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Research Article

Construction of Health Education Competency Model for Nurses Based on Fuzzy Comprehensive Evaluation Method and Fuzzy Cluster Analysis Method

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Health education competency is essential for nurses to engage in clinical nursing practice. Nurses with a high level of health education competency have a promising future. However, at the present stage, health education of nurses suffers from insufficient effective communication skills, poor skillfulness, and lack of health education knowledge. The above problems seriously affect the improvement of nurses' health education level and restrict the development of health education in health industry. Therefore, it is very important to construct a health education competency model on how to improve health education. This paper, by taking nurses as the research object, constructed a health education competency model for nurses using the fuzzy comprehensive evaluation method and fuzzy cluster analysis method. In this paper, we first applied the fuzzy cluster analysis method to classify the relevant factors affecting nurses' health education competency. Then, we investigated 10 experts from four tertiary general hospitals in Heilongjiang Province of China and asked them to rate nurses' health education competency through the fuzzy comprehensive evaluation method. According to the results of this research, nurses' knowledge and experience, nurse-patient communication competency, and health education implementation competency are the key factors affecting nurses' health education competency. But the influence from overall quality is relatively minimal. Among the indicators of knowledge and experience, nurses' health education knowledge is the most important indicator because it can provide objective basis and expand ideas for the hospital health education management and nursing personnel training.

1. Introduction

In the era of big data information, data processing level has become the core competitiveness of all industries' development. From a large number of complex, random, and imperfect data information, the excavation of valuable data information can help enterprises to understand the current market status, basic characteristics of customers, etc. It will also help enterprises to make important decisions. For the time being, the data mining technology is mainly used in the analysis and collation of image data and text data. By this technology, the target data in the mass of information can be accurately found [1]. Guo [2] analyzed various application scenarios of the big data mining technology, and he concluded that the data mining technology can be used in many fields because of its cluster analysis, correlation analysis, neural network simulation analysis, genetic gene algorithm analysis, and other data mining methods. But this technology needs to be reasonably improved by combining the actual needs of different fields. However, in the application of data mining technology, it is often encountered that the data are missing or incomplete, which requires data preprocessing, and the fuzzy cluster analysis method is one of the solutions. The fuzzy cluster analysis adopts the method of fuzzy mathematics to cluster some indicators that are not clearly delineated boundaries and are relatively fuzzy for analysis [3]. In the fuzzy cluster analysis method, each class of data has certain attributes, and its final data can be

attributed to a certain class of data, eventually forming a relatively complete set of data. In this paper, this property of fuzzy cluster analysis is applied to data mining for the construction of a nurse health education competency model.

In order to improve the core competitive advantage, more and more enterprises are using competency models to evaluate their employees [4]. Competency is the relevant competence required for an individual to assume the duties of a job, including basic knowledge, skills and personal attributes required for the job, and the key attributes required for outstanding performance in the job. The competency model is usually constructed based on the performance of the best performer in the job [5]. The model maps the future development path of the employees and helps them to improve the job competency and set up a personal development plan. In recent years, due to the important role of the competency model in employee job matching, improving organizational performance, and perfecting employees' personal career, many enterprises have used the job competency model in recruitment, promotion, and designing incentive mechanism. The construction of this model requires collecting relevant data through questionnaires, interviews, and data mining. When constructing the health education competency model for nurses, we also need to collect data through various ways.

Health education competency (HEC) [6] is the knowledge and skills that health educators shall have when they carry out health education activities. In recent years, with the continuous improvement of living standards, more and more people pay attention to their own health literacy. In August 2016, General Secretary pointed out at the National Conference on Hygiene and Health that the concept of "big health" shall be adopted to improve overall health literacy. As an important place for health education, the health education competency of nurses in hospital is very important. However, the health education has a short history in China, and the current situation of health education for nurses also suffers from lack of effective communication skills, poor skillfulness, and lack of health education knowledge [7]. Therefore, it is necessary to take relevant measures to improve the health education competency of nurses, and the competency model is an effective incentive means, which can improve the health education competency for nurses, so it is necessary to construct the health education competency model for nurses. Regarding the health education competency, although there are now some evaluation tools at home and abroad, most of these are aimed at public health educators. Although nurses are a kind of public health educators, the existing evaluation tools are not targeted and limited to improving nurses' health education competency. Therefore, it is necessary to use rough sets to construct a health education competency model for nurses through hierarchical analysis.

Fuzzy cluster analysis theory is a tool to deal with fuzzy and uncertain data, which can reduce the uncertainty of data quantitatively. According to the theory of fuzzy cluster analysis, any fuzzy and uncertain thing can be quantified eventually [8].

Fuzzy cluster analysis is a method to classify things according to certain rules. This method follows the principle of "like attracts like." When classifying data, we will use mathematical methods to quantitatively analyze the affinity of samples, so as achieve the objectivity in the typing and classification of the samples. In fact, in many studies, the research object itself has the fuzziness. Therefore, it is necessary to use the fuzzy mathematics method for cluster analysis, so that the whole classification is closer to the actual situation.

(1) Definition 1: a fuzzy matrix $R = (r_{ij})_{n*n}$ is considered as a fuzzy equivalence relation on a given universe of discourse U if it satisfies the following conditions.

Condition 1: reflexivity, i.e., $r_{ij} = 1$.

Condition 2: symmetry, i.e., $r_{ij} = r_{ji}$, where $(i, j = 1, 2, \ldots, n)$.

Condition 3: transitivity.

(2) Definition 2: a fuzzy matrix $R = (r_{ij})_{n*n}$ is considered as a fuzzy similarity relation on a given universe of discourse U if it satisfies the following conditions.

Condition 1: reflexivity, i.e., $r_{ij} = 1$.

Condition 2: symmetry, i.e., $r_{ij} = r_{ji}$, where $(i, j = 1, 2, \ldots, n)$.

2. Materials and Methods

According to the fuzzy cluster analysis theory and fuzzy comprehensive evaluation theory, this paper will construct the health education competency model for nurses, so as to improve the health education competence of nurses and promote the health literacy for all.

2.1. Objectives. In this paper, 10 specialists from 4 GIIIA hospitals in Heilongjiang Province were selected for the correspondence objects. Among them, the inclusion criteria for experts were (1) clinical nurses/nursing professors/nursing managers/health education managers; (2) bachelor's degree or above; (3) associate senior title or above; and (4) 10 years or more nursing work experience, excluding experts who could not participate due to vacation and other reasons.

2.2. Methods. This paper will construct the health education competency model for nurses based on fuzzy cluster analysis theory and fuzzy comprehensive evaluation theory.

2.2.1. Fuzzy Comprehensive Evaluation. The fuzzy comprehensive evaluation is based on the analysis of the experts' experience scoring results of each indicator. The method is often used for quantitative analysis of qualitative problems and for solving multi-factor, multi-objective, and multi-level problems. It has a very important role in strategic decision making. The research object of this paper is the health education competency of nurses. It is a more abstract evaluation object influenced by various factors, and the hierarchical analysis helps to make the above evaluation object more objective and concrete.

2.2.2. Fuzzy Cluster Analysis. The fuzzy cluster analysis is generally divided into three steps.

The first step is to standardize the data. Assume that the universe of discourse $U = \{x_1, x_2, \ldots x_n\}$ is the set of objects to be classified, and assume that each object x_i has m indicators needed to represent its shape, i.e., $x_i = \{x_{i1}, x_{i2}, x_{i3}, \ldots x_{im}\}$, where, $i = 1, 2, \ldots n$. Based on this, the following original data matrix can be obtained:

$$X_0 = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & & \\ \vdots & \vdots & \cdots & x_{2m} \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{pmatrix}, \quad (1)$$

where x_{nm} represent the raw data of the m^{th} indicator of the n^{th} classification object.

In specific problems, different data usually have different dimensions. To compare these dimensions, it is generally necessary to apply certain transformations to compress these data into [0, 1] by applying the following translation-standard deviation transformation of equation (2) to standardize the data.

$$x_{ik}' = \frac{x_{ik} - \overline{x}_k}{s_k}, \quad \text{where, } i = 1, 2, \ldots n, \quad k = 1, 2, \ldots m. \quad (2)$$

In the second step, a similarity matrix is built. After normalizing the data, it is necessary to determine the similarity coefficient according to the traditional cluster analysis method, i.e., to construct a fuzzy similarity matrix to determine the similarity degree of the related data. When determining $r_{ij} = R(x_i, x_j)$, the similarity coefficient method and the distance method in the traditional cluster analysis method can be applied. In this paper, the maximum-minimum method of the similarity coefficient method will be used for calculation.

The third step is the fuzzy cluster. The cluster is the use of the above-mentioned fuzzy matrix to classify the objects studied. Different classification results will be obtained for data with different confidence levels. In practice, the commonly used processing method is the traditional closure method, which transforms the constructed fuzzy similarity matrix into a fuzzy equivalence matrix. Finally, the reasonable matrix is determined to achieve the classification of research objects.

3. Results and Discussion

Combined with the basic idea of fuzzy cluster analysis and fuzzy comprehensive evaluation, the basic idea of constructing the health education competency model for nurses is as follows. Firstly, by using the interview method, the characteristics of health education competency for nurses were described preliminarily, and the questionnaire was designed to get the underlying indicators of health education competency for nurses. Secondly, by using the screening method and cluster method, the underlying indicators were preliminarily screened and divided to construct the health education competency model for nurses. Thirdly, by using the fuzzy comprehensive evaluation method, the indicator weight and dimension weight of the health education competency were calculated, so as to construct the evaluation model of the health education competency for nurses.

3.1. Identification of Underlying Indicators. In the construction of the health education competency, this paper will be based on the following three steps:

(1) The extraction of competency characteristics. According to the STAR principle, critical behavior event interviews are conducted with different nurses, doctors, patients, and nurse-patients. STAR principles are as follows: situation, task, action, and result. From these interviews, the specific performance, psychological activities, etc. of nurses in critical behavior are collected. These competencies obtained from the interviews are coded and analyzed to extract the key characteristics that led to the differences in competency. The interview of this paper initially gets the difference of knowledge and experience, skills and competence, and overall quality.

(2) The design and determination of the questionnaire. Based on the key characteristics of nurses' health education competency obtained, relevant information that can evaluate nurses' health education competency was collected by combining relevant literature, Internet databases, and other resources, and these kinds of information were summarized to form the first draft of the questionnaire. The final draft of the questionnaire was determined by discussing the first draft of the questionnaire and the initial survey in advance.

(3) Questionnaire distribution and data processing. SPSS 22.0 is used to test the validity and reliability of the questionnaire, namely, validity and reliability. If the validity and reliability are low, it is necessary to amend the questionnaire and reinvestigate.

Using the above ideas, this paper determines the preliminary underlying indicators as shown in Table 1.

3.2. Determination of Evaluation Indicator System of Health Education for Nurses. After obtaining the underlying indicators of nurse health education competency evaluation, this paper will use fuzzy cluster analysis method to construct an evaluation indicator system of health education for nurses.

3.2.1. Screening the Indicator of Health Education Competency for Nurses. When using the importance principle and the concept of information entropy to screen the evaluation indicator of health education competency for nurses, the information entropy of each dimension shall be calculated using (3) at first.

Table 1: Underlying indicators.

First-class indicator	Second-class indicator
A: knowledge and experience	A1: health education knowledge
	A2: medical knowledge
	A3: health education experience
B: skills and competencies	B1: competence to evaluate health education needs
	B2: competence to plan health education
	B3: competence to implement health education
	B4: competence to evaluate health education
	B5: communication competency
	B6: competence to innovate health education approaches
C: overall quality	C1: self-perception
	C2: professional loyalty
	C3: social role
	C4: personal attributes
	C5: motive

$$H(P) = -\sum_{i=1}^{n} p(X_i)\ln p(X_i), \tag{3}$$

where $P(X_i) = |X_i|/|U|$, $U/P = \{X_1, X_2, \ldots X_n\}$.

Assume that A_i is the set of all primed bottom indicators under each dimension, i.e., $A_i = \{a_{i1}, a_{i2}, \ldots, a_{in}\}$.

On this basis, the first round of screening of the underlying indicators can be done by using the following equation:

$$S_A(a) = |H(A) - H(A - \{a\})|. \tag{4}$$

By calculating $S_A(a_{ij})$, retain indicator a_{ij} of $S_A(a_{ij}) > 0$, and exclude indicatora_{ij} of $S_A(a_{ij}) = 0$.

The indicators screened in the first round are relabeled as $B_i = \{b_{i1}, b_{i2}, \ldots b_{is}\}$. The same method is applied to the second round of screening to obtain the importance of the indicators in the new indicator set Bi. If the correlation between two indicators is greater than a certain value, the relatively less important one needs to be eliminated according to the importance magnitude. After two rounds of screening, we can finally get the indicators that depict the competence level of health education of nurses.

3.2.2. Clustering of Indicators of Health Education Competency for Nurses. Based on the above analysis, the K-means clustering method needs to be applied to cluster analysis of nurse health education competency indicators, i.e., k indicators are defined as k cluster centers. For each remaining object, it is assigned to the cluster that is most similar to it according to the distance between the object and each cluster center. Then, the new center of each cluster is recalculated in this way. The above process is repeated until the criterion function converges. Specifically, this paper will use SPSS 22.0 to perform cluster analysis on the nurse health education competency indicators screened in two rounds to obtain nurse health education competency indicator clusters.

3.3. Determining Hierarchical Structure of Evaluation Indicator System for Health Education for Nurses. Based on the aforementioned nurse health education competency evaluation system, this section will further determine the hierarchical structure of the nurse health education evaluation system using the fuzzy comprehensive evaluation method. The fuzzy comprehensive evaluation method is mainly based on the evaluation of each indicator by experts. Before that, it is necessary to evaluate the experts' authority and coordination.

Table 2: Analysis of expert authority.

First-class indicator	Judgment coefficient	Familiarity	Authority
Knowledge and experience	0.73	0.78	0.76
Skills and competencies	0.82	0.81	0.82
Overall quality	0.77	0.84	0.81
Average	0.77	0.81	0.79

3.3.1. Evaluation of Authority of Experts. The Cr values of the 10 experts in this paper are 0.73~0.84, which show that the 10 experts have a high authority for this research. The results are shown specifically in Table 2.

3.3.2. Evaluation of Coordination of Experts. The coordination of experts is usually measured by the coefficient of variation and W values (0~1). Usually, the larger W, the smaller the coefficient of variation, indicating that the experts' opinions are more consistent and the coordination is better. However, the prerequisite is that the results of the degree of expert opinion coordination are credible when the χ^2-test is statistically significant. As can be seen in Table 3, after 2 rounds of expert correspondence, the overall W value of the indicator is greater than 0.2, $P < 0.01$, which indicates a higher degree of expert coordination.

3.3.3. Determination of Indicator Weight. Through fuzzy cluster analysis, this paper initially obtains the evaluation indicator system of nurses' health education and then applies the fuzzy comprehensive evaluation method to determine

Table 3: Analysis of expert coordination.

	Level	Coordination coefficient	X^2	P
1st round	First-class indicator	0.211	31.089	<0.01
	Second-class indicator	0.265	109.817	<0.01
	Third-class indicator	0.273	214.762	<0.01
2nd round	First-class indicator	0.337	43.601	<0.01
	Second-class indicator	0.312	67.512	<0.01
	Third-class indicator	0.354	167.871	<0.01

Table 4: 1–9 nine-scale quantity scale.

Scale	Definition	Description
1	Equally important	Another element is equally important
3	Slightly important	One element is slightly more important than the other
5	Obviously important	One element is obviously more important than the other
7	Much more important	One element is much more important than the other
9	Extremely important	One element is extremely more important than the other
2,4,6,8	Inverse comparison	Inverse comparison of the above comparisons

Table 5: Second-class indicator weight.

First-class indicator	Second-class indicator	Second-class indicator weight
A: knowledge and experience	A1: health education knowledge	0.42
	A2: medical knowledge	0.21
	A3: health education experience	0.37
B: skills and competencies	B1: competence to evaluate health education needs	0.19
	B2: competence to plan health education	0.12
	B3: competence to implement health education	0.21
	B4: competence to evaluate health education	0.14
	B5: communication competence	0.23
	B6: competence to innovate health education approaches	0.11
C: overall quality	C1: self-perception	0.26
	C2: professional loyalty	0.29
	C3: social role	0.22
	C4: personal attributes	0.14
	C5: motive	0.09

the indicator weights. The key to this aspect is the comparison of related factors. This research finally obtained the fuzzy complementary matrix by the scoring method based on the 1–9 nine-scale method. The meaning of the nine-scale method is as follows (Table 4).

When solving the weight vector, it is necessary to set the fuzzy complementary judgment matrix first.

According to this principle, this paper obtains the weight result of first-class indicator, namely, matrix: $W = (0.38, 0.41, 0.21)$.

At the same time, in order to ensure that the health education evaluation system has good consistency, this paper also carried out a consistency test.

Through the calculation, $CR = 0.078 < 0.1$, which shows that matrix W has good consistency; therefore, the weights of the first-class indicators of the nurse health education evaluation system, i.e., knowledge and experience, skills and abilities, and overall quality, are finally determined to be 0.38, 0.41, and 0.21.

Then, this paper finalized the second-class indicator weights according to the fuzzy comprehensive evaluation method, as shown in Table 5.

In this paper, 10 experts from 4 GIIIA hospitals in Liaoning Province will be selected as the objects of correspondence. All of them have bachelor's degree or above, associate senior title or above, 10 years or more nursing or health education experience, and rich knowledge and work experience related to health education. According to the aforementioned analysis, the authority coefficients of these 10 experts are 0.73~0.84, which indicate that the authority of the experts consulted in this paper is relatively strong and the results obtained from the consultation are relatively reliable. Meanwhile, the overall coordination degree W of experts is greater than 0.2 and $P < 0.01$. Therefore, the coordination degree of experts is relatively high, and the evaluation system of nurses' health education competency constructed in this paper is scientific.

Based on the initially determined health education competency evaluation system for nurses and the weights obtained for each indicator in the evaluation system, the following conclusions can be drawn.

(1) The three original attributes are used as three selectable main attributes in the construction of the

health education competency model for nurses, for example, if the initial attributes are (knowledge and experience, skills language competence, and general quality), this indicates that the actual health education competency model for nurses will also include these four indicators.

(2) The weights of the indicators at each level show that skills and competence are the largest factors influencing nurses' health education competency, followed by knowledge and experience. The influence of overall quality is relatively minimal. Among the indicators of knowledge and experience, the nurses' health education knowledge is the most important indicator. Among the skills and competences, nurses' communication skills and competences in implementing health education can improve nurses' health education competency. Among the overall qualities, professional loyalty will greatly affect nurses' health education competency, followed by self-perception situation. Therefore, when evaluating nurses' health education competency, hospitals shall focus on observing nurses' skills and competences, especially their communication skills and competences to implement health education.

(3) According to the three-level indicator weights, the factors influencing nurses' health education competency are theories related to health education, knowledge related to health promotion, health education curriculum vitae, basic medical knowledge related to health education, training experience related to health education, knowledge related to health behaviors, health education-related experience, medical expertise related to health education, assessment of health education effectiveness to meet goals, and protection of patients' privacy. This research adopts the fuzzy cluster analysis and fuzzy comprehensive evaluation method to simplify the influencing factors of nurses' health education competency, screen out the key influencing factors, and quantitatively analyze the weight of each factor, which is very important for evaluating nurses' health education competency.

4. Conclusions

With the increasing awareness of public health literacy improvement, health education talents and health education competence are becoming more and more important. How to improve health education competences and screen health education talents has also become one of the keys. Considering that health education competency is a more abstract concept, the traditional quantitative analysis method such as fuzzy comprehensive evaluation cannot completely quantify health education competency. Therefore, this paper also introduces the fuzzy cluster analysis method to construct the health education competency model for nurses, so as to provide reference for improving the health education competences of nurses and evaluating the health education competency of nurses.

Data Availability

The data supporting the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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