Post-print of a Study on the Development of an Evaluation Indicator System for Breast Cancer Screening Capacity in Primary Healthcare Institutions

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Abstract

Background Primary-level medical and health institutions are constrained by many factors in conducting breast cancer screening, making it difficult to ensure substantive progress. Therefore, establishing a scientific and effective evaluation index system for the capacity of primary-level medical and health institutions to conduct breast cancer screening is particularly important.

Objective To construct an evaluation index system for the capacity of primary-level medical and health institutions to conduct breast cancer screening.

Methods From September to October 2022, a preliminary database of evaluation indices for the capacity of primary-level medical and health institutions to conduct breast cancer screening was drafted through literature retrieval and group discussions, and an expert consultation questionnaire was designed. From November to December 2022, 21 experts were invited as consultation subjects using purposive sampling. Based on the consultation results, the expert positive coefficient, expert authority coefficient, and expert coordination coefficient were calculated. The index system was finalized through group discussions, and the Analytic Hierarchy Process was applied to determine the weight coefficients of indices at all levels and to test the logical consistency of indices at all levels.

Results All expert consultation questionnaires were returned and valid. The expert positive coefficient was 100.0%, the expert authority coefficient was 0.812, and the expert coordination coefficient for importance was 0.209 ($P<0.001$). The final established index system consisted of 3 first-level indices (structure, process, and outcome), 10 second-level indices, and 56 third-level indices. The weights of the three first-level indices were 0.3108, 0.1958, and 0.4934, respectively. The consistency ratios of indices at all levels were <0.100.

Conclusion The preliminary constructed evaluation index system for the capacity of primary-level medical and health institutions to conduct breast cancer screening demonstrates high authority and scientificity, and is expected to provide guidance and reference for research related to breast cancer screening capacity assessment. However, the applicability and application effectiveness of the index system remain to be further validated.

Full Text

Development of a Breast Cancer Screening Capacity Assessment System for Primary Care Institutions

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Abstract

Background: Due to numerous barriers, primary care institutions struggle to ensure substantial progress in breast cancer screening. Establishing a scientific and effective evaluation system for assessing breast cancer screening capacity in these settings is therefore critically important. **Objective:** To construct an evaluation indicator system for breast cancer screening capacity in primary care institutions. **Methods:** From September to October 2022, we developed an initial indicator pool through literature review and group discussion, then designed an expert consultation questionnaire. Between November and December 2022, we invited 21 experts using purposive sampling to participate in a Delphi survey. Expert engagement coefficient, authority coefficient, and Kendall's W coefficient were calculated based on survey results. The final indicator system was determined through group discussion, and the Analytic Hierarchy Process was applied to determine indicator weights and test logical consistency across all levels. **Results:** All questionnaires were returned and valid, yielding an expert engagement coefficient of 100.0%. The authority coefficient was 0.812, and Kendall's W for importance was 0.209 ($P<0.001$). The final system comprises 3 primary indicators (structure, process, and outcome), 10 secondary indicators, and 56 tertiary indicators. The weights for the three primary indicators were 0.3108, 0.1958, and 0.4934, respectively. Consistency ratios for all levels were <0.100. **Conclusion:** The developed Breast Cancer Screening Capacity Assessment System for Primary Care Institutions demonstrates high authority and scientific rigor, and is expected to provide guidance and reference for future

research on screening capacity evaluation. However, the system's applicability and effectiveness require further validation.

Keywords: Primary care institutions; Breast neoplasms; Early detection of cancer; Indicator system; Delphi method

1. Materials and Methods

1.1 Development of the Initial Indicator System

From September to October 2022, we searched relevant literature in CNKI and PubMed using terms including "screening evaluation," "screening capacity," "screening assessment," "capability evaluation," "general practitioner," and "quality indicators." Based on literature review, group discussion, and input from five experts, we preliminarily constructed a draft evaluation system for breast cancer screening capacity in primary care institutions. Grounded in the Structure-Process-Outcome (SPO) theoretical model, this draft included 3 primary indicators, 10 secondary indicators, and 62 tertiary indicators.

1.2 Finalization Through Delphi Method

1.2.1 Expert Selection From November to December 2022, we purposively sampled 21 experts from four domains: primary healthcare, breast specialties, public health, and health administration. Selection criteria included: (1) bachelor's degree or above, or intermediate professional title or above; (2) familiarity with domestic breast cancer screening status; and (3) high motivation to participate and willingness to complete the consultation.

1.2.2 Questionnaire Design The consultation questionnaire comprised three sections: (1) **Indicator evaluation form:** Experts rated each indicator's importance, sensitivity, and feasibility using a 5-point Likert scale (1="very unimportant/insensitive/unfeasible" to 5="very important/sensitive/feasible") [11], with space for modification suggestions; (2) **Open-ended questions:** Experts provided recommendations and rationales based on the research framework; and (3) **Expert demographic survey:** Including name, age, education, work domain, years in current position, years in breast cancer screening, professional title, familiarity with indicators, and judgment basis. Familiarity was scored as: very familiar (0.9), familiar (0.7), moderate (0.5), unfamiliar (0.3), very unfamiliar (0.1). Judgment basis was scored by influence level (major, moderate, minor) across four dimensions: practical experience (0.5, 0.4, 0.3), theoretical analysis (0.3, 0.2, 0.1), intuition (0.1, 0.1, 0.1), and knowledge of domestic/international peers (0.1, 0.1, 0.1).

1.2.3 Delphi Process and Indicator Screening We conducted the Delphi survey via Tencent Meeting, where we introduced the study background, objectives, and questionnaire design to invited experts. After obtaining informed consent, questionnaires were distributed online via WeChat. Following each round, indicators with mean importance score \$ \$4.00 and/or coefficient of variation (CV) \$ \$0.30 were eliminated [12]. A thematic group discussion was held to revise the system based on feedback, culminating in the final indicator framework.

1.3 Weight Determination Using Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a multi-objective decision-making method combining qualitative and quantitative analysis that calculates indicator weights by comparing relative importance across hierarchical levels [13]. We used the difference in mean importance scores to determine Saaty 1-9 scales for pairwise comparisons [14], constructing judgment matrices to calculate indicator weights (see Table 1). Consistency Ratio (CR) was calculated as CR=CI/RI (where CI is consistency index and RI is random index). A CR<0.100 indicated acceptable consistency; when CR>0.100, the Yaahp software automatically adjusted the matrix. After passing consistency tests, single-level sorting results were converted to obtain combined weights for all indicators relative to the overall system.

1.4 Statistical Analysis

Data were entered using Excel 2019. SPSS 22.0 was used to calculate full-mark ratios, means, and CVs for importance ratings. Expert engagement was measured by valid response rate (higher rates indicate greater engagement). Authority coefficient was calculated as (familiarity coefficient + judgment coefficient)/2, with values >0.700 considered reliable [15]. Expert agreement was measured by Kendall's coefficient of concordance (Kendall's W) with statistical inference; P<0.05 indicated consensus. Yaahp software was used to construct the hierarchical model, test logical consistency across levels, and determine indicator weights.

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2. Results

2.1 Expert Characteristics

Twenty-one experts were selected, including 18 females (85.7%). Mean age was (38.1\$±8.2)*years.Twelveheldmaster′sdegreesorhigher*(57.1±\$8.9) years. Fourteen had intermediate or higher professional titles (66.7%). Details are shown in Table 2 .

2.2 Expert Engagement

All 21 distributed questionnaires were returned valid, yielding a 100.0% response rate (expert engagement coefficient). Seven experts (33.3%) provided detailed revision suggestions.

2.3 Expert Authority

The familiarity coefficient was 0.719, judgment coefficient 0.905, and authority coefficient 0.812 (>0.700), indicating reliable consultation results.

2.4 Expert Coordination

Kendall's W coefficients were 0.209 (^{2}=308.733, P<0.001) for importance, 0.164 (^{2}=242.514, P<0.001) for sensitivity, and 0.094 (^{2}=138.476, P<0.001) for feasibility.

2.5 Indicator Scoring and Screening

Primary indicator importance scores ranged 4.71-4.95 (CV: 0.04-0.10; full-mark ratio: 71.4%-95.2%). Secondary indicators scored 4.33-4.95 (CV: 0.04-0.18; full-mark ratio: 47.6%-95.2%). Tertiary indicators scored 3.95-4.86 (CV: 0.07-0.25; full-mark ratio: 23.8%-85.7%). Sensitivity ratings of 4-5 points accounted for 47.6%-100.0%, and feasibility ratings of 4-5 points accounted for 71.4%-100.0%. Seven experts provided 17 revision suggestions for 15 indicators. After discussion and online consultation with some experts, we determined that a second Delphi round was unnecessary pending applicability evaluation. Revisions included: (1) Modifying one secondary indicator ("funding balance" to "institutional balance") and two tertiary indicators ("information management staff" to "dedicated information management staff," "screening rate" to "screening coverage"); (2) Deleting five tertiary indicators: "housing source," "nurse-physician ratio," "other income," "total institutional expenditure," and "number of breast cancer screening WeChat groups"; (3) Merging two tertiary indicators: "average daily screening hours" and "screening days" into "total annual screening hours."

2.6 Final Indicator System and Weight Analysis

The final Breast Cancer Screening Capacity Assessment System for Primary Care Institutions comprises 3 primary, 10 secondary, and 56 tertiary indicators. AHP-derived weights were 0.3108 (structure), 0.1958 (process), and 0.4934 (outcome). All CR values were <0.100, indicating reasonable weight allocation. Indicators and weights are detailed in Table 3 .

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3. Discussion

3.1 Design Concept

Grounded in the SPO theoretical framework, our evaluation system encompasses three dimensions: "Structure" represents the material foundation and essential conditions for service quality, including infrastructure, human resources, financial balance, and organizational structure, reflecting basic and operational capacity; "Process" refers to direct or indirect medical care and supplementary activities, including breast cancer screening promotion, supervision, and implementation, reflecting actual activity levels and management capacity; "Outcome" evaluates the results of promotion and screening, reflecting screening effectiveness and satisfaction among residents and physicians, thereby demonstrating overall professional capacity. The SPO model emphasizes comprehensive evaluation of the entire medical service process with clearly defined dimensions. Compared with other studies focusing on human and material resources [7-8], our system covers the complete workflow from preparation through follow-up, including promotion, organization, referral, and continuity of care, with comprehensive, systematic, and targeted design of indicators such as breast ultrasound equipment quantity, clinical breast examination physician numbers, annual promotion channel frequency, and early-stage cancer detection rates.

3.2 Weight Analysis

Weight calculations revealed the primary indicator ranking as: outcome (0.4934) > structure (0.3108) > process (0.1958). Among secondary indicators, the top three combined weights were "screening effectiveness," "human resource allocation," and "resident satisfaction." Among tertiary indicators, the top three combined weights were "early-stage breast cancer proportion," "satisfaction rate of screened women with medical staff services," and "satisfaction rate with waiting time." These results indicate that outcome-based screening capacity has the greatest impact, with "early-stage breast cancer proportion" being the key effectiveness metric. Adequate, high-quality human resources are fundamental to screening quality, and evidence confirms that human resource investment is critical for building screening capacity [7], suggesting institutions should increase both quantity and quality of screening personnel. As patient-centered care becomes increasingly emphasized, patient satisfaction has emerged as a core metric for service quality and provider capacity [16], influencing service utilization and compliance [17]. Our system balances institutional configuration with resident satisfaction regarding staff service and waiting times, suggesting primary care institutions should improve service attitudes, optimize screening workflows, and enhance counseling.

3.3 Scientific Reliability

Combining Delphi method with AHP ensures scientific rigor and reliability. Delphi method synthesizes subjective judgments and experience from multiple experts, widely used for indicator system development [18], with 10-50 experts recommended [19]. Our 21 experts from four domains (primary care, breast specialties, public health, and health administration), mostly holding intermediate or higher titles, represent a scientifically sound and representative sample. The 100.0% response rate and detailed suggestions from 33.3% of experts demonstrate high engagement and recognition. An authority coefficient >0.800 indicates reliable, authoritative results, and Kendall's W ($P<0.05$) confirms good consensus. Sensitivity ratings of 4-5 points exceeded 70.0% for most indicators (except screening room count at 47.6%), ensuring discriminatory capacity. Feasibility ratings of 4-5 points ranged 71.4%-100.0%, indicating high data availability. AHP consistency tests yielded $CR<0.1$ across all levels, confirming clear, reasonable, and well-defined indicators.

3.4 Limitations

This study has several limitations: (1) Most experts (76.2%) were from Tianjin's specialized hospitals, primary care institutions, and research groups, focusing on urban primary care capacity assessment. Caution is needed when applying this system to rural and other regions, requiring local adaptation. (2) The system addresses only breast cancer screening, though many cancer screening programs share commonalities. Future development of comprehensive evaluation tools integrating multiple cancer screening programs or annual physical examinations would be valuable.

In summary, our breast cancer screening capacity evaluation system is in the development stage, and its practical effectiveness requires validation. Our team will soon complete field survey data collection from primary care institutions to evaluate and refine the system's practical application.

Author Contributions: LIU Xuewei performed data analysis and manuscript writing; ZHONG Xinyuan conducted data organization; LU Xinlin, RUAN Zhanliang, WANG Yanbo, and WANG Yuan provided research guidance; LU Wenli oversaw quality control and manuscript review.

Conflict of Interest Statement: The authors declare no conflicts of interest.

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Note: Figure translations are in progress. See original paper for figures.