

Construction of an Evaluation Index System for Institutional Health Science Popularization Based on the Delphi Method (Postprint)

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Abstract

Background Currently, science popularization work in China faces issues such as unbalanced development among science popularization institutions, insufficient investment, and difficulty in conducting refined evaluation of science popularization effectiveness. Moreover, with the advent of the “science popularization boom,” the science popularization cause has exhibited new characteristics, urgently requiring a new evaluation system. Taking health science popularization as an example, research on institutional work evaluation is relatively weak, and existing evaluation systems suffer from practical problems such as single dimensionality, difficulty in quantification, and lack of systematicity and operability. **Objective** To construct an evaluation index system for health science popularization work, providing a reference basis for establishing evaluation standards for health science popularization work in social institutions. **Methods** Based on the “Structure-Process-Outcome” theory and literature reports, a Delphi questionnaire was developed. Fourteen senior professionals in the field of health science popularization were selected to form an expert panel. The Delphi method was employed to conduct three rounds of consultation via email from April to May 2022. SPSS 25.0 software was used for statistical data analysis. An evaluation index system for institutional science popularization work was constructed based on expert opinions. **Results** The response rate for the first-round questionnaire was 100%. Nine experts provided 34 revision suggestions for 19 indicators, with an expert opinion proposal rate of 64.29% (9/14), indicating high expert engagement. The authority coefficient of the consulted experts was 0.814, with a judgment basis of 0.886 and familiarity degree of 0.742. The Kendall’s W coefficients for the first and second rounds of expert consultation were 0.238 and 0.246, respectively ($P < 0.001$). The coefficient of variation for both rounds of expert consultation was < 0.250 , demonstrating good consistency in expert opinions. The evaluation index system for institutional science popularization

work was determined and constructed, comprising 3 first-level indicators (science popularization input, science popularization implementation, science popularization outcome), 16 second-level indicators, and 77 third-level indicators. Conclusion An evaluation index system for institutional science popularization work was constructed based on the Delphi method, comprising 3 first-level indicators (science popularization input, science popularization implementation, science popularization outcome), 16 second-level indicators, and 77 third-level indicators. Its application will help improve the efficiency of health science popularization work in social institutions.

Full Text

Preamble

Construction of an Evaluation Index System for Institutional Health Science Popularization Work Based on the Delphi Method

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Abstract Background: Currently, science popularization work in China faces several challenges, including unbalanced development among science popularization institutions, insufficient investment, and difficulties in conducting refined evaluations of science popularization effectiveness. Moreover, with the advent of the “science popularization boom,” science popularization endeavors have exhibited new characteristics, necessitating a new evaluation system. Taking health science popularization as an example, research on work evaluation for institutions remains relatively weak, with existing evaluation systems suffering from practical problems such as single-dimensional assessment, quantification difficulties, and lack of systematicity and operability.

Objective: To construct an evaluation index system for health science popularization work, providing a reference basis for establishing evaluation standards for social institutions.

Methods: Based on the “Structure-Process-Outcome” theory and literature reports, a consultation questionnaire was developed. Fourteen senior practitioners in the field of health science popularization were selected to form an expert panel. The Delphi method was employed to conduct three rounds of consultation via email between April and May 2022. SPSS 25.0 software was used for statistical analysis, and an evaluation index system for institutional science popularization work was constructed based on expert opinions.

Results: The first-round consultation questionnaire achieved a 100% recovery rate. Nine experts provided 34 revision suggestions for 19 indicators, with an expert opinion proposal rate of 64.29% (9/14), indicating high expert enthusiasm. The authority coefficient of the consulted experts was 0.814, with a judgment basis of 0.886 and familiarity degree of 0.742. Kendall's W coefficients for the first and second rounds of expert consultation were 0.238 and 0.246, respectively ($P < 0.001$). The coefficient of variation (CV) for both rounds was < 0.250 , demonstrating good consistency in expert opinions. The evaluation index system for institutional science popularization work was determined and constructed, comprising 3 primary indicators (science popularization input, implementation, and effectiveness), 16 secondary indicators, and 77 tertiary indicators.

Conclusion: Based on the Delphi method, an evaluation index system for health science popularization work for social institutions was constructed, including 3 primary indicators (science popularization input, implementation, and effectiveness), 16 secondary indicators, and 77 tertiary indicators. Its application will help improve the efficiency of health science popularization work in social institutions.

[Keywords] Science popularization; Medical science popularization; Evaluation model; Delphi technique

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1. Methods

1.1 Expert Selection

This study utilized the Shanghai Health Science Popularization Expert Database for stratified sampling by institution type. After the initial sampling, researchers contacted each expert to solicit their participation willingness. Due to some experts not responding promptly, a second sampling was conducted. To ensure broad representation of opinions while minimizing convergence, the study strictly adhered to the principles of expert opinion application in the Delphi method and restricted the composition of the expert panel [7,8]. Additionally, the size of the Delphi expert panel is primarily influenced by group dynamics for reaching consensus, with a recommended size of 10-18 experts [9]. The study ultimately invited 14 senior practitioners in health science popularization

to form the expert panel, all of whom were heads of science popularization departments or unit leaders from public hospitals, universities, academic societies, CDCs, and media organizations. With over three years of experience in science popularization work, they possessed bachelor's degrees or higher, had professional knowledge and practical experience in health science popularization, and were familiar with the work of science popularization institutions, ensuring the effectiveness of the Delphi consultation.

1.2 Delphi Expert Consultation

1.2.1 Questionnaire Development Based on Donabedian's "Structure-Process-Outcome" theory [10], this study distinguished three primary evaluation indicators for institutional medical science popularization work: science popularization input (the preparatory attributes of social institutions for conducting health science popularization activities, such as material resources, human resources, and organizational structure), science popularization implementation (the actual tasks completed by social institutions in health science popularization work, including content creation and dissemination, and organizing science popularization activities), and science popularization effectiveness (the impact of health science popularization work on the institutions themselves, primarily involving socio-economic impact and communication influence) [11]. The investigation of the institutional science popularization evaluation index system was conducted based on these three primary indicators. After comprehensively searching and reviewing relevant literature using Chinese keywords (KY=science popularization work AND institution AND (evaluation indicator OR evaluation system)) and English keywords (TS=(Science popularization AND (Evaluation indicator OR Evaluation system) AND Institution)) in databases including CNKI, Wanfang, and Web of Science, the research team internally analyzed and discussed the compiled indicators, ultimately drafting the first-round consultation questionnaire. A Likert 5-point scale was used to assign importance levels to each indicator: "very unimportant," "unimportant," "neutral," "important," and "very important," corresponding to scores of 1, 2, 3, 4, and 5 points respectively. Experts were asked to provide opinions (modification, supplementation, deletion) on each indicator based on their practical work experience, with an expert opinion column reserved for each indicator to facilitate open-ended feedback. Additionally, experts were required to provide qualitative feedback at the end of each section. Beyond the indicators, the questionnaire included: basic expert information; experts' familiarity with science popularization work and content; and expert authority degree, including judgment basis (Ca) and familiarity degree (Cs) for the overall evaluation indicators. Ca was assigned values based on large, medium, and small impact levels: practical experience (0.5, 0.4, 0.3), theoretical analysis (0.3, 0.2, 0.1), reference to domestic and foreign literature (0.1, 0.1, 0.1), and intuitive feeling (0.1, 0.1, 0.1). Cs was divided into very familiar, relatively familiar, generally familiar, not very familiar, and unfamiliar, assigned values of 1.0, 0.8, 0.6, 0.4, and 0.2 respectively.

1.2.2 Delphi Expert Consultation Process This study sent questionnaires individually to consultation experts via email, conducting three rounds of consultation between April and May 2022. The first-round questionnaire distribution and collection were completed in April 2022. The second-round consultation was conducted based on the first round, with indicators revised according to expert opinions, and was completed in May 2022. Relevant modifications were made based on expert suggestions. The third-round consultation was completed in May 2022. Ultimately, the expert panel's opinions converged, with no new revision suggestions proposed.

1.3 Quality Control Standards

Indicators with disputes were discussed by the expert panel that initiated this study, with relevant experts invited to provide explanations. For any feedback suggestion, if the number of supporting experts was no less than 75% of the total voters and the coefficient of variation (CV) was <25%, the suggestion was included without requiring further second or third rounds of consultation. If the number of supporting experts was less than 75% of the total voters and $CV < 25\%$, the suggestion was excluded. If $CV \geq 25\%$, the issue proceeded to the second and third rounds of consultation.

1.4 Statistical Methods

This study used SPSS 25.0 software for statistical analysis. Count data were expressed as $n(\%)$. Expert enthusiasm was represented by questionnaire recovery rate and expert opinion proposal rate [12]. The authority coefficient (Cr) was determined by C_a and C_s , with $Cr = (C_a + C_s) / 2$. The coordination degree of expert opinions was represented by Kendall's W coefficient and CV, where $CV < 0.250$ indicated good consistency in expert opinions, and a larger Kendall's W coefficient indicated higher expert coordination [13]. The analytic hierarchy process was used to calculate indicator weights, with the sum of secondary indicator weights and the sum of tertiary indicator weights constituting the weight of their respective primary indicators. The weight of tertiary indicators relative to primary indicators = tertiary indicator score \times percentage of primary indicator in total score \times percentage of secondary indicator in primary indicator total score \times percentage of tertiary indicator in secondary indicator total score; the weight of tertiary indicators relative to secondary indicators = tertiary indicator score \times percentage of secondary indicator in primary indicator total score \times percentage of tertiary indicator in secondary indicator total score.

2. Results

2.1 Basic Information of Consulted Experts

This study consulted 14 experts, among whom 11 (78.6%) held positions as heads of science popularization departments. The basic information of the consulted experts is shown in Table 1 .

2.2 Expert Enthusiasm

In the first round of consultation, 14 questionnaires were distributed and 14 were recovered, achieving a 100% recovery rate. Nine experts provided 34 revision suggestions for 19 indicators, with an expert opinion proposal rate of 64.29% (9/14), indicating high expert enthusiasm.

2.3 Expert Authority Degree

The authority coefficient (Cr) of the consulted experts was 0.814, with a judgment basis (Ca) of 0.886 and familiarity degree (Cs) of 0.742.

2.4 Expert Opinion Coordination Degree

Kendall's W coefficients for the first and second rounds of expert consultation were 0.238 ($P < 0.001$) and 0.246 ($P < 0.001$), respectively. The CV for both rounds of expert consultation was < 0.250 , indicating good consistency in expert opinions.

2.5 Determination of the Institutional Science Popularization Work Evaluation Index System

In the first round of consultation, nine experts provided 34 revision suggestions for 19 indicators. In the second round, experts offered limited suggestions on the definitions of some tertiary indicators, primarily recommending more quantifiable evaluation standards for certain tertiary indicators. The evaluation index system for institutional science popularization work was ultimately determined and constructed, comprising 3 primary indicators (science popularization input, implementation, and effectiveness), 16 secondary indicators, and 77 tertiary indicators, as shown in Table 3 .

3. Discussion

3.1 The “Structure-Process-Outcome” Framework Provides a Referential Framework for Evaluating Institutional Health Science Popularization Work

This study constructed a quantitative evaluation index system for health science popularization work for social institutions based on the Delphi method, clarify-

ing the weight coefficients and grading standards of each indicator, providing assurance for effective evaluation implementation. Although domestic scholars have produced some research results on the construction of science popularization evaluation indicators—for example, Tong Hefeng et al. [14] constructed a regional science popularization intensity evaluation index system based on national science popularization statistics, focusing on five dimensions: “science popularization personnel,” “infrastructure,” “funding input,” “science popularization media,” and “activity organization,” emphasizing evaluation and analysis of regional science popularization input and output status. Yang Ling et al. [15] explored a three-level index system for university science popularization service evaluation from four dimensions—“science popularization basic input,” “system and mechanism construction,” “science popularization platform,” and “science popularization activities”—based on grounded theory, aiming to provide pilot demonstration and research tools for national university science popularization service evaluation. Shao Xiaofeng et al. [16] constructed a clinical physician health science popularization work evaluation index system from three dimensions—“science popularization form,” “science popularization platform,” and “science popularization mediatization”—using the Delphi method. However, existing research has primarily focused on in-depth investigation of “science popularization resources,” concentrating on science popularization input, with dimensions such as “infrastructure,” “funding,” and “system and mechanism” all belonging to the input dimension. Although “science popularization activities” implies “implementation,” and “science popularization platform” can be regarded as a manifestation of science popularization work outcomes to a certain extent, these concepts cannot fully summarize the process and results of institutional science popularization work, resulting in a lack of “process” and “outcome”-oriented evaluation. In reality, health science popularization work is a continuous process with sequential impacts, where each component directly influences the next.

Based on the “Structure-Process-Outcome” framework, this study systematically identified and summarized indicators capable of evaluating institutional health science popularization from bottom to top, establishing a three-level index system. This system formulates a set of quantifiable health science popularization indicators for comprehensive evaluation of health education activities in different forms and content, and proposes optimization strategies based on target gap analysis. It can form a hierarchical evaluation standard for health science popularization work focusing on the entire life cycle, all health issues, and all media means. Overall, the index system incorporates the latest progress and emerging characteristics of science popularization practice, demonstrating significant meaning for promoting science popularization development in the new era. Regarding science popularization personnel, the indicator of personnel with science communication professional titles was included to further guide health science popularization toward greater professionalization. In information construction, the indicator of grafting external media communication platforms/special sections was incorporated to adapt to the current “grand science

popularization” construction pattern and social collaboration trends, facilitating the networked and digital development of health science popularization content construction under media convergence. In talent cultivation and output, the indicator of science popularization teams was included to guide science popularization toward professional team development, thereby facilitating advanced health science popularization technology updates and gradient development of health science popularization talent. In the intellectual property dimension, the number of authorized intellectual property rights was included to encourage the generation of original health science popularization IPs and improve the conversion rate of original health science popularization intellectual property, enhancing the capacity of health science popularization to serve society. In socio-economic impact, annual science popularization product sales and annual value of science popularization material donations were included to promote the sustainable development of the science popularization industry and form a virtuous cycle.

3.2 Layer-by-Layer Indicator Refinement Ensures Scientificity and Operability of the Health Science Popularization Index System

The index system constructed in this study can be applied to self-evaluation and mechanism improvement of science popularization institutions, as well as serving as a standard for scientific and comprehensive evaluation and comparison between different institutions. Regarding the ranking of indicator importance, the primary indicators were ranked as: science popularization input > implementation > effectiveness. Science popularization input focuses on resource management, implementation aims to enhance process effectiveness, and effectiveness promotes health science popularization work. On one hand, science popularization input provides material guarantees for science popularization capacity, requiring increased resource investment for capacity building. On the other hand, given fixed input, the efficiency of resource allocation needs improvement, as rational allocation directly affects utilization efficiency—higher allocation efficiency yields greater output [6]. The secondary indicators were ranked as: science popularization funding > personnel > socio-economic impact > content, with all four indicators having weights exceeding 0.1, demonstrating significant influence in the secondary index system. As an important condition for stable development of science popularization, funding plays a foundational role, requiring improved investment mechanisms and strengthened funding guarantees for school health and health education work in the new era, to be included in school annual budgets. Meanwhile, encouraging support from social funds and public welfare organizations can increase investment through multiple channels. Science popularization personnel reflect that health science popularization work requires professional interdisciplinary talents as support. The professionalism, enthusiasm, initiative, and innovation of health education workers can leave the audience with profound appreciation of the importance of science. Health education institutions and in-house science popularization talent play crucial roles in health education development. Socio-economic impact reflects whether

health science popularization work can facilitate institutional sustainable development at the economic level, with economic “monetization” capability being an important marker for testing the market fit of science popularization content and works. Science popularization content is an important carrier for improving public scientific and cultural literacy and represents important achievements in health science popularization implementation. Good science popularization content strengthens the connection between science and society and benefits the people through science and technology, possessing important knowledge value, social value, and cultural value. Only by popularizing scientific knowledge to the public and defeating misinformation with facts can rational light illuminate the path to health.

This study has the following limitations: the evaluation of tertiary indicators for the dimension of science popularization implementation—science popularization content—is currently relatively simplistic, and a more refined quantitative evaluation model will be developed subsequently. Additionally, for the dimension of science popularization effectiveness—socio-economic impact, more potential indicators will be identified to promote sustainable development of the science popularization industry.

In summary, this study, through expert consultation and analytic hierarchy process, constructed for the first time a quantitative evaluation index system for institutional health science popularization. Future research needs to further modify and improve this index system through empirical evaluation, and to understand the current level and differences in institutional health science popularization through inter-institutional assessment, thereby serving to improve institutional science popularization levels and work efficiency.

Author Contributions: LU Weiyi was responsible for overall research design, leading the application and implementation of the Delphi expert consultation method, selecting and contacting expert panel members, developing the first-round consultation questionnaire, and reviewing and finalizing the manuscript. ZHANG Shuxian was responsible for developing the second-round consultation questionnaire, distributing and recovering questionnaires, data analysis and statistics, and report writing. MA Chong was responsible for literature collection and organization. LU Weiyi and ZHANG Shuxian co-wrote the manuscript. SHI Jianwei was responsible for process control, maintaining the quality and reliability of the Delphi expert consultation method, assisting other researchers in completing research report revisions and improvements, and reviewing research methods and scientific validity.

Conflict of Interest: The authors declare no conflict of interest.

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