Developing and validating an assessment tool on Knowledge, Attitude, and Practice of Central Line-Associated Bloodstream Infection of ICU Nurses

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Research Article

Keywords: Assessment tool, Central-Line Associated Bloodstream Infection, knowledge, attitude, and practice.

Posted Date: May 16th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1628932/v1

Abstract

Background

Because limited assessment tool is available regarding knowledge, attitude, and practice (KAP) of Central-Line Associated Bloodstream Infection (CLABSI) of intensive care unit (ICU) nurses, we developed and validated an assessment tool on KAP of CLABSI of ICU Nurses.

Methods

Based on an extensive literature search, we initially developed this questionnaire. Pilot study were performed with the initial questionnaire. Then we evaluated the reliability and validity of the new questionnaire. We performed confirmatory factor analysis and exploratory factor analysis. The correlation coefficients were calculated. A test-retest was done to establish the reliability and to refine the items further.

Results

Initially, 54 items were formed in the questionnaire. The questionnaire was sent out twice and statistical analyses were made, reducing the number of items. We performed the pre-investigation and 255 participants responded to the questionnaire items. The overall content validity of the questionnaire was 0.95. The KMO value was 0.855, and the chi-square value of Bartlett's sphere test was 1479.609 (P 0.05). After the principal component analysis extraction method and the maximum variance orthogonal rotation, four common factors were extracted, and the cumulative variance contribution rate was 60.052%. The knowledge, attitude, and practice dimensions and the overall Cronbach's coefficient of the questionnaire were 0.927, 0.778, 0.923, and 0.946, respectively. Two weeks later, the test-retest reliability was 0.931, 0.825, 0.934, and 0.945, respectively.

Conclusions

A assessment tool for ICU nurses about KAP of CLABSI was developed, which included three domains covering knowledge, attitude, and practice. The questionnaire's validity, and reliability have been verified and can be used in clinical practice. The establishment of the tool will facilitate accurate monitoring for nursing managers to grasp the status quo about the KAP of CLABSI among ICU nurses so that nurses can be trained in a targeted manner.

Background

Central lines (CL) are life-sustaining devices and are commonly employed in hemodynamic monitoring, hemodialysis, injection of drugs, and total parenteral nutrition for the treatment of critically ill patients

due to its simple clinical operation, less traumatic, safe use, and improved nursing efficiency.

However, it has also carried a substantial infection risk. Catheter-related infections represent 10–20% of all nosocomial infections [1]. The median rate of Central-Line Associated Bloodstream Infection (CLABSI) in intensive care units (ICU) of all types ranges from 1.6 to 6.8 per 1000 catheter-days [2]. The catheter indwelling rate of ICU is about 44.12% [3]. Primary bloodstream infections resulting from central venous catheterization are a common cause of excess morbidity, mortality, and medical-care costs in the ICU setting [4].

Currently, the optimal approach to reducing CLABSI is unclear, but several studies indicated that the incidence of CLABSI can be decreased by improvements in the quality of care [5], such as hand hygiene, skin antisepsis with chlorhexidine, maximal barriers, insertion in subclavian vein and removing unnecessary catheters timely. The study had shown [6] that ICU nurses were unfamiliar with catheter placement procedures, lax implementation of the aseptic system, and improper care during the CL indwelling can significantly increase the occurrence of CLABSI. A survey of CL insertion and care of nurses in 415 ICUs in the United States [7] showed that after training, the nurse's knowledge scores increased, but there was no significant change in attitude, indicating that the training can improve the knowledge of nurses to prevent CLABSI, but the improvement of attitude is not obvious. How to improve nurses' attitudes to prevent CLABSI needs more research. Shimoyama et al. [8] conducted a KAP intervention research for ICU nurses, which included a 30-minute video introduction, a 120-minute lecture, and some practical training courses. In the 12 months before the intervention, 4 CLABSI occurred in the ICU of 1171 patients (i.e., the daily incidence rate of ICU per 1,000 patients was 3.4). In the first year after the intervention, the incidence of CLABSI in 1157 patients dropped to 0 ($P \leq 0.05$). In addition, the estimated economic cost savings are between 14,800$ and 216,000. However, in the next three years of follow-up, the incidence of CLABSI did not decrease significantly.

As ICU nurses, they are the primary executors of CL prevention strategies. Studies have shown that individuals with higher knowledge of CLABSI tend to have a higher practice of prevention measures [9]. Based on this fact, there is a need to measure the level of CLABSI knowledge among nurses to effectively prevent and control CLABSI.

However, as far as we know, nurses' KAP of these prevention strategies has not been assessed using a validated test, and requirements for a new usability questionnaire. Therefore, this study aims to develop and validate the tool for measuring nurse's knowledge of CLABSI prevention activities. This study is part of the evidence project, which aims to create and develop a reliable and customizable questionnaire and provide assessment tools for nurses on CLABSI prevention. The next step is that we will use our self-made assessment tool to investigate nurses and analyze the influencing factors, to fundamentally improve nurses' level of CLABSI prevention.

This study was approved by the Ethics Committee on Clinical Research, School of Nursing of Lanzhou University (No. LZUHLXY20200031) and was conducted in compliance with the Declaration of Helsinki. Written informed consent were obtained from all participants at each participating center.

Methods

Items Development

We used search terms “Central venous catheters”, or “Central vein line”, or “Central venous line”, or “Peripherally inserted central catheters”, or “CVL”, or “CVC”, or “CL”, or “Catheter-related infections”, or “Catheter-related bacteremia”, or “CRBSI”, or “CLABSI”, or “CRB” or “CRI” to search for guidelines, systematic reviews and evidence about the prevention of CLABSI. The literature search was run from inception to December 2021. Based on guidelines and norms, supplemented by systematic reviews, we mainly referred to the Class A and Class B recommendations of the Centers for Disease Control and Prevention (CDC) CLABSI prevention guide, and initially formed the items of the questionnaire.

A total of 54 items were initially formed. Among them, knowledge items were related to CLABSI definition, diagnosis, the extubating indications and cleaning methods, application of antibacterial dressings and drugs, sterility requirements during catheter insertion, catheter length, selection of puncture points, and disinfection of CL disinfectant time and reagents. There were 12 items on attitude, including the attitude to implement nursing measures when facing CLABSI. The questions were ranked in order of 1–5, from "strongly agree", "agree", "uncertain", "disagree" to "strongly disagree", 1 represented the most positive attitude, in descending order, 5 represented the most negative attitude. There were 15 items on practice, involving maintenance of catheter, and substantive measures to prevent CLABSI, etc., using a 1–5 rank order, from “never”, “occasionally”, “sometimes”, “usually” and “always”, with 1 representing the worst actionability, increasing in order (See Appendix S1 for details).

Content Validity Assessment

Content validity refers to the extent to which the instrument covers the content that it is meant to evaluate [10]. For content validity, the drafted questionnaire was reviewed by two-round Delphi technique, and invited subject matter experts from hospitals and colleges. The items were amended and further refined based on the outcome of the Delphi technique.

Experts were invited to rate their level of agreement with each statement on a five-point Likert scale (1 = very irrelevant, 2 = irrelevant, 3 = relevant, 4 = very relevant, 5 = totally relevant). Below each item, there was space for open-ended comments such as revisions to wording or explanations of the scores given (See Appendix for details). Each round was kept open for 4–5 weeks, with up to two reminders sent to non-responders. Consensus was defined as > 85% agreement. Round 1: panel members were sent an online questionnaire with 54 items using E-mail. Round 2: respondents to Round 2 were sent an online questionnaire comprising items that had failed to reach consensus in Round 1. The validity of panel experts could be quantified using response rate, Kendall’s, and the content validity index (CVI).

Face Validity Assessment

Face validity is the appropriateness, sensibility, or relevance of the test and its items as they appear to the persons answering the test and the degree to which test respondents regard the content of a test and its

items as relevant to the context in which the test is administered [11].

In this study, face validity was conducted by a group of trained researchers on 13 ICU nurses with similar characteristics to the actual respondents. The convenience sampling method was used to select ICU nurses by face-to-face interview or video telephone in a quiet and convenient place, and choose the free time, usually 20–30 minutes, which focused on whether the items could be correctly understood by ICU nurses, whether the expressions were ambiguous, and at the same time, there were any other suggestions for modification of the questionnaire content.

Pilot Study

In this study, pilot testing has been conducted on ICU nurses from four hospitals in Lanzhou city, and using the modified questionnaire followed by analyzing the reliability of the instrument. The sample was calculated based on the method of multiplying the number of items by 5–10 times, plus 15% of the questionnaire loss rate and invalid questionnaire. In this study, the initial questionnaire contained 54 items.

The questionnaire was distributed and returned on the spot. Two researchers immediately checked and eliminated invalid questionnaires. At the same time, the questionnaires were numbered and coded. Two researchers inputted the data separately into the EXCEL, and after further inspection, the data were imported into SPSS 22.0 for statistical analysis.

Analyses

Cronbach' alpha test and a test-retest analysis were used to assess the tool's reliability. For this survey, Cronbach' alpha test was used to assess the internal consistency of the items [12], while the test-retest reliability approach was used to assess the instrument's stability across time [13]. The instrument's stability refers to how similar the results are on two separate occasions or during a test-retest process [14].

Item analysis mainly tests the quality and reliability of items, and the results can be used as the basis for selection or modification of individual item [15]. Critical ratio (CR) is a method to divide respondents into high scoring and low scoring groups (using cut-offs such as 25th and 75th percentile) and evaluate the percentage of individuals in each group [16]. If CR is more than 3, it means that the item can be kept, otherwise, the item would be deleted. We evaluated the factor structure using exploratory factor analysis. Then through the principal component analysis (PCA) and the maximum variance orthogonal rotation method, the common factors were extracted. Confirmatory Factor Analysis (CFA) was carried out through the software AMOS 26.0.

Convergent validity, emphasized that those items that should belong to the same factor fell under the same factor when measured [17]. This study used Average Variance Extracted (AVE) and combined reliability to analyze it. If the AVE of each factor was greater than 0.5 and the combined reliability was

greater than 0.7, and the factor loading coefficient corresponding to each measurement item was greater than 0.5, indicating that the questionnaire had good convergent validity.

Discrimination validity, emphasized that the items that should not be under the same factor were indeed not under the same factor when measured. Using the AVE root sign value and the correlation result to compare, if the AVE root sign value of each factor was greater than the maximum value of the correlation coefficient between this factor and other factors, then it had good discrimination validity. The process of instrument validation and reliability is shown in Fig. 1.

Results

A total of 280 questionnaires were distributed, and 255 questionnaires were returned. The effective recovery rate was 91.07%.

Reliability Testing and Test-retest Reliability

As shown in Table 1, the three dimensions of knowledge, attitude, and practice and the overall Cronbach's α coefficient of the questionnaire were 0.927, 0.778, 0.923, and 0.946, respectively. The questionnaire had fit internal consistency. The second survey of 41 ICU nurses was conducted two weeks later and obtained the test-retest reliability coefficient.

Table 1
Cronbach's α and test-retest reliability of the questionnaire

	The number of items in each dimension	Cronbach' s α	Test-retest
Knowledge dimension	17	0.927	0.931
Attitude dimension	10	0.778	0.825
Practice dimension	18	0.923	0.934
Overall questionnaire	45	0.946	0.945

Items analysis results

According to the statistical results, the significance test probability *p-value* of items K18, K19, P16, P17, P18 was greater than 0.05 and the critical ratio was less than 3, and the discrimination was poor, so they were deleted. The result of the homogeneity test showed that the correlation between A10 and the total score was low, and it did not reach the significance level of 0.05, so deleting this item (Appendix S4).

Validity Assessment

A total of 10 experts were invited. The details on the respondents' characteristics are given in Table 2. The average number of years engaged in intensive care was 16.83. After two rounds of Delphi, the rates of expert opinions were 88.89% and 37.50% respectively. The authority of expert opinions is 0.86 and 0.87

respectively (see Appendix for details). Meanwhile, we interviewed 13 ICU nurses and the results were shown in the appendix.

Table 2
Basic information of experts (N = 10)

	Group	Number	Percentage (%)
Gender	Male	3	30.0
	Female	7	70.0
Age	30–39	1	10.0
	40–49	7	70.0
	≥ 50	2	20.0
Job title	Nurse-in-charge	3	30.0
	Vice professor of nurse	4	40.0
	Professor of nurse	2	20.0
	Chief Physician	1	10.0
Professional	Integrated ICU	4	40.0
	Surgical ICU	3	30.0
	Internal Medicine ICU	1	10.0
	Neurosurgery ICU	1	10.0
	Neurology ICU	1	10.0
Working years	10–15	4	40.0
	16–20	4	40.0
	≥ 20	2	20.0
Highest education level	College degree	1	10.0
	Bachelor’s degree	5	50.0
	Master’s degree and above	4	40.0

Exploratory factor analysis

The KMO value was 0.855 and the chi-square value of Bartlett's sphere test (in Table 3) was 1479.609 ($P < 0.05$), which meant that the data was suitable for exploratory factor analysis.

Table 3
The results of KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sample adequacy		**0.867**
Bartlett's sphericity test	Approximate chi-square	5825.869
	df	780
	Sig.	0.000

Then we used the maximum variation method to extract the common factor with the characteristic value greater than 1. Table a6-1 (Appendix S6) shown the result of the common factor variance of each item. We could find that the commonality of all items was more than 0.5, so there was no need to delete any items.

Table a6-2 (Appendix S6) was the component matrix after the first rotation, and the cumulative variance contribution rate was 62.938%, which contained 11 common factors. If the number of items contained in the common factors was less than or equal to 3, the meaning represented by the common factor could not be displayed. Therefore, the items K2, K4, K7, K5, and K15 were deleted and the factor analysis would performed again.

After four rotations, we get the final component matrix (Appendix S6). The cumulative variance contribution rate was 60.52%, which contained 4 common factors. The first common factor contained thirteen items, including P15, P14, P8, P13, P12, P6, P7, P9, P3, P2, P11, P5, P4, and second common factor included A2, A4, A5, A1, A7, A6. Common factor 3 contained A8, A9, A10, and A3. Common factor 4 contained seven items including K12, K10, K14, K11, K9, K13, and K1.

To confirmed whether it was necessary to perform exploratory factor analysis again, we continued to use the scree plot to determine the number of factors. It could be seen from the scree plot that the four factors on the left shows a steep curve, and the fifth factor showed a flat curve, so the four common factors were retained, as shown in scree plot (Fig. 2).

Confirmatory factor analysis

The value of x^2/df was 2.578, and the RMSEA was 0.084, which was less than 0.1, indicating a good degree of fit. The values of TLI and NFI were 0.962 and 0.921, respectively, which were both greater than 0.9, and the adaptation was ideal. The values of CFI and IFI were 0.780 and 0.882 respectively, and the results were well-fitted. On the whole, the model of CLABSI related KAP fit well. Figure 3 showed the structural equation model and standardized path coefficients.

It could be seen that each item was significant ($p < 0.001$) (Appendix S7), the AVE was greater than 0.5, the combined reliability was greater than 0.7, and the standardized factor load coefficient was greater than 0.5 (except for K6, K7). There was a good corresponding relationship between the factors and the items, and the convergent validity was great.

Table 4 indicated that there was a significant correlation between CLABSI related KAP ($P < 0.01$). In addition, the absolute value of correlation coefficients was all less than the square root of the corresponding AVE, which showed that each latent variable had a correlation and distinction between each dimension.

Table 4
The correlation between CLABSI related knowledge, attitudes and practice

	Knowledge	Attitude	Practice
Knowledge	0.76		
Attitude	0.20**	0.36	
Practice	0.28**	0.10**	0.50
Square root of AVE	0.873	0.60	0.707
Note: ** means that the p value is less than 0.01, which is a significant correlation.			

The diagonal line is the AVE value of the factor to evaluate the amount of variance variation extraction.

The final questionnaire

The final questionnaire (Appendix S8) had three domains: knowledge (nine items), attitude (ten items), and practice (thirteen items), which took about 10 to 20 min to complete the questionnaire.

Discussion

Knowledge and attitude of ICU nurses plays a vital role in implementing actions for CLABSI. Despite such importance of nurse's knowledge for CLABSI prevention, less research attention has been paid by the researchers to examine nurse's knowledge of CLABSI prevention [18]. There is an immense need to develop an instrument for measuring nurse's knowledge on CLABSI prevention control. Therefore, to determine to which extend ICU nurses understand the correct way of preventing CLABSI, a survey across the province will be conducted, and this instrument was developed for this province-wide study.

In this study, we had outlined key methodologies and considerations for researchers who were interested in developing and verifying a questionnaire about CLABSI. The improved methods used in the development of the questionnaire will enable more confidence in reported measures of CLABSI.

CLABSI is associated with a reported mortality rate of 42% [19], and it can result in delays in primary disease treatment, increased morbidity and mortality, prolongation of hospital stays, and substantial financial burden. The study had shown that it was essential that nurses receive training and that quality improvement programs were in place to decrease ICU-acquired catheter-related infection [20].

The study carried out has a sample size of 280 participants. As this is a pilot study, researchers followed the principles of pilot test participants, and the sample size is recommended to be larger than 30 and less

than 500 participants [21, 22]. Then we selected 280 ICU nurses using the convenience sampling method for pre-survey in Lanzhou City. While developing the tool, this study also assessed the validity and reliability to ensure the tool is appropriate. Results of this study indicated that the tool has acceptable validity and reliability.

This study was part of the evidence-project, which aimed to create and develop a reliable and customizable questionnaire and provide assessment tools for nurses on CLABSI prevention. Then we used the questionnaire to investigate on KAP of CLABSI of ICU nurses and analyze the influencing factors, to better and more targeted training of ICU nurses and reduce the incidence of CLABSI.

In this study, we first made an initial questionnaire containing 54 items. Then we tested the content validity by panel experts who are ten intensive care experts. After two rounds of panel experts. The Kendall's were 0.491 and 0.589 respectively. Therefore, the score indicated moderate reliability. At the same time, the coefficient of variation indicated that the expert opinions tend to be consistent. According to the opinions of the interviewed ICU nurses, two items were deleted and adjusted the expressions for seven items.

Items analysis was mainly carried out through critical ratio and homogeneity tests. The results of the critical ratio showed that five items with poor discrimination were deleted. According to the results of the homogeneity test, the correlation between A10 and the total score was low and did not reach the 0.05 level of significance, so it was deleted.

The principal component analysis method and the maximum variation method were used for the orthogonal rotation axis, and the common factor with a characteristic value greater than 1 was extracted. After rotating four times and deleting 10 items, we contained the ultimate component matrix which contains 4 common factors. At the same time, we verified that the four common factors are the most appropriate by the scree plot.

To further verify whether the corresponding relationship between the measurement factors and the items was consistent with expectations, confirmatory factor analysis was carried out. The result showed that the knowledge, attitudes, and practice of CLABSI were both consistent in direction and there were certain differences.

Cronbach's alpha (α) internal consistency reliability reached the acceptable threshold value. In social science, the acceptable α value is 0.70 [23], which is also practiced by other researchers. Two weeks later, we conducted a second survey of 41 ICU nurses who participated in the preliminary survey. The results showed that the questionnaire had great stability across time. Finally, we got the ultimate version of the questionnaire, which mainly included three dimensions and 32 items.

The tool may be used as a simple guide to aid researchers in studies related to ICU nurse's knowledge on CLABSI prevention activities, and a more in-depth instrument can be developed to further improve this instrument.

Several limitations of the present study deserve mention. First, limited by time and resources, the experts are all from Gansu province, which may have a certain impact on the preparation of the initial questionnaire. In addition, we adopted the convenience sampling method and only pre-surveyed ICU nurses in four tertiary general hospitals in Lanzhou City, which may produce a certain selection bias. While the sample size for the study is enough, the additional sample size may add further value to the validation test. Therefore, whether the research results apply to other hospitals and regions will need further verification.

Conclusion

In summary, our study indicated that the self-made assessment tool on CLABSI was reliable to be used to measure the knowledge, attitude, and practice of CLABSI of ICU nurses which includes a total of 32 items. In China, there is a limited study conducted on ICU nurses in regard to CLABSI prevention activity probably due to no appropriate instrument that can be used in assessing the knowledge. Further improvement is needed to develop an appropriate instrument to measure the attitude and practice of ICU nurses in regard to CLABSI prevention activities. This study hopes to contribute to facilitate other research studies that aim to assess nurses' knowledge on CLABSI prevention. Meanwhile, our study provided the survey tools for nursing managers to better understand the status of nurses on CLABSI, to develop targeted management strategies and training programs for ICU nurses.

Abbreviations

CL
Central lines
CLABSI
Central-Line Associated Bloodstream Infection
ICU
Intensive Care Units
KAP
Knowledge, Attitude, and Practice
CDC
Centers for Disease Control and Prevention
CVI
Content Validity Index
CR
Critical Ratio
PCA
Principal Component Analysis
CFA
Confirmatory Factor Analysis

AVE
Average Variance Extracted

Declarations

Author contributions

Fang-ping Dang put forward the conception and designed this study. Fang-ping Dang and Jing Gao acquired the data. Tian-tian Zhai, and Nan-nan Ding helped to check and input the data. Fang-ping Dang and Hui-Ju Li analyzed and interpreted the data. Fang-ping Dang wrote the first draft. Xing-wu Ran reviewed and modified the manuscript. All authors critically appraised and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest

Funding

This study was partial supported by West China Nursing Discipline Development Special Fund Project, Sichuan University [Grant No. HXHL20005], 1.3.5 Project for disciplines of excellence, West China Hospital, Sichuan University [Grant No. ZYGD18025].

Ethical approval

This trial was approved by the Ethics Committee on Clinical Research, School of Nursing of Lanzhou University (No: LZUHLXY20200031) and was conducted in compliance with the declaration of Helsinki. Written informed consent were obtained from all participate at each participate centre.

Acknowledgments

We thank each ICU nurses for the time and effort devoted to this study.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

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Figures

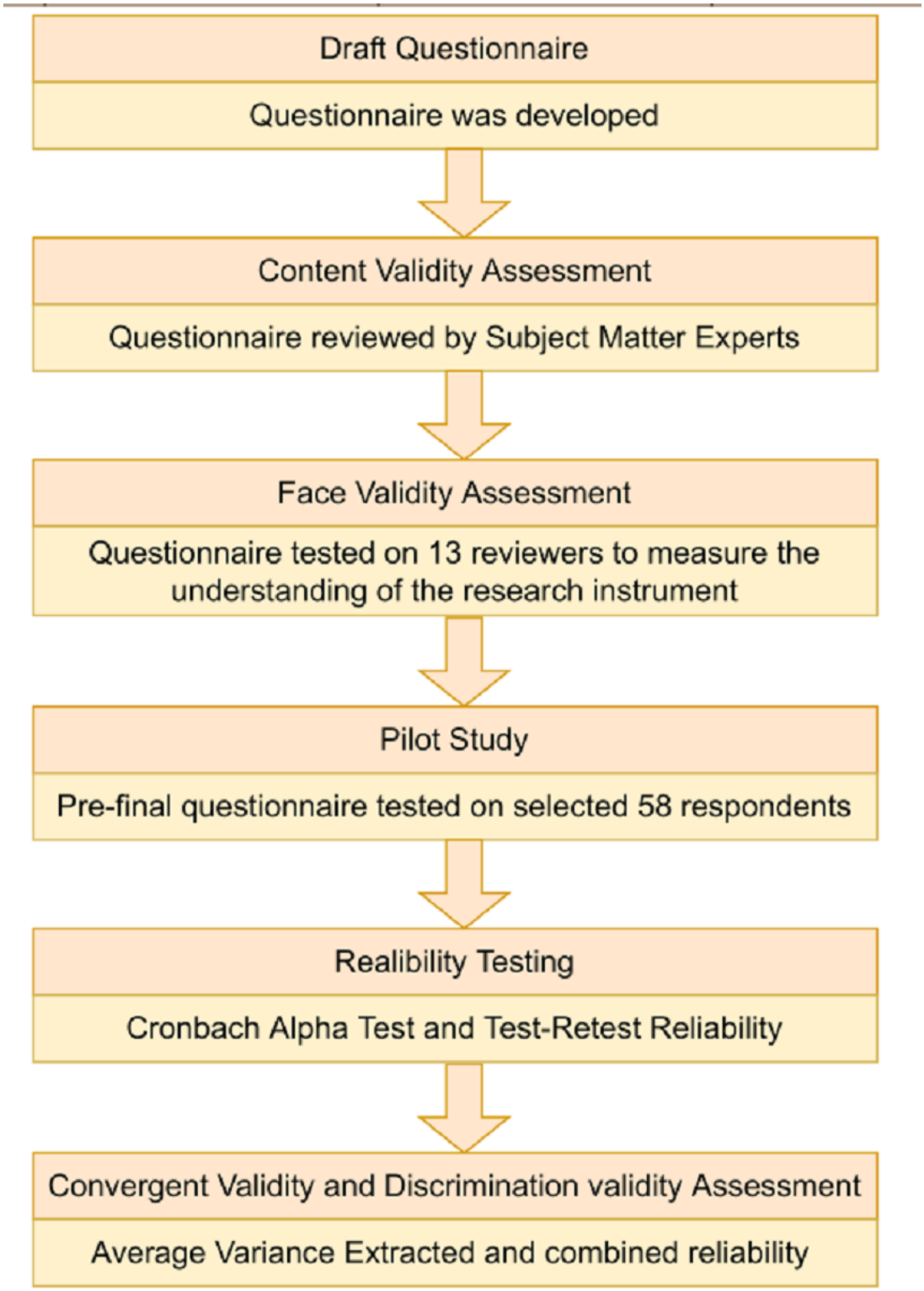

Figure 1

Flowchart of instrument validation and reliability

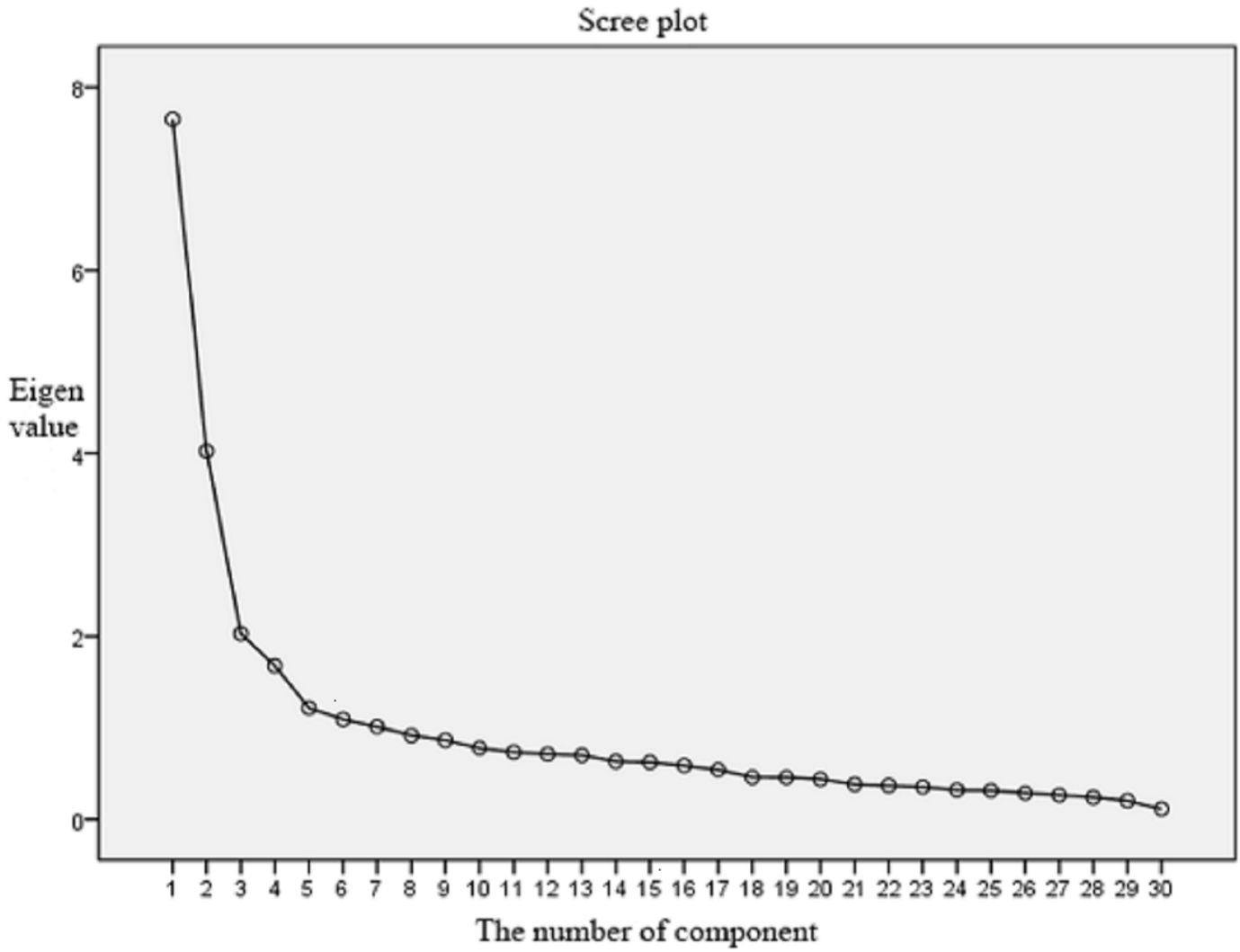

Figure 2

Scree plot

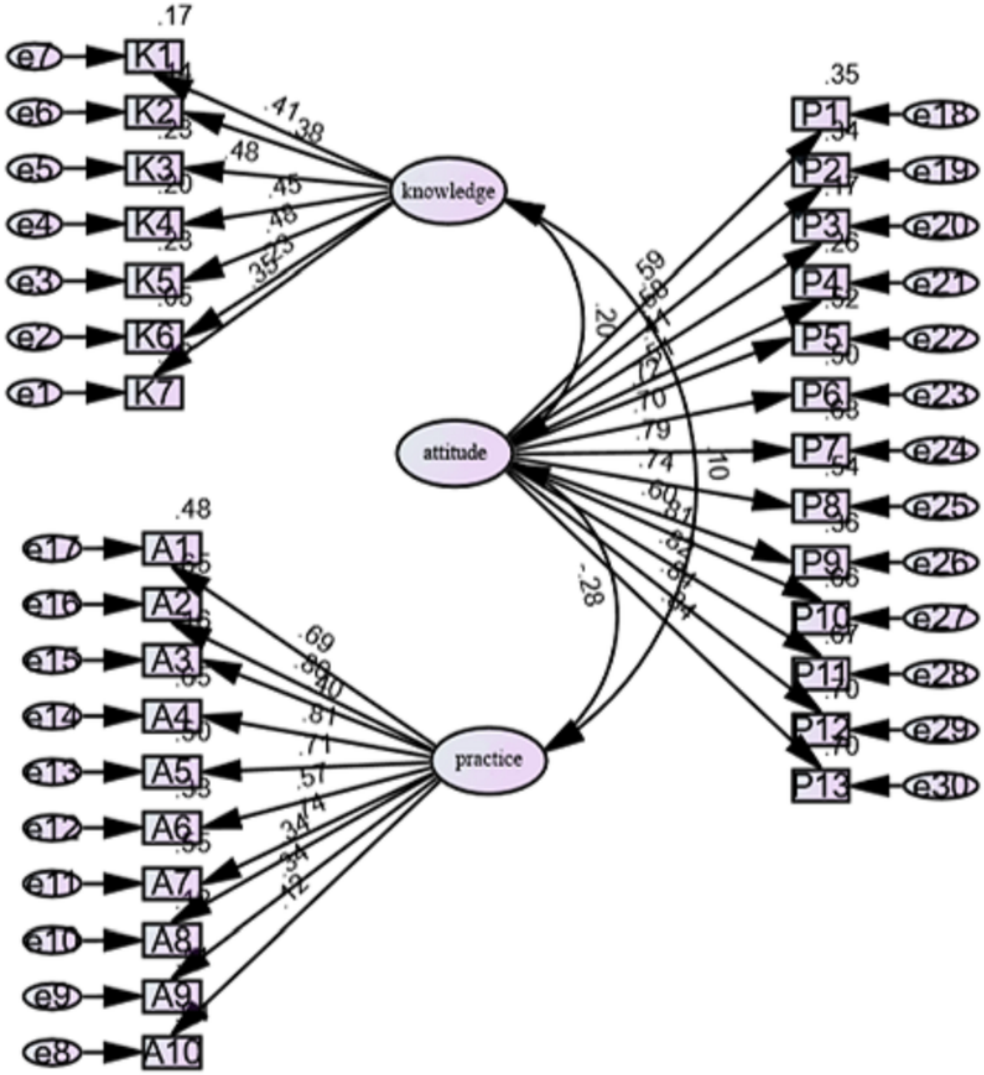

Figure 3

Structural equation model and standardized path coefficients

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