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Online health community–An empirical analysis based on grounded theory and entropy weight TOPSIS method to evaluate the service quality

Yang Hua, Wang Shujuan and Wang Fucheng

Abstract

Introduction: With the enhancement of people's health awareness and the impact of the coronavirus pandemic in recent years, people's demand for online health information continues to expand, and online health communities (OHCs) have developed rapidly. However, the service quality of OHCs is uneven, and problems such as content quality, privacy disclosure are increasingly prominent. It's of great significance to establish normalized OHC service quality evaluation standards and develop effective evaluation tools and methods for the improvement of OHC service quality.

Material and Methods: Based on the grounded theory, the raw materials obtained from semi-structured interviews were coded in three stages to construct a service quality evaluation system for OHC. Through empirical analysis, the rationality and effectiveness of the evaluation system were verified. Then six representative Chinese OHCs were selected and their service quality was evaluated by the entropy weight TOPSIS method.

Results: The service quality evaluation system of OHC was constructed which includes 4 first-level indicators and 16 second-level indicators. The weights of the first-level indicators from large to small are content quality, emotional experience quality, interaction quality and function quality. Among the second-level indicator weights, the top three are perceived cost reasonableness, content professionalism and effectiveness of interactive content.

Conclusions: The indicator system is reasonable and effective and the evaluation method has strong applicability and operability. This study will provide theoretical guidance for community platform operators and relevant departments to design effective evaluation mechanism of OHC service quality, offering a reference for decisions and policymakers.

Keywords

Online health community (OHC), service quality, evaluation, grounded theory, entropy weight TOPSIS method

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Introduction

In recent years, with the rapid development of information technology and enhancement of people's health awareness, people's demand for online health information continues to expand. Online health issues have received much attention. Online health community (OHC), which is an open network platform for users which can provide Q&A consultation, information exchange, experience sharing and social support on health care issues[1] are prospering in many countries such as Doctor on Demand in America, Covidom in France and Patient Voice in Spain.[2,3] China has been actively promoting the implementation of the Health China strategy. In April 2018, the General Office of the State Council of China issued the opinions on promoting the development of "Internet plus Medical Health,"[4] stressing the need to accelerate the development of "Internet

School of Business and Management, Jilin University, Chang Chun, China

Corresponding author:
Wang Shujuan, No. 2699, Qianjin Street, Chaoyang District, Changchun City, Jilin Province 130012, China.
Email: wangshujuan_1997@163.com

plus Medical Health" and proposed various development measures. In November 2020, the Ministry of Industry and Information Technology and the National Health Commission of China jointly issued the Notice on further strengthening telemedicine network capacity building,[5] which proposed to improve the network standard system, increase network capacity, promote network applications and accelerate the application and development of "Internet plus" in the field of medical and health care. At the same time, with the impact of the coronavirus pandemic, residents' demand for medical e-commerce and OHCs also shows explosive growth. By June 2022, the number of online medical users in China has reached 300 million, accounting for 28.5% of the total Internet users. Online health business revenue continues to grow and various OHCs are in fullswing.[6]

Online Health Community plays a very important role in disseminating health information, popularizing medical knowledge, seeking medical treatment and improving users' health literacy.[7,8] However, the current service quality of OHCs is uneven.[9] Problems such as information service homogenization, charging and pricing confusion, lack of emotional care, inaccurate retrieval results, serious information pollution, difficult to distinguish true and false information, user's privacy leakage have come one after another, which not only has a great impact on the user's search, identification and use of health information, but also seriously restricts the sustainable development of OHCs. Therefore, there is an urgent need to build a scientific and reasonable evaluation mechanism for the service quality of OHC. How to construct a reasonable evaluation indicator system? How to choose an appropriate evaluation method and comprehensively evaluate the service quality of OHC? These problems have become urgent practical problems for managers to solve.

The grounded theory emphasizes that theory comes from practice, which can abandon preconceived thinking and improve the scientific and credibility of research results.[10] It has good applicability in the identification of cause and effect, process interpretation and exploration of new things. Therefore, this study collected data by semistructured interviews and coded the obtained original materials based on the grounded theory. An indicator system for evaluating the service quality of OHCs was established. Then an empirical test was conducted through questionnaires. Six representative OHCs were selected and their service quality was evaluated using the entropy weight TOPSIS method. Specific suggestions are put forward from the aspects of content quality, function quality, interaction quality and emotional experience quality to improve the development of OHC. The study will help relevant operators improve their service quality on the one hand. On the other hand, it can help industry associations and government departments to regulate OHC service quality and guide the healthy and benign development of the industry. Our study plans to achieve the following objectives:

1. Construction of evaluation system of OHC service quality.
2. Evaluating of OHC service quality based on entropy weight TOPSIS method.
3. Targeted suggestions for improving the service quality of OHCs according to the research results.

Literature review

The rapid development of OHC has attracted extensive attention from scholars at home and abroad. Relevant researches such as community value, operation mechanism, service optimization and user behavior are constantly emerging. Among them, the service level of OHC fundamentally determines whether the goal of alleviating doctor–patient conflicts and reducing information asymmetry can be achieved. Therefore, the research on OHC service has become an important topic for scholars. Through literature review, the existing research relevant to OHC service can be divided into the following four aspects:

(1) Influencing factors of OHC service quality. Jung *et al.* (2015)[11] proposed a method to identify key hospital service quality factors from user-generated content of OHC based on text mining technology. Kuang *et al.* (2018)[12] discuss the impact of online medical service penetration rate on the quality and price of doctors' online consulting services using a linear regression model. Based on the theory of finite rationality and evolutionary game, Zhao Dongxiang (2018)[13] found the factors that affecting the quality of OHC information services contain information, users, platform and technology. Wang *et al.* (2020)[14] conducted an in-depth exploration of the relationship between gift prices and the quality of online consultation services for doctors based on social exchange theory. Based on the analysis of gift types and motivation, Peng *et al.* (2020)[15] explained the differences between doctors' service quality and pointed out that users' gift-giving behavior would affect doctors' service attitude.

(2) Evaluation criteria and evaluation methods of OHC service quality. Using cross-sectional survey, Sowter *et al.* (2016)[16] evaluated the commercial and noncommercial websites related to menopause symptoms from three aspects which are information quality, readability and information coverage. Rajak *et al.* (2019)[17] develop a mobile medical evaluation model combining analytic hierarchy process and fuzzy TOPSIS method and determine four evaluation indicators which are user satisfaction, functionality, ease of learning and use and information quality. Based on frame semantic theory, You Liping *et al.* (2019)[18] established a semantic classification dictionary for doctors' service quality comments and a subject knowledge base for doctors' service quality evaluation. Combined with semantic similarity algorithm, the evaluation topics about online comments are identified.

On the basis of the E-SERQUAL evaluation model, Qian Minghui *et al.* (2019)[19] built an evaluation indicator system for the information service quality of China's online health platform from six dimensions. The relationship model between information service quality and user participation is constructed and verified. Jiang Zhiyi *et al.* (2021)[20] constructed an evaluation system of information service quality of OHC based on user portrait theory. Through fuzzy comprehensive evaluation method, the "clove doctor" community was empirically analyzed. In view of the complexity and uncertainty of evaluation tasks, Hao (2022)[21] proposed a comprehensive evaluation method based on q-rung orthopair fuzzy linguistic aggregation operators for service quality of OHC.

(3) The relationship between service quality and users' willingness to use OHC. Lu *et al.* (2016)[22] studied the impact of word-of-mouth about Physician's service quality on patient choice based on OHCs. They found that functional quality negatively moderated the relationship between technical quality and patient choice, and disease risk negatively moderated the relationship between doctor's service quality and patient choice. Wu and Li (2017)[23] constructed a model of factors influencing users' willingness to use information services in OHCs based on perceived value theory. They found that social support, perceived trust and need for achievement had a positive effect on users' willingness to use information services, while perceived risk had a negative effect. Combining the success model of information system with the characteristics of OHC, Wu (2018)[24] studied the influencing factors of patients' continuous use of OHC and found that social support, information quality and service quality have significant effects on patients' continuous use of OHC. Based on the transaction cycle framework, Wu *et al.* (2020)[25] explored how a patient's choice for psychological and material compliments is affected by service quality received at different stages, and how the effects vary depending on the service price. Based on the technology acceptance model, Zhang (2021)[26] analyzed the impact of doctors' ability and enthusiasm on the willingness of patients with chronic diseases to use the doctor-centered OHC. Guo Yu *et al.* (2022)[27] used a meta-analysis to analyze the literature related to users' willingness to use OHCs and found that 33 factors had a significant effect, with emotional trust having the highest correlation and perceived risk having the weakest correlation and negatively related to users' willingness to use.

(4) User's demand of OHC service. Zhang *et al.* (2013)[28] analyzed the questions and answers related to diabetes in the Yahoo Q&A community. Using visual methods, it reveals the 12 categories of health topics that diabetes patients are concerned about. Yang Lei *et al.* (2019)[29] built a Q-LDA model to mine topics of online healthy communities and identify hidden themes. By improving the accuracy and efficiency of topic discovery, users can obtain high-quality health information. Zhu *et al.* (2020)[30] analyzed the content information published by opinion leaders in cancer forums and cancer survivor communities based on grounded theory and determined that patients topics of concern included cancer history and treatment, health status progression and emotional venting and resolution. Ye Yan *et al.* (2022)[31] proposed a medical service quality identification framework based on LDA-BiLSTM model. Using Chinese online patient reviews as data source, the service quality themes and their sentiment tendencies of OHCs were obtained based on the topic model and sentiment analysis methods. From the perspective of information demand cognition, Cheng Quan *et al.* (2022)[32] carried out content analysis and statistical research on users' questions in the online mother-infant community. The coding model of pregnant women's health information needs is constructed and the characteristics of pregnant women's needs are summarized.

In summary, scholars at home and abroad have carried out many researches on OHC services and actively explored the evaluation of OHC service quality. However, there are still several deficiencies. First, there are relatively few studies on the comprehensive evaluation of OHC service quality. A systematic and convincing evaluation indicator system and evaluation model is still lacking. Second, the determination of service quality evaluation indicators focuses on the micro perspective, which is more subjective and lack of empirical testing. Third, the evaluation method relies too much on qualitative analysis. Analytic hierarchy process and other subjective methods are often used to calculate the indicator weight, which is difficult to effectively evaluate the quality of OHC service. To solve the above problems, this paper firstly constructs an evaluation indicator system of service quality of OHC based on the grounded theory. Through empirical research the indicator system is tested. Then the entropy weight TOPSIS method which combines qualitative and quantitative methods and objectively reflects the gap between evaluation schemes is used to evaluate the service quality of OHC. Finally, relevant suggestions are put forward in order to provide reference for the development of OHC.

Methods and results

Initial evaluation indicator system of OHC service quality based on grounded theory

The grounded theory, proposed by Galsser and Strauss in 1967, is a set of methods to generalize and construct theories from original data. It includes three steps: open coding, spindle coding and selective coding. It has been widely used in conceptual development and theoretical construction. The grounded theory emphasizes that theory comes from practice, which can abandon preconceived thinking, improve the scientific and credibility of research results,[10]

overcome the problems of insufficient depth of traditional qualitative and quantitative research to a certain extent, and has good applicability in the identification of cause and effect, process interpretation, complex logical relationship chain and exploration of new things. This paper collected data through semi-structured interviews. Then grounded theory is adopted to carry out open coding of data and the relationship between categories is established through spindle coding. Finally, an evaluation indicator system through selective coding is constructed.

Sample selection and data collection. The survey objects selected in this study were mainly Internet users aged 18–40 years who used OHC regularly (at least 6 months to 1 year) and had sought health information in the OHC and communicated with physicians. These users have experience in using OHCs and good expression ability.[33] According to Holstein, the sample size of in-depth interviews should be controlled at 28–40 people to ensure the validity and focus of the study.[34] The interviewees were selected in the following ways: (1) Survey the understanding and usage of OHC among friends, relatives and classmates and select eligible users to participate in the interview. (2) Recruit eligible volunteers on social platforms such as Weibo, Zhihu and WeChat groups, and attract users to participate in interviews through material rewards (50 RMB). Then, through semistructured interview, focusing on the theme of "service quality of OHC," the interviewees were interviewed in depth according to the outline as follows.

1. What OHC do you use most? How often is it used?
2. What is your expectation of using OHC to enjoy medical services?
3. Does the actual use of OHC reach the expected effect? What factors do you feel affect the use of OHC?
4. When enjoying the medical services of OHC, what aspects do you attach more importance to?
5. What do you think should be done to improve the quality of OHC service?

From June 2022 to July of 2022, we conducted in-depth interviews with 36 interviewees through a combination of offline and online (mainly one-to-one WeChat or telephone communication), of which 61.1% were online and 38.9% were offline. Each interview lasted between 15 and 30 min. The interview sample consisted of 44.4% males and 55.6% females. 33.3% of the interviewees had completed a master's degree or higher. 41.7% had completed a bachelor's degree. And the remaining 25% had completed junior college or less. In terms of monthly income, 11.1% earn less than 3000 RMB per month, 19.4% earn 3001–5000 RMB per month, 41.7% earn 5001–8000 RMB per month and 27.8% earn 8000 RMB or above. People who use OHC more than three years accounted for 36.1%; 1–3 years accounted for 41.7%; half a year to a year accounted for 22.2%. According to the 2021 China Internet Medical Content Industry Research Report,[33] as well as the research of Lu X, Yan Z, A.F. Audrain-Pontevia[25,35–37] etc., OHCs' users are characterized as young, female and highly educated. Therefore, this sample is representative to a certain extent and can be used to analyze the service quality of OHCs.

After the interview, the materials were transcribed and 36 original data with about 98,000 words were obtained after excluding the content significantly unrelated to this study. According to Glaser and Strauss, the theoretical model based on grounded theory should be tested for theoretical saturation, which means that if additional sampling continues, no new genera or related topics will emerge.[38] Quality (sufficient) is the key to saturation and the sample size of saturation test is generally selected according to actual research.[39] In this research, we select 31 samples randomly from the obtained data for analysis, and five samples (more than 10%) were reserved for saturation testing. The standardized text was imported into NVivo Plus12—an analysis software commonly used in qualitative research to prepare for further text analysis.

Data analysis and construction of indicator system

(1) Open coding. In the process of open coding of original text materials, the requirements of Glaser's rooted paradigm[38] were strictly followed. It was carefully checked whether each line contains events which may come from a word, a sentence or multiple lines of text. By coding and refining the 31 text materials sentence by sentence and line by line, more than 450 original statements and their corresponding concepts such as rich experience, convenient navigation and comprehensive content were finally obtained. Examples of the original statements and the first-order codes are shown in Table 1.

The text materials were further analyzed by referring to a large amount of literature and communicating with users of OHCs. By comparing the original texts, concepts and initial categories, 39 first-order codes and 16 second-order codes were finally extracted as shown in Table 2.

(2) Spindle coding. Spindle coding is to correlate the second-order codes formed in the previous step and summarize the concepts that express the same subject to form a theme through comparative analysis. By analyzing the connotation and internal relations of each second-order code, four themes of content quality, function quality, interaction quality and emotional experience quality are finally refined, as shown in Table 3.

(3) Selective coding. Selective coding is the process of systematically analyzing concepts and codes, identifying core categories and exploring the connections between core categories and other categories to form theories.

Table 1. Examples of original materials and open coding.

First-order codes	Part of original materials
A1 Rich experience	When selecting a doctor, I found that many doctors have up to ten years of medicinal experience. One doctor has treated nearly 700 patients with hypertension.
A2 Convenient navigation	The navigation of OHC is clear and quick. It's easy to find information about a disease or a doctor.
A3 Comprehensive content	In addition to consultation, I often browse information in the section of knowledge and science popularization of the community. There are a lot of articles about diseases, vaccines etc. which are very useful.
A4 Timely response	Sometimes doctors may be busy and slow to respond. So I was a little worried when waiting.
A5 Stable technology	Sometimes it took several seconds to refresh the page when I clicked the button. At first, I thought that the Internet speed was slow. But there was no problem with other software.

Table 2. Open coding results.

	Second-order codes	First-order codes
B1	Content richness	A3 Comprehensive content A35 Sufficient cases
B2	Update timeliness	A14 Update of resources A32 Real-time science popularization
B3	Content professionalism	A16 Authority A15 Doctor qualification A1 Rich experience
B4	Expression friendliness	A19 Easy to understand A36 Moderate speed of speech A29 Popular expression
B5	Ease of use	A27 Easy to operate A9 Clear interface A2 Convenient navigation
B6	Function soundness	A11 Comprehensive function A12 Reasonable function
B7	Technology reliability	A5 Stable technology A18 Running speed
B8	Search intelligence	A22 Advanced algorithm A33 Comprehensive search results
B9	Friendliness of interactive service	A28 Friendly attitude A39 Patience and meticulosity
B10	Timeliness of interactive response	A4 Timely response A20 Smooth communication
B11	Diversity of interactive mode	A8 Rich communication Channels A37 Diversified interactive Media A13 Various forms of interaction
B12	Effectiveness of interactive content	A6 Reasonable treatment plan A23 Useful communication
B13	Protection of privacy security	A26 Information confidentiality A17 Use's privacy A30 information security
B14	Perceived cost reasonableness	A24 Charge mechanism A25 High cost performance A21 Value for money
B15	Service continuity	A10 Care after diagnosis A38 Post-disease follow-up
B16	Perceived social support	A7 Companion support A34 Spiritual motivation A31 Experience sharing

In this study, on the basis of comparing the second-order codes and the themes with each other, we compared the summarized first-order codes and second-order codes, extracted four themes of content quality, functional quality, interaction quality and emotional experience quality, and built a theoretical model

Table 3. Spindle coding results.

Theme	Second-order codes	Connotation
C1 Content quality	B1 Content richness	The medical information is rich which can meet the needs of users.
	B2 Update timeliness	Information such as hospital, doctor qualification and typical cases is updated timely.
	B3 Content professionalism	Doctors are highly professional in diagnosing users' symptoms. Prescriptions and suggestions issued are in accordance with medical standards.
	B4 Expression friendliness	The expression is easy to understand and the professional vocabulary can be explained in popular language.
C2 Functional quality	B5 Ease of use	The navigation is clear. The layout is reasonable. Users are easy to operate and complete tasks such as query, browsing and consultation by themselves.
	B6 Function soundness	The functions are comprehensive and reasonable which can meet the different needs of users for medical information such as personalized recommendation, service push, intelligent prediction, etc..
	B7 Technology reliability	Advanced technology of page display, search engine etc. are utilized to ensure the smooth use of the user.
	B8 Search intelligence	Users can intelligently retrieve the desired content by querying words such as diseases or doctors.
C3 Interaction quality	B9 Friendliness of interactive service	The service provided by doctors in OHC such as disease consultation and drug purchase is friendly.
	B10 Timeliness of interactive response	The information communication between doctors and users is in time and without delay.
	B11 Diversity of interactive mode	Users and doctors can communicate in a variety of ways such as voice, text, pictures and video.
	B12 Effectiveness of interactive content	The communication between users and doctors is effective and can produce practical effects.
C4 Emotional experience quality	B13 Protection of privacy security	The community can provide functions or services that can protect privacy and security.
	B14 Perceived cost reasonableness	The user feels that the charges are reasonable in the process of consultation, drug purchase or other services.
	B15 Service continuity	The community or doctor will provide follow-up services after the diagnosis such as return visit.
	B16 Perceived social support	Users can feel the encouragement, accompaniment and support from doctors and other users of OHC.

accordingly (see Figure 1). In this model, the influencing factors of OHC service quality have four first-level indicators of C1, C2, C3 and C4 and 16 second-level indicators from B1 to B16.

(4) Theoretical saturation test. The theoretical saturation test is to check whether the model built by the researcher can reflect all the original materials and whether the recoding process will produce new concepts. In this process, the five reserved text materials were refined and coded sentence by sentence and line by line. Finally, no new concepts and categories were refined during the coding process, indicating that the model established in this study has a good theoretical saturation.

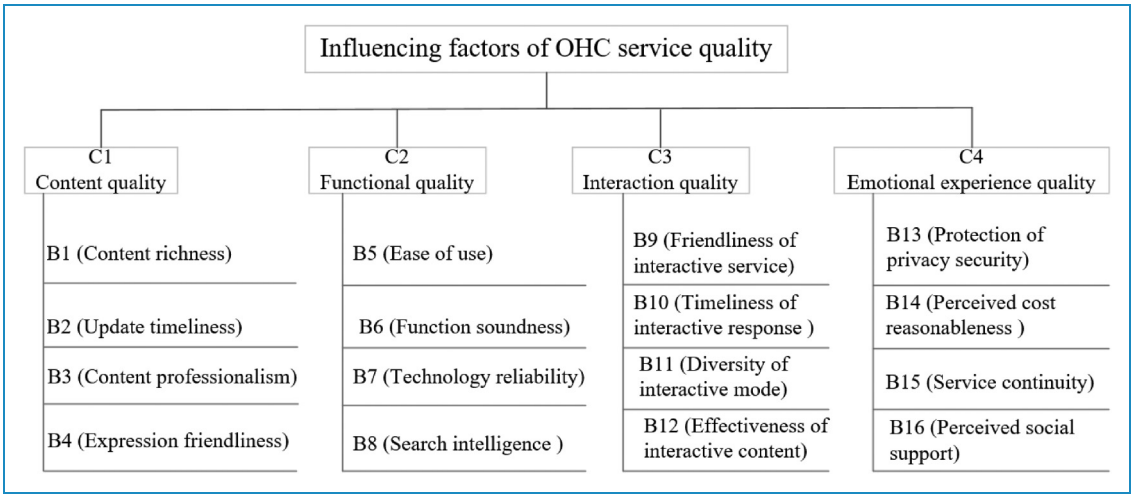

Figure 1. Construction of theoretical model.

Empirical test of evaluation indicator system of OHC service quality

Descriptive statistical analysis and reliability test. To further verify the validity of the indicator system proposed above, we designed questionnaires. The five-point Likert-type response format that ranges from "strongly disagree" to "strongly agree" was used to measure items. The questionnaires were distributed nationwide in China to users who had experience of using OHC by on-site and Wenjuanxing platform, WeChat, QQ, email, etc. We collected questionnaires in the following ways: (1) Target subjects were recruited to fill out questionnaires on the Wenjuanxing platform. As a powerful Chinese online survey platform in China,[40] Wenjuanxing has a large number of users. (2) Solicit eligible OHC users on social platforms such as Weibo, Zhihu and WeChat groups, and then send questionnaires to them through WeChat, QQ, email and other means. (3) We also look for OHC users in hospitals and nearby communities and fill in the paper questionnaire on site. After all questionnaires were completed, the online subjects received reward through the Wenjuanxing platform and the on-site users were presented with small gifts. Finally, a total of 667 questionnaires were distributed and 641 questionnaires were returned, of which 628 questionnaires are valid. The effective rate of recovery is 94.2%. The sample information is shown in Table 4. Over half were 19–35 years old (69.4%), female (54.5%), and had at least a bachelor's degree (64%). OHCs' users are characterized as young, female and highly educated.[25,33,35–37] Therefore, this sample is representative to a certain extent and can be used to verify the validity of the indicator system.

Then SPSS 26.0 is used to test the reliability of the data. The results showed that the overall Cronbach's α coefficient of the scale was 0.882. The Cronbach's α coefficient of each dimension was greater than 0.8, which indicated that the questionnaire had good reliability.

Exploratory factor analysis. Exploratory factor analysis (EFA) and Confirmatory factor analysis (CFA) require to use different data for testing.[41] The 628 questionnaires collected were randomly divided into two parts. The former 314 questionnaires are for EFA and the latter 314 questionnaires are for validation factor analysis. The KMO value of the former data was 0.875. The approximate chi-square significance level of Bartlett's spherical test was 0.000 which is less than 0.01, indicating that this part of data is suitable for factor analysis.

Principal component analysis was used for EFA. Orthogonal rotation was performed based on the maximum variance method and a total of four principal components were extracted from the 16 independent variables, which explained 76.81% of the variance. The rotating component matrix is shown in Table 5, indicating that the indicators of this study have good construction validity. Therefore, it can be concluded that the four extracted factors are ideal in adequately extracting and explaining the information of the original variables.

Confirmatory factor analysis. Confirmatory factor analysis of the latter data was performed by AMOS25.0. The results showed that CMIN/DF = 1.049 < 3, GFI = 0.963 > 0.9, AGFI = 0.949 > 0.9, NFI = 0.968 > 0.9, TLI = 0.998 > 0.9, IFI = 0.998 > 0.9, CFI = 0.998 > 0.9, RMR = 0.043 < 0.08 and RMSEA = 0.013 < 0.08. Therefore, the model exhibited a good fit.

From the results of CFA in Table 6, it can be seen that the standardized factor load of the 16 variables is greater than 0.6. CR of the four factors is greater than 0.7 and AVE is greater than 0.5, indicating that the variables have good convergent validity. Meanwhile, the square root of AVE of the 16 variables is greater than the normalized correlation coefficient. Therefore, the model had good discriminant validity. In summary, according to the results of CFA, the indicator system proposed above is reasonable and valid.

Table 4. Sample distribution.

Properties	Category	Number of people	Percentage (%)
Gender	Male	286	45.5
	Female	342	54.5
Age	18 and younger	10	1.6
	19–25	304	48.4
	26–35	132	21
	36–45	108	17.2
	46 and above	74	11.8
Academic qualifications	Junior high school and below	26	4.1
	Technical secondary school or high school	58	9.2
	Junior college	142	22.6
	Undergraduate	275	43.8
	Master's degree and above	127	20.2
Occupation	Students	163	26
	Corporate employees	156	24.8
	Civil servant	117	18.6
	Personnel of public institutions	90	14.3
	Private businessman	66	10.5
	Freelancer	36	5.7
Duration of use	Less than 6 months	140	22.3
	6 months to 1 year	256	40.8
	1–3 years	148	23.6
	More than 3 years	84	13.4

Evaluation of OHC service quality based on entropy weight TOPSIS method

To further verify the applicability and operability of the evaluation model, 6 relatively representative OHCs in China named Haodf (P1), WeDoctor (P2), Chunyu Doctor (P3), Clove Doctor (P4), Ping An Good Doctor (P5) and AliHealth (P6) were selected for service quality evaluation. Questionnaires were distributed to 24 senior experts and scholars in this field, of which 20 experts completed the scoring for the six communities. The return rate of the questionnaire was 83.3%. Then the entropy weight TOPSIS method was used for evaluation, and the steps were as follows.

Table 5. Rotating component matrix[α].

	Component			
	1	2	3	4
B10	0.877			
B11	0.869			
B9	0.855			
B12	0.846			
B14		0.870		
B16		0.855		
B15		0.854		
B13		0.836		
B5			0.857	
B6			0.856	
B8			0.854	
B7			0.827	
B1				0.868
B4				0.865
B2				0.837
B3				0.808

Step 1. Establish the original judgment matrix of evaluation indicators

Suppose there are m OHCs and n evaluation indicators. a_{ij} denotes the evaluation value of the j-th evaluation indicator of the i-th OHC. Then the original judgment matrix is $A = [a_{ij}]_{mn}$, i = 1, 2, …, m; j = 1, 2, …, n.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad (1)$$

Step 2. Normalize the values of evaluation indicators.

$$c_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}} \quad , j = 1, 2, \ldots, n \quad (2)$$

Step 3. Calculate the entropy value E_j and entropy weight W_j of the j-th indicator E_j.

$$E_j = -\frac{1}{\ln m}\sum_{i=1}^{m} c_{ij} \ln c_{ij} \quad , j = 1, 2, \ldots, n \quad (3)$$

$$W_j = \frac{1 - E_j}{\sum_{j=1}^{m}(1 - E_j)} \quad , j = 1, 2, \ldots, n \quad (4)$$

The indicator values were substituted into formula (2) for normalization. Then the normalized values were substituted into formulas (3) and (4) to obtain the entropy values and weights of different indicators. The results are shown in Table 7.

Step 4. Construct the weighted normalized matrix

On the basis of the original matrix A, perform vector normalization for attribute and multiply it with the weight of each indicator w_j obtained by the entropy weight method. Then the weighted normalized decision matrix is constructed, as seen in Table 8.

$$z_{ij=} \frac{x_{ij} \times w_j}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (5)$$

Step 5. Determine the positive ideal and negative ideal solution

The positive ideal solution Z^+ is:

$$Z^+ = (\max\{z_{11}, z_{21}, \ldots z_{n1},\}, \max\{z_{12}, z_{22}, \ldots z_{n2}\}, \ldots, \max\{z_{1m}, z_{2m}, \ldots, z_{nm}\}) = (z_1^+, z_2^+, \ldots, z_m^+) \quad (6)$$

The negative ideal solution Z^- is :

$$Z^- = (\min\{z_{11}, z_{21}, \ldots, z_{n1}\}, \min\{z_{12}, z_{22}, \ldots, z_{n2}\}, \ldots, \min\{z_{1m}, z_{2m}, \ldots, z_{nm}\}) = (z_1^-, z_2^-, \ldots, z_m^-) \quad (7)$$

Step 6. Calculate the distance of each object to Z^+ and Z^-

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (z_j^+ - z_{ij})^2} \quad (8)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (z_j^- - z_{ij})^2} \quad (9)$$

Step 7. Calculate the closeness of each object to the ideal solution C_i.

$$C_{i=} \frac{100 \times D_i^-}{D_i^+ + D_i^-} \quad (10)$$

Substitute the value of the weighted normalized matrix Z into formula (8)–(10), so the closeness of indicators C_i can be calculated. The closeness C_i is to 100, the better the level of service quality is. Therefore, the indicator rank and comprehensive rank of each OHC can be got, as shown in Table 9.

Table 6. Results of CFA.

First-level indicator	Second-level indicator	Average value	Standard deviation	Factor load	CR	AVE	C1	C2	C3	C4
C1	B1	3.75	1.139	0.838	0.891	0.672	0.672			
	B2	3.74	1.192	0.816						
	B3	3.69	1.187	0.785						
	B4	3.73	1.198	0.839						
C2	B5	3.78	1.183	0.851	0.893	0.678	0.337	0.678		
	B6	3.73	1.238	0.819						
	B7	3.78	1.195	0.786						
	B8	3.68	1.228	0.837						
C3	B9	3.79	1.192	0.838	0.907	0.709	0.326	0.362	0.709	
	B10	3.68	1.318	0.849						
	B11	3.75	1.244	0.864						
	B12	3.74	1.205	0.817						
C4	B13	3.66	1.236	0.813	0.903	0.701	0.334	0.298	0.315	0.701
	B14	3.83	1.210	0.853						
	B15	3.81	1.207	0.858						
	B16	3.79	1.185	0.825						

Discussion

First-level indicator analysis. Based on the research results above, it can be seen that the indicator system is reasonable and effective and the evaluation method has strong applicability and operability.

Analyze the first-level indicators according to Table 7. It can be seen that the weights of indicators are C1 (0.3169), C4 (0.2893), C3 (0.2234) and C2 (0.1704) from large to small. That is content quality, emotional experience quality, interaction quality and functional quality, of which content quality has the highest weight.

Users often seek health information to prevent diseases and maintain health. High-quality health information can answer users' health doubts and improve health literacy, while vague or incorrect information may lead to serious adverse consequences. Therefore, content quality is the most important factor of OHC service quality, which is consistent with the findings of Qian Minghui (2019).[18]

When users are emotionally supported by companions, receive follow-up services after consultation and their privacy is protected, they can gain emotional comfort and satisfaction, which in turn motivates them to continue using OHC and are likely to recommend it to others.[36,42,43] Thus, the quality of emotional experience is the second critical factor of the service quality of OHCs.

Frequent and effective communication and interaction between users and doctors, especially the timely and friendly responses from doctors to users' questions and the variety of interaction modes are the basic and key services of the community. It is also the key aspect to increase users' stickiness. Therefore, interaction quality has an important impact on the service quality of OHC.

Users' behaviors of usage and participation in various services of OHCs need to be supported by community functions. The quality of functions has a significant impact on user satisfaction.[44] Easy-to-use, practical and humanized functions, as well as search intelligence are important factors that influence user experience. Although the functions of each community vary and have their own characteristics, due to the rapid development of present technology,

Table 7. Entropy values and weights of each indicator.

First-level indicator	Second-level indicator	Weight (W_j)	Rank
C1(0.3169)	B1	0.0913	4
	B2	0.0794	6
	B3	0.1121	2
	B4	0.0341	12
C2(0.1704)	B5	0.0282	15
	B6	0.0666	8
	B7	0.0352	11
	B8	0.0404	10
C3(0.2234)	B9	0.0327	14
	B10	0.0670	7
	B11	0.0270	16
	B12	0.0967	3
C4(0.2893)	B13	0.0572	9
	B14	0.1127	1
	B15	0.0336	13
	B16	0.0859	5

most communities have functions that can meet the basic needs of users. So the weight of function quality is low.

Second-level indicator analysis. Analyze the indicators of the second level. It can be seen that B14 (Perceived cost reasonableness) is ranked first with a weight of 11.27%, followed by B3 (Content professionalism), B12 (Effectiveness of interactive content) and B1 (Content richness). The weight of B9 (Friendliness of interactive service), B5 (Ease of use) and B11 (Diversity of interactive mode) are the lowest.

Users traditionally pay for consultation and medical treatment offline according to hospital grade, doctor's qualification and title etc. While currently more and more people use online consultation due to time, distance, environmental safety and other factors. There are many online hospital and doctor resources of various grades and qualifications. The fees vary widely from a few yuan to hundreds of yuan. Due to the inability to conduct face-to-face communication and diagnosis, many users concern about the quality of online consultation because of reasons such as the trust of doctor's professional skills and ability etc. They are generally unwilling to pay the same cost for online consultation compared to offline consultation. So they attach great importance to the reasonableness of perceived cost, which affects their choice of hospitals and doctors and even whether they will adopt online consultation. Thus, the reasonableness of perceived cost has the greatest weight.

Indicators such as the content professionalism, effectiveness of interactive content and content richness are crucial to answering users' health questions, solving health problems and improving health literacy. Therefore, they are the second more important factors affecting the service quality of OHC.

For the indicators of friendliness of interactive service, ease of use and diversity of interactive mode, the resources and services vary across communities, but the differences are not very pronounced. Physicians in OHCs have generally experienced the training of communities and the interactive services are generally friendly due to assessment of their service performance and personal characteristics. In terms of community function design, due to the current technological development and the community's concern for user experience, the ease and convenience of use are often considered. In addition, most communities have text, graphic and voice interaction together. Some communities also have video interaction. And most users have strong ability to understand and operate software, so the impact of ease of use and the diversity of interactive mode on service quality of OHCs are not very different. Therefore, these three indicators have the lowest weights.

Rank analysis of service quality of OHC. According to the closeness of the service quality in Table 9, the OHC P5 and P6 are in the first and second place with the closeness of 62.6 and 53.44, respectively, followed by P4, P1 and P3. P2 is in the last place. So from a practical perspective, this paper has the following practical implications:

1. In terms of content quality, P4 leads and performs well in terms of content richness, content professionalism, update timeliness and expression friendliness. This is followed by P5, P6 and P2, but P1 and P3 have lower closeness. As the saying goes, content is king. Content quality is an important means for OHCs to promote user growth, enhance user stickiness and reduce user churn, so P1 and P3 community should strengthen content quality management and improve the richness and professionalism of content. Specifically, improvements can be made in the following areas.

First of all, improve the comprehensiveness and professionalism of information. Medical resources should be included as much as possible. Disease introduction, prevention, discovery, clinical manifestation, treatment and related cases should be integrated and shown to users in the form of scientific articles or reports to meet their different health

Table 8. The weighted normalized matrix.

Second-level indicators	P1	P2	P3	P4	P5	P6
B1	0.0378	0.0363	0.0363	0.0383	0.0388	0.0359
B2	0.0321	0.0342	0.0313	0.0334	0.0334	0.0330
B3	0.0442	0.0436	0.0454	0.0478	0.0472	0.0460
B4	0.0142	0.0137	0.0141	0.0141	0.0135	0.0141
B5	0.0113	0.0115	0.0115	0.0116	0.0119	0.0115
B6	0.0280	0.0267	0.0267	0.0274	0.0280	0.0263
B7	0.0141	0.0143	0.0144	0.0141	0.0144	0.0148
B8	0.0159	0.0164	0.0164	0.0170	0.0166	0.0166
B9	0.0131	0.0133	0.0133	0.0138	0.0133	0.0136
B10	0.0266	0.0266	0.0269	0.0283	0.0280	0.0276
B11	0.0108	0.0109	0.0108	0.0112	0.0112	0.0111
B12	0.0412	0.0407	0.0391	0.0376	0.0396	0.0386
B13	0.0231	0.0228	0.0228	0.0237	0.0243	0.0231
B14	0.0459	0.0459	0.0479	0.0439	0.0445	0.0479
B15	0.0135	0.0139	0.0139	0.0140	0.0137	0.0133
B16	0.0347	0.0338	0.0338	0.0357	0.0362	0.0362

information needs. For the authority and professionalism of information, it can be ensured and improved by strengthening the control of information source and intensifying the supervision and audit of information.

Secondly, timely update the website information and pay attention to the reliability and accuracy of the information. Clarify the rules of information release and audit. If there is any problem, both the publisher and the auditor should take the responsibility to avoid false and wrong information to mislead the consumers, so that users can enjoy comprehensive and high-quality services.

Thirdly, plan the boards of OHC occupied by advertisements properly and control the quantity and quality of advertisements. Advertisements are helpful to improve users' health level and literacy and expand their horizons. But too many advertisements in the community may cause users to resist and think the site is not reliable enough. So OHC should pay attention to the quality and quantity of advertisements placed.

2. In terms of emotional experience quality, the OHC P6 leads with the closeness of 76.57. While P3, P5, P1 and P2 are in the second to fifth positions, and P4 is at the bottom. Protection of user's privacy security, perceived cost reasonableness and perceived social support are helpful for improvement of user's emotional experience and have a significant impact on users' continued use of OHCs. The OHC P4 needs to pay particular attention to the improvement of emotional experience quality. Specifically, this can be done in the following ways.

First, design a reasonable pricing mechanism to enhance user's perceived cost reasonableness. Some famous doctors and experts have higher pricing for their services. The community can take measures such as propagating the doctor's title, reputation, successful cases and patient comments to improve user's perceived cost reasonableness.

Second, enhance users' sense of community belonging. By providing positive psychological relief, giving incentives and following up with patients after diagnosis, users will deeply appreciate the community's concern for their illness and health, which will make them generate the sense of belonging and enhance their willingness to continue using OHC.

Table 9. The closeness rank of OHC.

OHC	C1		C2		C3		C4		Comprehensive results	
	C	Rank	C	Rank	C	Rank	C	Rank	C	Rank
P1	35.16	5	54.43	3	64.64	1	44.52	4	47.47	4
P2	37.90	4	26.28	6	61.25	2	37.54	5	42.39	6
P3	30.13	6	29.56	5	38.03	4	58.95	2	43.94	5
P4	84.30	1	58.74	2	35.36	6	35.26	6	52.77	3
P5	80.05	2	77.52	1	60.45	3	46.43	3	62.60	1
P6	44.87	3	35.41	4	37.43	5	76.57	1	53.44	2

Third, users' privacy information should be fully protected. There is a risk of information leakage when users consulate and comment in OHC, which may pose a threat or harm to them. For this reason, the construction of information security should be strengthened to prevent the intrusion of lawless elements. Technical support should be increased. The privacy terms of OHC should be open and transparent to enhance users' trust. The rules and regulations of OHC should be improved and the sense of social responsibility should be enhanced. A complaint function could be added in the community so that when users' privacy is violated, they can timely defend rights through complaints.

3. In terms of interaction quality, the closeness of P1 ranks first followed by P2 and P5. P3, P6 and P4 rank lower. High quality interactive services in the OHC can enhance user stickiness. The diversity of interactive mode and the warmth and friendliness of doctors all will have a positive impact on users' community engagement. P3, P6 and P4 should pay attention to improving the interaction quality of services. Specifically, it can be carried out in the following aspects.

Firstly, the online consultation channels for users should be expanded. On the basis of user's single text and picture inquiry, voice or video interaction, personal doctors and other channels can be explored to form a multi-level online communication channel and interaction system.

Secondly, the training of OHC doctors should be strengthened to improve the service quality. For example, a reasonable interval could be set for the timeliness of reply, and the reply should be targeted and friendly.

Thirdly, intelligent robots could be added to answer questions for some patients. Through the combination of intelligent robots and doctors' services, the problem of unequal number of patients and doctors and the difficulty of timely answer by doctors can be solved. But the accuracy and effectiveness should be noticed.

Fourthly, the interaction function of OHCs should be improved. User recommendation could be well developed so that users in OHC can easily find others with similar health conditions or experiences. The health group can be established so that users can join the corresponding group according to their health conditions or diseases. Users will not only get more health information but also share their treatment experience to get comfort and support.

4. In terms of functional quality, the OHC P5 is in the first place with the closeness of 77.52 which is much higher than P4 and P1, while the closeness of the rest OHCs are all below 40.00. Especially P2 is in the last place. Since functional quality can directly affect users' smooth usage and continuous engagement with OHC,[45] P2, P3 and P6 need to furtherly improve functional quality. Specifically, it can be carried out in the following ways.

Firstly, the technology advanced level of OHC should be improved. The quality of information systems should be improved according to user needs to ensure their experience. For example, the web server can be regularly optimized and communication technology can be timely updated.

Secondly, optimize the level of intelligent retrieval. On the one hand, the accuracy of information retrieval should be improved. On the other hand, duplicate and useless information should be filtered to reduce the impact of information overload on users.

Thirdly, the design and perception of software interface should be optimized. A simple and beautiful interface with reasonable perceptual design can improve users' experience. Hence, it is important to improve the empathy perception of users and strengthen design innovation to enhance the micro-sensory experience of users. For example, personalized menu could be developed so that users can add frequently used functions to the main page according to their needs, which will provide convenience for subsequent use. A map of a website can be set up to improve the efficiency of community use, according to which users can directly and conveniently access health information without searching through layers of navigation.

Conclusions

This study provides a unique approach to solve the problem of service quality evaluation of OHCs. The evaluation system of OHC service quality was firstly constructed based on the grounded theory which includes 4 first-level indicators and 16 second-level indicators. Then the rationality and validity of the evaluation system were verified through empirical analysis. The results show that the weights of the first-level indicators from large to small are content quality, emotional experience quality, interaction quality and function quality. Among the second-level indicator weights, the top three are perceived cost reasonableness, content professionalism and effectiveness of interactive content. Then six OHCs were selected and evaluated by applying the entropy weight TOPSIS method and relevant conclusions and recommendations were given from quality of content, function, interaction and emotional experience etc. This study will provide theoretical guidance for community platform operators and relevant departments to design effective evaluation mechanism of OHC service quality, offering a reference for decisions and policymakers.

OHCs are in a phase of rapid growth with constant changes. With the development of information technology and related industries, the research horizon should also keep pace with the times and the following aspects could be further explored in future research.

1. Objective data such as Internet comments could be obtained. Through text mining and other methods, the evaluation indicator system could be further improved and the scientific rationality of the indicator system could be enhanced.
2. Explore other more effective evaluation methods. The entropy weighted TOPSIS method used in this paper can reflect the gap between the evaluated OHC service quality and reveal the characteristics and problems of OHC services. But it is slightly complicated in calculating the distance from the standardized vector of each indicator to positive ideal solution and negative ideal solution. In the future, other evaluation methods such as artificial neural networks could be explored. The evaluation results of each method could be compared to improve the accuracy of evaluation.
3. Explore the relationship between the OHC service quality and factors such as user loyalty and user churn. Moreover, the service quality evaluation system could also be combined with the annual report of enterprises to explore the relationship between OHC service quality and profitability.

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Guarantor: YH

ORCID iD: Wang Shujuan https://orcid.org/0000-0002-1182-3745

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