Design and Psychometric Evaluation of the Mobile Health Tool Acceptance Scale for Nurses (NMHDA-Scale): Application of the Expectation-Confirmation Theory

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Abstract

Background: The use of mobile health tools in nursing care is indispensable. Given the importance of nurses' acceptance of these tools in providing nursing services

Objective: This study aimed to design the Mobile Health Tool Acceptance Scale for nurses based on the Expectation-Confirmation Theory and to evaluate it psychometrically

Methods: In this methodological study, using a Waltz-based approach grounded in existing tools, and considering the constructs of the Expectation-Confirmation Theory, the initial version of the scale was designed, and its face and content validity were assessed. A total of 250 eligible clinical nurses in Kashan City in the year 1401 were selected through a stratified random sampling method The construct validity was examined using exploratory factor analysis, concurrent validity, known-group comparison, and reliability were assessed using internal consistency and stability. Ceiling and floor effects were also evaluated. Data were analyzed using SPSS, including exploratory factor analysis, one-way analysis of variance, intraclass correlation coefficients, Pearson correlation, and Cronbach's alpha and omega coefficients

Results: The initial version of the scale consisted of 33 items. In the stage of qualitative and quantitative content validity, one item was added and one item was removed. Exploratory factor analysis with the retention of 33 items identified 6 factors (explained variance = 70.539%). A significant positive correlation was found between the scores of the designed tool and nurses' attitudes toward the use of mobile-based applications in nursing care ($r = 0.655$, $p < 0.001$). There was a significant difference in the acceptance score of the Mobile Health Tool Acceptance Scale among nurses based on their agreement or disagreement with the use of mobile health tools in nursing care ($p < 0.001$). The intraclass correlation coefficients, Cronbach's alpha, and omega coefficients were 0.938, 0.953, and 0.907, respectively. The standard measurement error and the smallest detectable change were calculated as 0.184 and 1.91, respectively. The minimum and maximum possible scores that could be obtained from the scale were zero.

Conclusions: The 33-item scale developed can be used as a valid and reliable instrument to measure the acceptance of mobile health tools among nurses

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Design and Psychometric Evaluation of the Mobile Health Tool Acceptance Scale for Nurses (NMHDA-Scale): Application of the Expectation-Confirmation Theory

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Abstract:

The use of mobile tools in nursing care is indispensable. Given the importance of nurses' acceptance of these tools in providing nursing services, this study aimed to design the Mobile Health Tool Acceptance Scale for Nurses based on the Expectation-Confirmation Theory and to evaluate it psychometrically. Using a Waltz-based approach grounded in existing tools and considering the Expectation-Confirmation Theory constructs, the scale's initial version was designed, and its face and content validity were assessed. The construct validity was examined using exploratory factor

analysis, concurrent validity, and known-group comparison, and reliability was assessed using internal consistency and stability. The initial version of the scale consisted of 33 items. In the qualitative and quantitative content validity stage, one item was added, and one item was removed. Exploratory factor analysis with the retention of 33 items identified six factors (explained variance = 70.53%). A significant positive correlation was found between the scores of the designed tool and nurses' attitudes toward using mobile-based applications in nursing care ($r = 0.655$, $p < .001$). The intraclass correlation coefficients, Cronbach's alpha, and omega coefficients were 0.938, 0.953, and 0.907, respectively. Similar studies in this field have used measurement tools to assess the use of mobile devices in different groups in general. It is important to use a psychometric tool that is specifically designed for nurses. The 33-item scale developed can be a valid and reliable instrument to measure nurses' acceptance of mobile health tools

Keywords: Mobile Health, Acceptance, Psychometric Evaluation, Nursing, Expectation-Confirmation Theory

Introduction:

Mobile phones and other electronic devices are becoming increasingly important among healthcare professionals[1]. These devices and mobile applications offer numerous benefits to healthcare professionals[2], including time savings[3], cost-effectiveness[4], improved self-efficacy[5], increased access to evidence-based resources[6], reduced medication errors[5], decision support[6], medication guides and guidelines[5], video chats with other physicians, alerts, patient education[7], and improved communication[5]. Since the majority of hospital staff are nurses[8], with an estimated

number of around 140,000 nurses in Iran, according to a report from the Ministry of Health (2018) [9], it has been reported that approximately 80% of them use mobile phones[8]. Another similar study indicates that 98% of nursing students use mobile phones to access drug guidelines, while 83% use them for medical terminology [10]. Unfortunately, hospitals do not provide personal mobile phones, and their use may raise concerns for healthcare organizations, potentially leading to healthcare organizations implementing policies to restrict the use of mobile phones [11]. These concerns may include nurses' distraction[12], infection control concerns[13], and patient privacy concerns[14]. Considering the importance of nurses' use of mobile phones in their professional practice and the widespread population of the nursing profession[15], healthcare stakeholders, managers, and planners should develop policies for mobile phone use in nursing care and ensure its continuity[16]. To achieve this, the first step is to assess the current situation, which requires a suitable tool. The desired tool should propose a comprehensive model based on individuals' characteristics, technology, and tasks and validate it. This model considers user satisfaction, confirmation, M-health continuance, maturity, mobility, individual performance, perceived usefulness, and personal habits[17]. In similar studies, tools used to identify the specific needs of different stakeholders, such as physicians, nurses, and patients, who have other priorities and requirements for using mobile tools, have not been designed. Many of these tools are general questionnaires used in healthcare and other industries, such as mobile banking and e-commerce, and are not specifically designed for nursing [18]. This is even though, from a socio-technical perspective, identifying behavioral and social factors among users of information technology tools, in conjunction with technical factors, has been highly emphasized [19]. On the other hand, the tools used in these studies do not adhere to appropriate psychometric principles and often lack background, individual, social, organizational, and cultural factors in their tool design [20]. research studies have not found a tool with a suitable theoretical framework designed and localized specifically for nursing based on research and psychometric principles. Additionally, some healthcare

organizations are actively pursuing the establishment of mobile health stations. Therefore, this current study aimed to design and psychometrically validate a Mobile Health Acceptance Tool among clinical nurses in Iran based on the constructs proposed in the Expectation-Confirmation Theory. According to behavior change theories, such as the confirmation-expectation theory, nurses who have a positive perception of using mobile devices in healthcare and believe in their usefulness, effectiveness, and ease of use are more likely to adopt mobile health tools. The concept of acceptance has been explained using the constructions of the confirmation-expectation theory. The scale of accepting the use of mobile health tools by nurses includes questions about different dimensions of attitude, belief, and desire towards the use of mobile tools in providing nursing services based on ECM theory structures The utilization of confirmation-expectation theory to define acceptance of usage behavior, focusing on principles and stages of tool design according to the theory, and the varied research units based on individual characteristics, particularly employment context, were key strengths of the study.

Materials and Methods:

The researchers initially aimed to identify factors influencing nurses' adoption of mobile devices using the ECM model. They identified influential factors such as security risk, new technology anxiety, subjective norm, perceived ease of use, and approval. Subsequently, they reviewed other studies on mobile application evaluation and created a preliminary list of measurement items.

This research used a tool design and psychometric validation approach, conducted in two phases as follows:

Preliminary Phase: Designing the Initial Version of the Tool

Researchers In the preliminary phase, the tool was designed based on the four-stage approach of Waltz and colleagues[21]. Firstly, the concept to be measured and its constructs were identified based on the Expectation-Confirmation Model. Secondly, based on the characteristics of the acceptance

concept in the ECM, measurement objectives based on seven constructs were determined: perceived ease of use, perceived social norm, perceived new technology anxiety, personal habit, perceived security risk, confirmation, maturity, and perceived usefulness. In the third stage, the initial draft of the tool was developed. This involved conducting a comprehensive search of both Persian and English articles in national and international databases, including PubMed, Ovid, Scopus, Web of Science, Magiran, IranDoc, Noor Mags, Science Direct, Jihad Daneshgahi Scientific Information Center, ProQuest, CINAHL, and SAGE, without time restrictions. The search utilized keywords related to mobile health, nursing, acceptance, scale, and attitude. All the articles were critically reviewed, and the scales used to measure their acceptance of mobile health tools were identified. Items from existing tools, such as perceived usefulness, user satisfaction, acceptance, and others[22-25], were gathered from relevant texts, reviewed, categorized, and then, after integrating overlapping and eliminating inappropriate items, the research team determined the appropriate number of items for each decision domain. In the fourth phase, which involved the tool's development, ~~the items' wording was defined based on the conceptual constructs of the theory.~~ The researchers defined the case wordings based on the theory's conceptual structures. They were then revised, and scoring rules were established. Considering the cultural context of Iranian society and the organizational structure of Iranian hospitals, the research team reviewed the items designed based on existing tools.

Regarding item scoring, the Likert seven-point scale (ranging from 1, completely disagree, to 7, completely agree) was employed, following the principles commonly used in attitude measurement tool design. For negatively phrased questions, reverse scoring was applied[26]. The average score of all items was considered the total score of the tool.

Phase Two: Psychometric Validation of the Tool

Step 1: Face and Content Validity Assessment:

The preliminary questionnaire was provided to 10 experts with expertise in nursing, tool design, psychometric validation, health information management, and health informatics to assess qualitative

content validity. In the section on instrument validity assessment, a qualitative approach was initially used by consulting experts to gather their opinions regarding the questionnaire's comprehensibility, grammar, language, scoring, key aspects, essential components of the concept under investigation, question parts, [27]the adequacy of the questions, as well as the clarity and simplicity of the items. Based on the feedback received from these experts, necessary revisions were made to the instrument.

For quantitative content validity assessment, the Content Validity Ratio (CVR) Strict, Content Validity Index (CVI), and Modified Kappa statistic (Kappa Modified) were employed. For each item, CVRStrict was calculated, taking into account the necessity level. CVI and Modified Kappa were also calculated for each item, considering the relevance criterion[28]. The Lawshe table, Waltz and Bausell's index, and Polit and Beck's viewpoint were utilized to judge the results regarding CVI, CVR, and Modified Kappa results. Also, to calculate the overall CVI for the entire instrument, the S-CVIAverage was used [29].

To assess face validity qualitatively, regardless of the examination conducted by experts, the questions in the questionnaire were individually read aloud to 10 clinical nurses by the article's first author. Their interpretations of each question were compared to the original intent. The research team revised the items in cases of ambiguity, inconsistency, or difficulty understanding the questions[30]. Additionally, a professional Persian language editor was consulted during this phase

For the quantitative face validity assessment, the opinions of the nurses regarding the importance of each item were collected individually. They were asked to rate the importance of each item on a Likert 5-point scale, and based on these ratings, an item impact score was calculated for each item. An item impact score above 1.5 was desirable for each item[31].

Step 2: Questionnaire Item Analysis, Construct Validity (Factor Analysis, Concurrent Validity, Comparison of Known Groups), and Ceiling and Floor Effects

Some experts recommend a sample size of 100 to 300 individuals for the psychometric validation of

a tool, regardless of the number of items[31]. Therefore, this study targeted a sample size of 250 individuals. The inclusion criteria were as follows: working in clinical settings (direct patient care), a minimum of six months of work experience in clinical settings, having a university degree in nursing, no known psychological disorders, Iranian citizenship, and consent to participate in the study. The exclusion criteria were an unwillingness to continue cooperation or withdrawal from questionnaire completion during the study.

After assessing the face and content validity of the instrument and obtaining the necessary permissions, the first author of the paper visited the nursing offices of the hospitals and conducted the sampling with the presentation of an introduction letter. Sampling was conducted in a stratified random manner (based on the type of clinical ward) in the years 2021- 2022. Different clinical departments in the hospitals under Kashan University of Medical Sciences coverage were identified, and a list of qualified nurses working in those departments was compiled. A simple random sample of participants was selected based on a random number table from each department in proportion to the required sample size and the number of nurses employed in that department. A questionnaire on personal and occupational information (age, gender, education, marital status, work experience, department of employment, predominant shift, holding positions in nursing management, having a smartphone, type of smartphone operating system, daily internet usage duration, and duration of smartphone usage) was used for the collection of demographic data, along with the initial version of the designed Mobile Health Acceptance Tool (the confirmed version validated in the final phase of face and content validity assessment) and a single-item tool to assess nurses' attitudes towards using mobile-based applications in nursing care, rated on a scale from 1 (completely disagree) to 7 (completely agree). At the beginning of each shift, the department was visited. After obtaining the nurses' consent and providing them with general instructions on how to complete the tools, the questionnaires were collected at the end of the shift. In cases where the questionnaires were not completed on time, an agreement was reached with the relevant nurse. If access was impossible or

cooperation was not obtained from the selected sample, another individual from the same department was randomly chosen as a replacement.

After collecting the data, the analysis of the items was initially performed using the loop method. Then, Exploratory factor analysis (EFA) was conducted to extract data using the Maximum Likelihood method with varimax rotation. Eigenvalues greater than one and scree plots were considered to determine the number of factors. A factor loading above 0.44 was used as a threshold for item retention. Regarding the common factor loads, items were loaded onto the factor that conceptually aligned with them. After factor analysis, the ceiling and floor effects were evaluated. In this way, the instrument's ceiling and floor effects were assessed based on the relative frequencies of samples with the highest and lowest achievable scores[32].

Concurrently, the known-groups comparison method was used to assess the construct validity of the final version of the instrument. Nurses were divided into seven groups, from completely agree to disagree, based on their responses to a question assessing their professional performance when using mobile health applications. The acceptance score for the Mobile Health Tool Acceptance Scale within these groups was compared.

Step 3: Reliability Assessment:

The internal consistency of the entire designed instrument (final version) and its sub-scales (factors extracted in the factor analysis) was calculated over the whole sample using Cronbach's alpha coefficient and McDonald's omega.

The test-retest method [33] was employed to assess the instrument's stability. For this purpose, the final version of the instrument was completed again by ten samples (randomly selected from the study participants) one week apart, and the intra-cluster correlation coefficient between the scores in the two assessments was calculated. SEM and SDC were also estimated [34].

Data Analysis:

Data analysis was performed using version 16 of the SPSS software. Quantitative variables were described using central tendency and dispersion measures, and categorical variables were described using absolute and relative frequencies. CVI, CVR, and the modified kappa statistic were used to assess the content validity quantitatively, and the impact factor was used to determine the quantitative face validity. The normality of quantitative data was assessed using skewness and kurtosis indices (a range of ±2 was considered indicative of normal data). To check the construct validity, exploratory factor analysis was performed using the maximum likelihood method with Varimax rotation. The Kaiser-Meyer-Olkin statistic and Bartlett's test were used to evaluate the suitability of the data for exploratory factor analysis. The Pearson correlation coefficient was used to assess the concurrent validity of the instrument with the single-item attitude measurement scale. One-way analysis of variance was employed to compare known groups. Cronbach's alpha and omega coefficients were utilized to examine the instrument's internal consistency. Intraclass correlation coefficients within categories were calculated to assess the correlation of scores from the two assessments in the retest. SEM was computed based on formula 1, where SD represents the standard deviation of scores, and r is the Cronbach's alpha coefficient.

Formula (1):

$$SEM=SD\sqrt{1-r}$$

SDC was reported based on formula 2. A significance level of less than 0.05 was considered in all analyses.

Formula (2): $SDC=1.96\times\sqrt{(2\times SEM)}$

Results:

Preliminary Phase:

The initial draft of the instrument consisted of 33 items in 7 domains: perceived ease of use, perceived social influence, perceived anxiety about new technology, personal habit, perceived security risk, confirmation, maturity, and perceived usefulness. These domains included 5, 6, 4, 3, 3, 5, 3, and 4 items.

Psychometric Phase:

Stage 1: Content and Face Validity Assessment:

In the qualitative content validity assessment, some items changed in their appearance. For instance, the item "Nurses can easily use mobile app-based applications in patient care" was replaced with "The interaction of nurses with mobile tools for providing nursing services is a simple task." Additionally, the item "The use of mobile apps by nurses in patient care saves time" was added to the perceived ease of use domain.

In the quantitative content validity assessment, the CVR_{Strict} for all items except one removed from the instrument were equal to or higher than the acceptable value in the Lawshe table (the minimum acceptable CVR for ten experts is 0.62). The CVI and the modified kappa statistic calculated for the 33 retained items in the CVR assessment were within the range of 0.80 to 1. Additionally, the $S\text{-}CVI_{Average}$ was calculated at 0.98.

In the face validity assessment, no changes were made to the items. Also, in the quantitative face validity assessment, the impact score for all items was calculated to be above 1.5.

In summary, based on the changes made in the initial psychometric phase, the final version of the instrument consisted of 33 items.

Stage 2: Questionnaire Item Analysis, Construct Validity (Factor Analysis, Concurrent Validity, Comparison of Known Groups), and Ceiling and Floor Effects

During the sampling process, 357(%44) eligible nurses out of 810 were selected. Among them,

107(%29/9) nurses did not consent to participate, resulting in data analysis for 250 (%70)individuals.

The mean age of the participants was 35.624 ± 7.582 years, and their work experience averaged 11.594 ± 6.722 years. Over 231(92%)of the participants owned mobile phones; on average, they had used this technology for approximately nine and a half years (Table1).

Table 1: Characteristics of clinical nurses working in hospitals under the coverage of Kashan University of Medical Sciences, 2022 (n = 250) (Categorized Variables)

Count (%)	Variable	
44(17/6)	Male	Gender
206(82/4)	Female	
201(80/4)	Married	Marital Status
47(18/8)	Single	
2(0/8)	Divorced	
0	Widow	
217(86/8)	Bachelor's	Education
33(13/2)	Master's	
0	Doctorate	
23(9/2)	Emergency	Department of Employment
31(12/4)	Internal	
50(20/0)	General Surgery	
51(20/4)	Intensive care unit	
7(2/8)	Pediatrics	
34(13/6)	Operating Room	
54(21/6)	Other	
49(19/6)	Yes	Holding a Position in Nursing Management Levels
201(80/4)	No	
114(45/6)	Morning	Primary Shift
29(11/6)	Evening	
36(14/4)	Night	
71(28/4)	Rotating	
231(92/4)	Yes	Having a Smartphone
19(7/6)	No	
207(82/8)	Android	Mobile Operating System (if smartphone) N=231
24(9/6)	Apple iOS	
49(19/6)	Less than 1 hour	Duration of Internet Usage During the Day
91(36/4)	1 to 2 hours	
62(24/8)	2 to 4 hours	
48(19/2)	More than 4 hours	

The item analysis determined that removing any items with correlation coefficients less than 0.30 or greater than 0.70 with the total score would not significantly affect the instrument's alpha coefficient. Therefore, all items were retained.

Kaiser-Meyer-Olkin (KMO) measure (0.943) and Bartlett's Test of Sphericity (chi-square = 8651.805, df = 528, p < 0.0001) were performed to assess the suitability of the 33-item instrument for factor analysis, indicating that there were no issues for factor analysis. All items had factor loadings above 0.44, and none of the items were removed in this phase. Factor analysis extracted five factors that explained 70.539% of the total variance of the Mobile Health Tool Acceptance Scale score (Table 2, 3, and Figure 1).

Based on the instrument validated in the exploratory factor analysis (33 items), the Mobile Health Tool Acceptance Scale in Nurses's acceptance score was 4.207±0.740on on a 1 to 7 scale. With 95% confidence, this range was estimated to be between 3.29 and 5.124 for the nursing population working in hospitals under Kashan University of Medical Sciences coverage. The score for nurses' attitudes towards using mobile app-based programs in nursing care, using the single-item tool on a 1 to 7 scale, was 4.340 ± 1.510, estimated with 95% confidence between 2.468 and 6.212 for the target population. In the concurrent validity section, it was revealed that there is a significant positive correlation (p <.001) between the score of the Mobile Health Tool Acceptance Scale and the score of the single-item tool measuring nurses' attitudes, indicating that higher acceptance scores were associated with more positive attitudes (Table3).In the known-groups comparison method, one-way ANOVA showed a statistically significant difference in the score of the Mobile Health Tool Acceptance Scale (as scored from the final 33-item version) among groups based on their agreement or disagreement with using the Mobile Health Tool (p <.001) (Table 4).

In the floor and ceiling effect assessment, the relative frequencies of the nurses' lowest and highest possible scores for the Mobile Health Tool Acceptance Scale were less than 15%.

Stage 3: Internal Consistency and Stability

In the assessment of internal consistency, Cronbach's alpha coefficient and the omega total coefficient for the entire instrument were calculated as 0.938 and 0.953, respectively. Both

coefficients for the five extracted factors were also above 0.88 (Table 2).

In the tool's stability assessment, the instrument's ICC between test and retest scores was 0.907 (95% CI: 0.615 to 0.977, p <.001).

The standard measurement error of the designed instrument was ± 0.184, and the most minor detectable change by the instrument was 1.19, with 95% confidence.

Table 2. Special Values, Explained Variance Percentage, and Internal Consistency Coefficients of the Factors Extracted from the Mobile Health Tool Acceptance Scale in Nurses Along with Their Correlation Coefficients with the Single-Item Attitude Assessment Tool Score

Correlation with the Single-Item Attitude Assessment Tool Score		Internal Consistency Coefficient		Percentage of Variance Explained by Each Factor	Special Value	Question number	Factor
p-value	Pearson Coefficient	Omega	Cronbach's Alpha				
<0.000	0.794	0.923	0.882	20.313	6.703	10	Factor 1
<0.000	0.642	0.919	0.916	14.155	4.671	7	Factor 2
<0.000	0.537	0.935	0.935	13.268	4.378	5	Factor 3
<0.000	0.591	0.950	0.950	11.469	3.844	7	Factor 4
<0.000	-0.447	0.907	0.907	11.155	3.681	4	Factor 5
<0.000	0.655	0.953	0.938	70.539	Total Factors		

Table 3: Items of the Extracted Factors in the Factor Analysis of the Mobile Health Tool Acceptance Scale and Their Factor Loadings

Extracted Factor Number*					Item	Item Number
5	4	3	2	1		
				0.818	Using mobile app-based tools in nursing care, beyond nurses' expectations, helps in team coordination in processing patient information and making appropriate decisions.	23
				0.803	Using mobile app-based tools in nursing care, beyond nurses' expectations, contributes to the improvement of care quality.	22
				0.760	Using mobile app-based tools in nursing care, beyond nurses' expectations, accelerates the execution of therapeutic and care interventions.	24
				0.741	Using mobile app-based tools in nursing care, beyond nurses' expectations, assists in the proper and effective implementation of clinical care guidelines and instructions.	26
				0.739	Using mobile app-based tools in nursing care, beyond nurses' expectations, enhances the management of nursing services.	25
	0491			0.576	Nurses can use mobile app-based tools for their primary duties.	27**
				0.573	The more confident nurses are about the security of patients' information when using mobile app-based tools for nursing care, the more they use them.	19
				0.564	Nurses are willing to use mobile app-based tools for care, provided they are confident that patient or hospital data is not accessible to unauthorized individuals.	20
				0.499	Nurses must use mobile app-based tools for nursing care.	18
				0.452	The use of mobile app-based tools in providing nursing care increases the potential risk of unauthorized individuals tampering with patient or hospital data.	21
				0.442	Nurses prefer to use mobile app-based tools in patient care.	17
			0.783		Senior hospital and university managers support the use of mobile app-based tools by nurses.	8
			0.736		Nurses recommend and emphasize the use of mobile app-based tools for care to their colleagues.	9
			0.690		Nursing managers believe that nurses should use mobile app-based tools in patient care.	6
			0.680		Physicians welcome the use of mobile app-based tools in nursing care.	10
			0.595		Messages sent through social media and group media encourage nurses to use mobile app-based tools in patient care.	11
			0.463		Higher authorities such as the Ministry of Health, Treatment, and Medical Education play a vital role in	7

						the use of mobile app-based tools by nurses.	
				0.442		Using mobile app-based tools in patient care is considered normal among nurses.	16
			0.797			Learning how to use mobile app-based tools for nursing care is easy.	3
			0.770			Gaining skills in using mobile app-based tools for nursing care is easily possible.	4
			0.755			Nurses can easily use mobile app-based tools for patient care.	1
			0.739			Nurses can perform patient care activities more easily using mobile app-based tools.	2
			0.686			Nurses' use of mobile app-based tools in patient care helps save time.	5
		0.738				Using mobile app-based tools in nursing care improves the process of collecting, documenting, and analyzing patients' clinical data.	31
		0.690				Using mobile app-based tools in nursing care enhances communication among nurses and other members of the health care team.	33
		0.617				Using mobile app-based tools in nursing care supports family-centered care and reduces nurses' direct involvement in some interventions, such as medication administration.	32
		0.612				Using mobile app-based tools in nursing care increases nurses' productivity.	30
		0.543			0.525	The features of mobile app-based tools are adaptable and compatible with nurses' clinical performance.	28 **
		0.527			0.488	Mobile app-based tools for assisting with daily nursing activities are sufficiently adequate.	29 **
	-0.864					Nurses experience high stress when using mobile app-based tools in patient care due to their inability to manage potential problems.	15
	-0.828					Using mobile app-based tools in patient care confuses and bewilders nurses, making them feel disoriented.	14
	-0.719					Nurses have doubts about using mobile app-based tools for patient care due to the fear of not being able to correct mistakes.	12
	-0.715					Mandatory use of mobile app-based tools for patient care causes fear and anxiety in nurses.	13

* A minimum factor loading of 0.44 was considered. Factor loadings less than 0.44 are not included in the table.

** For common factor loadings, the item was loaded on a factor that conceptually aligned with the item's content.

Factor Naming:

1. Factor 1 encompasses 10 questions consisting of items 17, 18, 19, 20, 21, 22, 23, 24, 25, and 26, which were named "Application and Performance."
2. Factor 2 encompasses 7 questions consisting of items 6, 7, 8, 9, 10, 11, and 16, which were named "Social Impact."
3. Factor 3 encompasses 5 questions consisting of items 1, 2, 3, 4, and 5, which were named "Perceived Ease of Use."
4. Factor 4 encompasses 7 questions consisting of items 27, 28, 29, 30, 31, 32, and 33, which were named "Effectiveness."
5. Factor 5 encompasses four questions consisting of items 12, 13, 14, and 15, which were named "New Technology Anxiety."

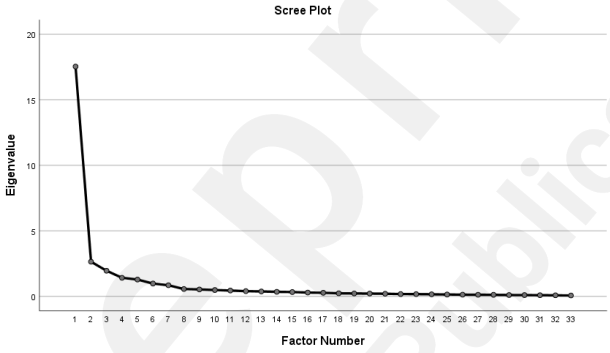

Figure1: Scatterplot of the Mobile Health Tool Acceptance Scale in Nurses

Table 4: Acceptance Score of the Mobile Health Tool Acceptance Scale in nurses, Differentiated by Their Overall Agreement or Disagreement Regarding the Use of Mobile App-Based Nursing Care (Single-Item Tool Score) (n = 250)

Mobile Health	Nurses' Agreement or Disagreement with the Use of Mobile App-Based Tools in Nursing Care (Single-Item Tool)							One-Way Analys
	Completely Agree (n=43)	Agree (n=43)	Somewhat Agr	Neutral (n=64	Somewhat Dis	Disagree (n=	Completely D	

Tool Acceptance Scale	agree (n=14)		agree (n=67)	)	agree (n=27)	22)	is agree (n=13)	is of Variance Results
Welch statistic = 31.26	4.869±1.195	4.820±0.436	4.489±0.443	4.0109±0.324	3.6786±0.546	3.4840±0.833	3.2630±0.782	Score (Standard Deviation± Mean)

6 P < 0 . 0 0 0 1								
	In terms of comparing the two groups, the Games-Howell post hoc test showed that there is a significant difference between the acceptance scores of the Mobile Health Tool in the following group pairs: 1 and 7 (p <.006), 1 and 6 (p <.000), 1 and 5 (p <.001), 2 and 5 (p <.000), 2 and 6 (p < 0.000), 2 and 7 (p <.016), 3 and 5 (p < 0.000), 3 and 6 (p <.000), 3 and 7 (p <.035), 4 and 3 (p <.000), 4 and 5 (p <.000), and 6 and 5 (p <.004).							

Discussion:

Previous studies have used measurement tools for assessing the use of mobile health tools in various healthcare and other groups [18, 35, 36]. However, none of these studies utilized a psychometrically tested tool specifically designed for nurses. Therefore, this study aimed to develop and validate the Nursing Mobile Health Device Acceptance (NMHDA) scale based on the Expectation-Confirmation Model.

~~A 33-item questionnaire was designed to assess the acceptance of mobile health tools among clinical nurses, demonstrating good validity and reliability within the target population.~~ Researchers created a 33-question survey to assess the adoption of mobile health tools by clinical nurses, demonstrating strong validity and reliability within the specific group.

The draft of the NMHDA scale was developed based on the Waltz four-step approach and the Expectation-Confirmation Model. In the current study, due to its theoretical foundation and the utilization of the principles and stages of designing the tool based on the Expectation-Confirmation Model[37], compared to other existing tools[38, 39], it encompasses a broader range of acceptance dimensions. Experts believe that having a theoretical basis for determining the content domains of a

tool leads to the generation of appropriate items and essentially ensures the acceptable validity of the tool [40].

In the content validity assessment, changes were applied to the tool by considering experts' opinions with various relevant and specialized backgrounds. The content validity ratio (CVR), content validity index (CVI), and modified kappa statistic for all retained items were higher than 0.08, 0.79, and 0.74, respectively. Moreover, the entire tool's S-CVI (S-CVI average) was greater than 0.90. Experts believe assessing content validity is necessary to ensure the coverage of all essential and critical aspects of the intended concept. The more knowledgeable individuals selected in this stage, the more reliable the process of content validity assurance[21]. In addition, when the S-CVI average is greater than 0.9, it is considered desirable for the content validity ratio[41]. Therefore, based on the presented information, the developed tool meets the criteria for establishing content validity.

In the section on face validity assessment, based on the issues raised by the clinical nurses (the target group), some modifications were made to the tool. Additionally, the impact scores of all preserved items in the tool were higher than 1.5. Janice Connell suggests that face validity is crucial for assessing the needs of the target group, as what is essential from a researcher's perspective may be perceived differently by the primary group. Therefore, face validity can improve measurement's acceptability, relevance, and quality[42]. Hence, it can be claimed that there is no issue with understanding the items of the tool designed by the target group, and its face validity is confirmed.

The exploratory factor analysis identified five factors: "Application and Performance," "Social Impact," "Perceived Ease of Use," "Effectiveness," and "New Technology Anxiety." These factors collectively explained more than half of the total score variance, each contributing over five percent. Furthermore, the factor loadings for all items loaded on factors exceeded 0.5, and there was no common factor among them. Some experts argue that for construct validity, the identified factors should account for at least 40 percent of the total variance[43], and each identified factor alone

should explain more than 5 percent of the total variability [44]The construct validity of the tool is well-established. Some sources also argue that, for construct validity, the identified factors should account for at least more than 50 percent of the total variance[45]. Therefore, the exploratory factor analysis results suggest the construct validity of the tool. However, the high factor loadings of the items and the absence of a common factor support the desirable structure of the tool [46].

The content of the loaded items on the extracted factors indicates compatibility between these factors and the intended acceptance concept. For example, the factors "Technology Anxiety," "Social Impact," and "Perceived Ease of Use" align with the same name in theory. The factor "Usefulness and Performance" is adaptable to the "Security Risk" factor, and "Confirmation" and "Effectiveness" match with the elements "Maturity" and "Perceived Benefit." Compared to other tools used to assess the acceptance of mobile health tools[47], the structure of this tool is more desirable.

A comparison of known groups showed a significant difference between nurses' acceptance scores based on their agreement or disagreement with using mobile health tools. This means that the designed tool can distinguish nurses based on their agreement or disagreement with using mobile health tools. This latter point also favors the validity of the tool's structure since it is used for groups that are expected to have differences in a specific characteristic, and their scores are compared; if a significant difference is observed, the structural validity of the tool is confirmed [48].

In our study, the relative frequency of the minimum and maximum possible scores obtainable from the acceptance measurement tool was zero, meaning that the tool has no floor or ceiling effects. This is in favor of the sufficiency of appropriate items in the tool. Floor and ceiling effects occur when more than 15% of respondents obtain the highest or lowest possible score on a tool. The absence of floor and ceiling effects supports the content validity and reliability of the tool [49].

In our study, the total Cronbach's alpha coefficient of the tool was 0.938. Faust and Greti mention the acceptable lower limit of Cronbach's alpha for reliability as 0.70[50]. Values between 0.60 and 0.80

are considered average, while values between 0.80 and 1.00 are considered very good [51]. Therefore, the tool demonstrates desirable internal consistency.

The correlation coefficient between the scores obtained from the two test sessions was 0.655. Polit and colleagues state that the correlation coefficient between scores obtained from two test sessions determines the test's stability and repeatability. They add that correlation coefficients higher than 0.70 are considered acceptable, and coefficients higher than 0.80 are considered very good [52]. Therefore, the calculated number indicates the desirability of the stability of the designed tool and shows that this tool has higher consistency than similar tools [39].

In our study, the standard error of measurement was estimated to be ±14.68, and the most minor detectable change of the tool was 10.6. If the test is repeated for an individual, their score may change by as much as 14.68. Considering the small SEM of the tool [53], it is essential and supports the stability of the tool [43]. Given the score range of this tool, the calculated number, based on this index, can be considered an indicator of stability, repeatability, and, ultimately, reliability.

Study Limitations

This study has certain limitations, which can be summarized as follows: Simultaneous data collection during the COVID crisis, high workload among nursing staff during this period, and a lack of willingness to cooperate from a significant number of them, as well as the absence of appropriate tools in the Persian language for convergent validity, are among the constraints.

Conclusion:

This study reports the development and psychometric evaluation of the Mobile Health Tool Acceptance Scale in nurses using the Expectation-Confirmation Theory. Exploratory factor analysis supported a five-factor model containing 33 items. These five factors, which include usability and performance, social influence, perceived ease of use, effectiveness, and anxiety about new technology, are distinct and collectively reflect nurses' intention to accept mobile phones for

professional and job-related purposes. Therefore, future studies can use this tool to measure nurses' (or other healthcare professionals') intention to use mobile phones for work purposes and link it with predictors and outcomes that address both theoretical and practical needs.

This tool, by providing essential information for managers at various levels, Can assist in creating guidelines and organizing these letters related to the design and use of mobile applications in the health sector. It can also be a way forward in the plans of the Ministry of Health and Medical Sciences Universities regarding changing the curriculum of nursing education to develop the use of information technology tools and expanding the use of tools according to the Efficient factors. Given that health service providers share common missions and goals and collaborate as a team during clinical activities, it is likely that with some modifications and psychometric testing of the revised scale, it could also apply to other target groups.

Application of findings:

The current research is a valuable tool across various organizational dimensions. It caters to senior organizational managers and decision-makers needing to assess the success likelihood of new technologies. For instance, it aids in reshaping nursing education curricula by considering organizational and environmental variables, crafting guidelines and regulations for application design, and more. This assists nurses in comprehending the advantages of technology use, emphasizing perceived usefulness, ease of use, technology adoption concerns, security perceptions, user satisfaction, habit maturity, acceptance, and societal impact. The use of mobile tools among nurses necessitates the establishment of national policies that offer a precise framework for designing, implementing, and auditing mobile applications among nurses.

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Competing interests

Authors NM, ZM, ZT, FH, WS, and FRJ declare no financial or non-financial competing interests.

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Supplementary Files