.888, with the maximum interfactor correlation coefficient being 0.672. The square root of the AVE of risk perception was 0.811, with the maximum interfactor correlation coefficient being 0.315. The square root of the AVE of the professional knowledge requirement was 0.933, with the maximum interfactor correlation coefficient being 0.872. The square root of the AVE of the extra knowledge requirement was 0.952, with the maximum interfactor correlation coefficient being 0.888. The square root of the AVE of each dimension was greater than the correlation coefficient between that dimension and the other dimensions, indicating good discriminant validity among the four dimensions (Fig. 4). Path analysis revealed that all the dimensions were significant ($p < 0.001$), indicating that the hypothesis model in the early stage of this study was valid (Table 5).

Discussion

Necessity and innovation of scale development

Reducing premature mortality from major chronic diseases is one of the main indicators of the "Healthy China 2030" planning outline [24], which requires a comprehensive strategy for the prevention and control of chronic diseases throughout the entire lifespan of an individual. "Internet + Nursing Services" form a closed-loop management system for patients during in-hospital treatment and postdischarge rehabilitation, which is a powerful measure to promote hierarchical diagnosis and treatment and reduce medical costs [25]. However, the top-level design of the system and regulations for chronic disease management based on "Internet +" remain unsatisfactory, and the management team used for chronic diseases is still in the developmental stages [9]. Therefore, the construction of nursing staff qualifications, talent training, quality supervision, and other aspects is crucial for the development of "Internet + Nursing Services" [26, 27]. According to the research results of Jia et al., the awareness and willingness of nurses to participate in "Internet + Nursing Services" are relatively low, with 37.00% of nurses willing to participate, 18.40% refusing to participate, and 44.60% undecided [28]. Therefore, only by first understanding the cognitive level, concerns, and needs of nursing staff can targeted training programs be developed. Currently, no tool is available to assess the obstacles and promoting factors for nurse participation in "Internet + Nursing Services". This study aimed to establish an effective evaluation system for identifying the factors that promote and inhibits nurses' participation in "Internet + Nursing Services", providing a reference

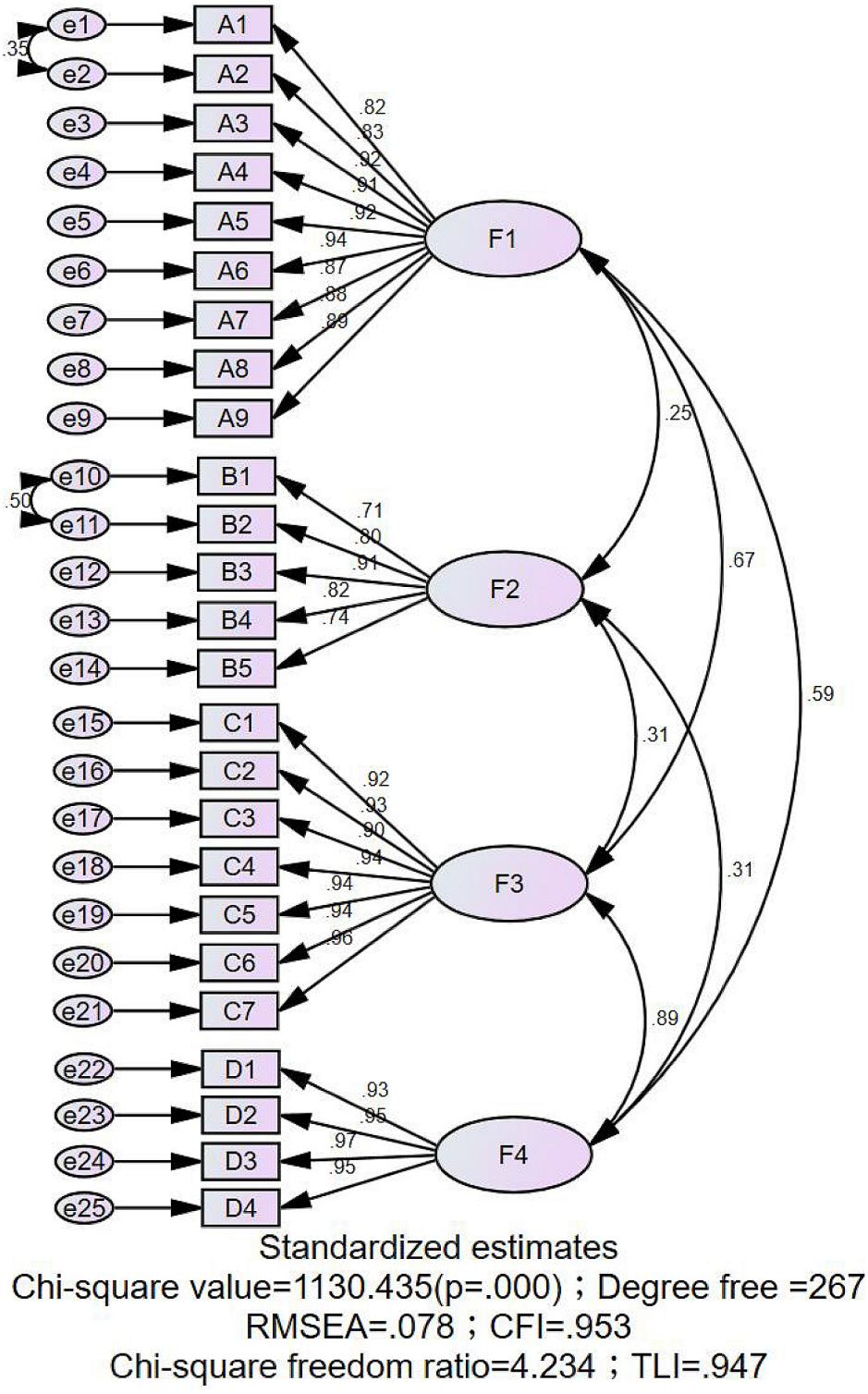

Fig. 4 Standardized and adjusted model diagram for the four-factor confirmatory factor analysis. Note: F1 = Performance expectation; F2 = Perceived risk; F3 = Professional knowledge needs; F4 = External knowledge needs

Table 5 Path coefficients of the initial hypothesis model

Name			Estimate	SE	CR	*P* value
Performance expectation	<—>	External knowledge needs	0.287	0.027	10.801	< 0.001
Perceived risk	<—>	Professional knowledge needs	0.319	0.027	11.669	< 0.001
Performance expectation	<—>	perceived risk	0.100	0.019	5.175	< 0.001
External knowledge needs	<—>	Professional knowledge needs	0.511	0.036	14.324	< 0.001
Professional knowledge needs	<—>	Perceived risk	0.150	0.024	6.310	< 0.001

for the training and evaluation of nursing staff in "Internet+Nursing Services". "Internet+Nursing Services" remain in the early stages of development in China and face many difficulties and challenges. The research team has developed a scale for assessing the barriers to and facilitators of nurse participation in "Internet+Nursing Services". Through assessing nursing staff's knowledge level, confusion, and needs, targeted knowledge training can be provided, theoretical knowledge can be updated, and regulations and systems can be gradually improved, providing a theoretical and evaluation tool for the sustained and healthy development of "Internet+Nursing Services" innovation.

The scientific basis and practicability of the scale

The item pool and preliminary draft of the scale were established under the guidelines of UTAUT model theory [11, 12]; after reviewing the relevant literature and policy documents, the results of the study group discussion and expert consultation were combined. To ensure the appropriateness of the expression of the scale items for the current professional cultural background in China, clinical nursing experts and nursing management experts with extensive qualifications in this field were selected for interviews to ensure the accuracy of the language and clarity of the content. On this basis, 20 authoritative experts in the research field were selected for two rounds of expert consultation using the Delphi method. The content of the scale was adjusted repeatedly according to expert opinions and group discussions.

The total correlation coefficient method, internal consistency coefficient method, critical ratio method, and homogeneity test method were used to screen the scale items, and the structure was reasonable. Exploratory factor analysis was used in conjunction with the scree plot to extract factors from each dimension item to ensure the reliability and accuracy of the analysis results. Confirmatory factor analysis was also used to validate the structural validity and fit of the model. Finally, the internal consistency coefficient, split-half reliability, and test–retest reliability were used to analyze the reliability of the scale.

The overall process of scale development in this study complied with the development procedure, and the process and methods were rigorous and highly scientific. The formal scale item content was clearly expressed and easy for nurses to understand, and the dimension results were clear and comprehensively reflect the content structure of the current barriers to and facilitators for nurses' willingness to participate in "Internet+Nursing Services" in China. For example, the performance expectation dimension reflects nurses' emotional experiences of the advantages and development prospects of "Internet+Nursing Services"; the perceived risk dimension reflects nurses' concerns and confusion about engaging in "Internet+Nursing Services"; and the knowledge training requirements dimension reflects nurses' self-assessment of core competency in engaging in "Internet+Nursing Services" and their need for knowledge acquisition within and outside of their profession.

Scientific evaluation tools are beneficial for motivating clinical nurses to evaluate and improve their own abilities and provide a reference for nursing managers to evaluate and train nurses. Therefore, the structure of the scale developed in this study is reasonable and can be used to assess obstacles effectively and promote nurses' willingness to participate in "Internet+Nursing Services". This method has high scientific and practical value.

Scale reliability and validity

The results of the reliability and validity analysis of this study show that the overall Cronbach's α coefficient of the scale is 0.955, indicating that the scale meets the requirements of an ideal measurement tool [29]. The split-half reliability coefficient is 0.778, and the test–retest reliability coefficient is 0.944, indicating that the data have high reliability and that the scale has good internal consistency and external stability [30]. Exploratory factor analysis was conducted using the total scale in this study, and the KMO value of the scale was 0.960, with a Bartlett's sphericity test value of $\chi^2 = 22558.002$ ($p < 0.001$). After multiple explorations using principal component analysis and varimax orthogonal rotation methods, four factors and 25 items were extracted. The factor loadings ranged from 0.542 to 0.901, and all of the values were above 0.4. In addition, the cumulative variance contribution rate of each dimension was 83.147%. The factor loading coefficients of the scale's confirmatory factor analysis were all greater than 0.7, with AVE values ranging from 0.658 to 0.907, all of which were greater than 0.5. The CR values ranged from 0.905 to 0.979, all greater than 0.7, indicating that the model has good convergent validity. The square

root of the AVE of each dimension was greater than the correlation coefficient between this dimension and other dimensions, indicating good discriminant validity among the four dimensions [31]. The overall content validity index (CVI) of the scale was 0.914, which is greater than 0.80, and the validity level coefficients of each item ranged from 0.776 to 1.000, meeting the requirements of the content validity index of the scale and indicating that the scale has good content validity [32].

Limitations and perspectives

In this study, an analysis was not conducted on the measurement invariance of the scale for different groups, and it remains unclear whether there are differences in application among different characteristics and populations [33]. Regarding next steps, we will conduct group testing research and reevaluate the scale via generalizability theory (GT) to further validate and improve its reliability and validity [34]. Moreover, most of the study participants were limited to the central and southern regions of China, and "Internet+Nursing Services" are still in the early stages of development in China, thus possibly leading to some bias in the results. Therefore, in the future, it is necessary to expand the scope of the research to include multiple centers and larger sample sizes. Furthermore, as "Internet+Nursing Services" continue to develop, the items of each dimension of the scale also need to be further adjusted and improved in subsequent practical applications.

Conclusion

This study developed a scale consisting of four dimensions and a total of twenty-five items to assess the barriers to and facilitators of nurse participation in "Internet+Nursing Services". The scale objectively reflects nurses' willingness to participate in "Internet+Nursing Services" based on policy guidelines for the industry's development, facilitators of and obstacles to nurses' practice in "Internet+Nursing Services", and self-evaluations of nurses' abilities and needs. The validity and reliability of the scale for evaluating the barriers to and facilitating factors of nurse participation in "Internet+Nursing Services" were verified, and the scale can be used as an evaluation tool for measuring nurses' willingness to participate in "Internet+Nursing Services".

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Author contributions

The research design, data analysis, and writing of the paper were contributed by Fei Tian, Zuyang Xi, and Zhekang Peng. Shengmin Gui and Jinglan Liu distributed and collected the questionnaires. Min Liu and Ting Zhang was responsible for writing the paper and verifying the English version. Yuanyuan Mi were responsible for analyzing the data, while Zhaohui Zhang and Xingguang Qu was responsible for designing the study and providing statistical guidance. All authors have read and approved this manuscript.

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Data availability

Due to the need to protect the privacy of the consultation experts, the data sets generated and analyzed during this study will not be publicly available. However, they can be obtained from the corresponding author upon reasonable request at 90347043@qq.com.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Helsinki Declaration. All methods were performed in compliance with relevant guidelines and regulations. The study was approved by the Ethics Committee of Zhongxin People's Hospital of Yichang City (Approval No. 2023-038-01). All participants in the study provided informed consent and had the right to withdraw from the study at any time for any reason. Furthermore, they were assured that the survey would be used only for research purposes.

Consent for publication

Written informed consent for publication was obtained from all participants.

Competing interests

The authors declare no competing interests.

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