Application and Implications of an Outcome-Oriented Comprehensive Evaluation Indicator System for Basic Public Health Services in Retrospective Evaluation in Shenzhen City: Postprint

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Abstract

Background To promote the transformation of national basic public health service assessment and evaluation from process to outcome, our research team previously constructed an "effectiveness-oriented comprehensive evaluation index system for basic public health services" theoretically, but the practical application of this index system remains insufficient. Objective To further improve the practical application of this index system, this study utilized the index system to conduct a retrospective evaluation of the implementation effectiveness of basic public health services in Shenzhen from 2017 to 2022. Methods From July 2022 to April 2023, index data were collected through literature review and correspondence survey methods, and the comprehensive index method was used to calculate the comprehensive index and various dimensional indices for basic public health services in Shenzhen from 2017 to 2022. Results Of the 54 indicators in the index system, 49 were collected, with a completion rate of 91.8%. From 2017 to 2022, the comprehensive index for basic public health services in Shenzhen increased from 46.62 to 51.37, the project input index increased from 3.75 to 10.40, the project implementation index increased from 11.23 to 19.36, and the project effectiveness index decreased from 31.65 to 21.61. Looking solely at the effectiveness indices of each sub-project, the health education effectiveness index showed a substantial increase, rising from 0.067 in 2017 to 4.079 in 2022; the chronic disease patient health management effectiveness index decreased from 13.469 in 2017 to 3.571 in 2022, with a minimum of 3.223 (in 2021) and a maximum of 14.970 (in 2019). The minimum values for child health management effectiveness index and awareness rate and satisfaction effectiveness index were 3.374 and 1.987 respectively, both occurring in 2019. The

minimum value for maternal health management effectiveness index occurred in 2022 (4.052). Conclusion The effectiveness-oriented comprehensive evaluation index system for basic public health services has certain feasibility and scientific validity when applied to evaluate basic public health services at the municipal level, but some indicators reflecting population health risk factors and health status still have low availability. Information-based comprehensive assessment can solve the problem of data falsification and improve project supervision efficiency. However, its promoting effect is limited when service coverage approaches saturation. Future basic public health services should aim to improve service quality and enhance population health benefits, with particular emphasis on awareness rate and satisfaction, to continuously enhance residents' sense of gain.

Full Text

1.1 Effect-Oriented Comprehensive Evaluation Indicator System for National Essential Public Health Services

The evaluation indicator system was developed by our research team in prior work [4], adopting a structure-process-outcome framework. It comprises 3 primary indicators, 20 secondary indicators, and 54 tertiary indicators, covering three dimensions: project input, project execution, and project effect, with weights of 11.35%, 26.48%, and 62.18% respectively.

The secondary indicators under the project input dimension include organizational management, fund management, and human resources, accounting for 2.17%, 4.72%, and 4.46% respectively. The project execution dimension includes 12 secondary indicators: health records, health education, vaccination, child health management, maternal health management, elderly health management, chronic disease patient health management, severe mental disorder patient management, tuberculosis patient health management, traditional Chinese medicine health management, infectious disease and public health emergency reporting and handling, and health and family planning supervision coordination, with weights of 1.53%, 5.91%, 1.29%, 0.9%, 1.14%, 4.66%, 6.95%, 1.43%, 1.16%, 0.74%, 0.43%, and 0.35% respectively. The tertiary indicators are largely consistent with the work indicators of each program in the *National Essential Public Health Service Specifications (Third Edition)* [5].

The secondary indicators under the project effect dimension include health education effect, chronic disease patient health management effect, maternal health management effect, child health management effect, and awareness and satisfaction, with weights of 5.43%, 14.97%, 12.42%, 12.96%, and 16.39% respectively. Specifically, "health education effect" comprises residents' health literacy rate, adult smoking rate, and proportion of regular physical exercise participants; "chronic disease patient health management effect" comprises blood pressure control rate and blood glucose control rate among managed populations; "maternal health management effect" comprises cesarean section rate, birth defect incidence, maternal mortality rate, and neonatal mortality rate; "child health

management effect" comprises infant mortality rate, under-5 mortality rate, low birth weight rate, exclusive breastfeeding rate for infants under 6 months, under-5 low weight rate, under-5 anemia prevalence, and under-5 obesity rate; and "awareness and satisfaction" comprises public awareness rate and residents' satisfaction rate.

1.2 Data Collection and Quality Control

1.2.1 Data Collection

Using the correspondence survey method and literature review method, we retrospectively collected relevant data on essential public health services in Shenzhen from 2017 to 2022 between July 2022 and April 2023. The dataset included 54 tertiary indicators, of which 50 were quantitative and 4 were qualitative. The early pregnancy registration rate, postpartum visit rate, and maternal systematic management rate under project execution, as well as maternal mortality rate, neonatal mortality rate, infant mortality rate, under-5 mortality rate, under-5 low weight rate, and under-5 obesity rate under the project effect dimension were sourced from the *Shenzhen Health Statistics Yearbook* [6-11]. All other indicators were obtained through correspondence surveys, with data retrieved from Shenzhen' s Essential Public Health Service Statistics Information System, annual work reports, and municipal performance assessment results, facilitated by the Shenzhen Essential Public Health Service Project Technical Guidance Center.

1.2.2 Quality Control

A multi-level data quality verification mechanism was established. The research team verified indicator values using multiple data sources (Shenzhen Essential Public Health Service Statistics Information System, annual work reports, municipal performance assessment results, and health statistics yearbooks), with quality inspections and supervision conducted by relevant Shenzhen health administrative departments.

1.3 Data Processing Methods

All statistical analyses and chart generation were performed using Microsoft Excel 2019. Data normalization was first conducted [12], with individual evaluation indicators normalized and inverse indicators processed for trend consistency. Inverse indicators included adult smoking rate, cesarean section rate, birth defect incidence, maternal mortality rate, neonatal mortality rate, infant mortality rate, under-5 mortality rate, low birth weight rate, under-5 low weight rate, under-5 anemia prevalence, and under-5 obesity rate (11 indicators). Positive indicators were normalized using the formula (X-XMin)/(XMax-XMin), while inverse indicators were normalized and trend-adjusted using the formula (XMax-X)/(XMax-XMin), where X represents the individual indicator value,

XMax represents the maximum value of the indicator over the six-year period, and XMin represents the minimum value.

The index calculation procedure involved multiplying the normalized data of individual indicators by their corresponding weights to obtain individual indicator indices, which were then summed to derive project indices, dimension indices, and the composite index. The formulas were: Dimension Index = $\Sigma(Vijk \times \omega ijk)\$ \times \$100$, where V represents the normalized value of an individual indicator and ω represents its weight; Composite Index = Sum of all dimension indices.

Since the indicator system employed combined weighting during construction, this study adjusted weights for deleted indicators as follows: primary and secondary indicator weights remained unchanged to preserve their relative importance; within each secondary indicator category containing deleted tertiary indicators, weights were redistributed among retained tertiary indicators based on their relative weight proportions. For example, under awareness and satisfaction (weight 16.39%), there were three tertiary indicators: public awareness rate (weight 3.96%), residents' satisfaction (weight 7.25%), and provider satisfaction (weight 5.19%). The provider satisfaction indicator needed to be removed. The relative proportion of public awareness rate was 35.32% (3.96%/(3.96%+7.25%)), resulting in an adjusted weight of 5.79% for awareness rate (35.32%×(3.96%+7.25%)).

This study collected 49 indicators through correspondence surveys and literature review, achieving a collection completion rate of 91.8%. The completion rate was 90.0% (45/50) for quantitative indicators and 100% (4/4) for qualitative indicators. Seven indicators were not collected: number of full-time public health personnel per 1,000 population, proportion of full-time public health personnel with college degree or above, adult overweight and obesity rate, adult hazardous drinking rate, incidence of diabetes complications in managed populations, incidence of hypertension complications in managed populations, and provider satisfaction. The first two were replaced with "community health service center personnel number" and "proportion of public health physicians among primary care medical staff," while the remaining five indicators were excluded from index calculations. Weight adjustments for other indicators included: residents' health literacy rate from 1.04% to 1.76%, adult smoking rate from 1.04% to 1.76%, proportion of regular physical exercise participants from 1.12% to 1.91%, blood pressure control rate in managed populations from 2.11% to 7.26%, blood glucose control rate from 2.24% to 7.71%, public awareness rate from 3.96% to 5.79%, and residents' satisfaction from 7.25% to 10.60%.

Some collected indicators also had missing data for certain years: community health service center personnel numbers for 2017 and 2018; proportion of public health physicians for 2017, 2018, 2019, and 2022; vaccination rates for 2021 and 2022; cesarean section rate, birth defect incidence, low birth weight rate, exclusive breastfeeding rate for infants under 6 months, and under-5 anemia prevalence for 2022; and public awareness rate and residents'satisfaction for 2017.

Missing data were estimated using average annual growth rates and included in index calculations.

2.2 Comprehensive Evaluation Index

Shenzhen' s essential public health service composite index increased from 46.62 in 2017 to 67.87 in 2021, then decreased to 51.37 in 2022, with the lowest value of 33.62 occurring in 2018. The project input index rose from 3.75 in 2017 to 10.40 in 2022. The project execution index increased from 11.23 in 2017 to 19.36 in 2022, with a minimum of 5.06 (2018) and a maximum of 19.37 (2021). The project effect index decreased from 31.65 in 2017 to 21.61 in 2022, with a maximum of 40.74 (2020) and a minimum of 23.23 (2018) [Figure 1: see original paper].

2.3 Project Input Index

The organizational management index increased from 0.35 in 2017 to 1.82 in 2022. The fund management input index rose from 3.40 in 2017 to 4.12 in 2022. The human resources index showed substantial growth, increasing from 0 in 2017 to 4.46 in 2022 [Figure 2: see original paper].

2.4 Project Execution Index

The project execution index increased from 5.06 in 2018 to 19.36 in 2022, though the 2017 index was higher than those in 2018 and 2019 [Figure 3: see original paper]. The health records execution index reached its lowest point in 2022 at 0.114. Execution indices for vaccination, child health management, and maternal health management were lowest in 2017. Execution indices for health education, elderly health management, chronic disease patient health management, and infectious disease and public health emergency reporting and handling were lowest in 2018, with chronic disease patient health management execution index peaking in 2017 at 6.950 [Figure 4: see original paper].

2.5 Project Effect Index

The project effect index first decreased from 31.65 in 2017 to 23.23 in 2018, then increased to 40.74 in 2020, before declining to 21.61 in 2022 [Figure 5: see original paper]. Notably, the health education effect index showed substantial growth, increasing from 0.067 in 2017 to 4.079 in 2022. The chronic disease patient health management effect index decreased from 13.469 in 2017 to 3.571 in 2022, peaking at 14.970 in 2019. The lowest values for child health management effect index and awareness and satisfaction effect index were 3.374 and 1.987 respectively, both occurring in 2019. The maternal health management effect index reached its lowest value in 2022 at 4.052 [Figure 6: see original paper].

2.6 Tertiary Indicator Index

The index results for tertiary indicators of Shenzhen' s essential public health service project from 2017 to 2022 are presented in Table 1 .

3.1 Feasibility of Applying the Effect-Oriented Indicator System at Municipal Level

The "effect-oriented comprehensive evaluation indicator system for essential public health services" validated in this study covers evaluation indicators at input, execution, and effect levels, with indicators reflecting "effect" accounting for 62.18% of the total weight, fully demonstrating the system' s outcome orientation. The study found that most indicators could be obtained from existing archived data and information systems during application in Shenzhen' s essential public health service evaluation, and the evaluation did not impose additional workload on primary care medical staff. However, a few indicators still had availability issues: (1) Quantifying organizational management indicators such as "division of labor and collaboration, performance assessment, information system construction, and program promotion" posed certain challenges. This study standardized "excellent, good, and fair" ratings to "1, 0.5, 0," but this approach still struggled to objectively reflect changes in organizational management indicators. (2) The original indicator system used "number of full-time public health personnel per 1,000 population" and "proportion of full-time public health personnel with college degree or above" to reflect human resources for essential public health services. However, these two indicators proved difficult to obtain in practice, and the database contained no other indicators reflecting educational background. Field investigations revealed that public health physicians in Shenzhen' s essential public health service institutions primarily performed supervision and verification functions. The number of community health service center personnel could reflect the total human resources invested in essential public health services. Therefore, this study replaced these two indicators with "community health service center personnel number"and "proportion of public health physicians among primary care medical staff," reflecting human resources from both "quantity" and "proportion" perspectives. (3) The original indicator system included "adult overweight and obesity rate, adult hazardous drinking rate, incidence of diabetes complications in managed populations, incidence of hypertension complications in managed populations, and provider satisfaction." These five indicators were considered important direct measures of essential public health service effectiveness. Previous research proposed extracting the first four indicators from residents' health records and obtaining the "provider satisfaction" indicator through field surveys [4]. However, in Shenzhen' s practical application, obtaining reliable data proved difficult. Current routine monitoring does not cover adult obesity and drinking conditions or complications in chronic disease populations, while provider satisfaction generally relies on field surveys. Therefore, this study ultimately excluded these five indicators and adjusted weights proportionally for index calculations.

Tong Xinyue et al. [14] also suggested that to facilitate public health service personnel's timely and dynamic grasp of residents'health information and needs, and to propose targeted health interventions that improve service efficiency, monitoring should focus on indicators such as residents' satisfaction, health literacy, and complications in managed populations (e.g., stroke). Overall, further advancing effect-oriented comprehensive evaluation of essential public health services requires greater emphasis on monitoring and collecting health outcome indicators, strengthened management and information utilization of residents' health records, and more comprehensive improvement of the overall quality of national essential public health services to provide reliable data sources for performance assessment and academic research.

3.2 Information-Based Full-Quantity Assessment Significantly Promotes Project Process Index Improvement

The overall implementation of essential public health services in Shenzhen from 2017 to 2022 showed a steady growth trend, with the composite index increasing from 46.62 in 2017 to 51.37 in 2022. However, the 2018 composite index decreased substantially from 2017, reaching the six-year minimum of 33.62. Analysis of the composite index composition revealed that 2018 saw the lowest six-year values for important indicators such as per capita essential public health funding, health education index, elderly health management index, and chronic disease patient health management index. Additionally, health education effect index and child health management effect index ranked second-lowest in 2018. Furthermore, chronic disease patient management rates and control rates decreased significantly from 2017 to 2018, with standardized hypertension patient management rate dropping from 72.48% to 47.70%, standardized diabetes patient management rate from 72.09% to 52.76%, blood pressure control rate among managed populations from 70.84% to 67.50%, and blood glucose control rate from 67.41% to 66.96%. The total weight for chronic disease management reached 21.91%, which may have been the primary reason for the substantial decrease in the 2018 composite index.

Moreover, Shenzhen began gradually establishing a unified city-wide essential public health service information management platform in 2018, introducing quality control measures through the information system. The 2018-2022 data included in this study were based on full-quantity assessment results from the information system, whereas 2017 data were from non-full-quantity institutional self-reported results. The significant decrease in execution index from 2017 to 2018 likely occurred because Shenzhen' s adoption of information-based full-quantity assessment "squeezed out" previous inflation in self-reported data, making essential public health assessment data more objective and authentic. During the subsequent four years from 2018 to 2021, Shenzhen vigorously promoted the full-quantity assessment mechanism, continuously improving service volume and population coverage, with project execution process indices showing clear and sustained upward trends. The project process index peaked in 2021, remain-

ing essentially flat in 2022 compared to 2021, suggesting that information-based full-quantity assessment and quality control measures have limited promoting effects when service coverage approaches saturation. Therefore, the future focus of essential public health services should shift from pursuing "quantity" improvements to "quality" breakthroughs, with continuous improvement in residents' health outcomes serving as the sustained driving force for enhancing the essential public health service composite index.

3.3 Improving Service Quality and Effectiveness as the Next Stage Goal

Both the 2022 composite index and project effect index were lower than in 2021. Examining the index composition revealed that 2022 saw substantial decreases in child health management effect, maternal health management effect, and awareness and satisfaction effect indices. Specifically, maternal mortality rate increased from 1.91 per 100,000 in 2021 to 7.21 per 100,000 in 2022, infant mortality rate from 1.06‰ to 1.18‰, under-5 mortality rate from 2.03‰ to 2.47‰, public awareness rate from 77.04% to 68.77%, and residents' satisfaction from 95.23% to 91.00%, further reducing the 2022 effect index.

Analysis of indicator trends revealed that electronic health record establishment rates continuously increased from 2017 to 2022, while health record utilization rates continuously decreased. The standardized management rate for type 2 diabetes patients increased from 52.76% in 2018 to 66.32% in 2022, while blood glucose control rate among managed populations decreased from 66.96% to 60.82%. Early pregnancy registration rate increased from 92.61% in 2021 to 97.06% in 2022, while maternal mortality rate increased from 1.91 per 100,000 in 2021 to 7.21 per 100,000 in 2022. Therefore, essential public health services should focus not only on population coverage proportions but also on health management effectiveness among managed populations. Given that the promoting effect of information technology on essential public health services has reached saturation, future efforts need to target service quality improvement as the breakthrough point, enhancing project effectiveness through improved quality of various services.

3.4 Focusing on Awareness and Satisfaction to Continuously Strengthen Residents' Sense of Access

This indicator system includes awareness and satisfaction as important effect indicators with a relatively high weight (16.39%), consistent with essential public health assessment priorities. The index results showed considerable variation in awareness and satisfaction indices across years: 1.987 in 2019 and 4.700 in 2022, compared to 13.157 in 2020 and 12.774 in 2021. Residents' satisfaction in Shenzhen showed a fluctuating upward trend from 2018 to 2022, increasing from 88.51% to 95.23% before decreasing to 91.00% in 2022. Public awareness rate declined from 86.26% in 2018 to 68.77% in 2022.

As a major public welfare project, the national essential public health service program' s public awareness and satisfaction rates are important indicators reflecting whether the demand side receives needed essential public health services, directly relating to residents' sense of access and satisfaction with government-provided essential public health services. Field investigations revealed that since 2022, Shenzhen CDC has implemented an intelligent outbound call system [16] to survey awareness and satisfaction among essential public health service recipients. Compared to traditional manual callbacks, this system offers greater efficiency, authenticity, and statistical significance. While eliminating manual sampling bias may cause short-term numerical decreases, the intelligent outbound call system is expected to more authentically and objectively reflect residents' awareness and satisfaction in the long term. The continuous decline in public awareness may be associated with weakened program promotion investment in Shenzhen from 2017 to 2022, while public awareness of national essential public health services affects service utilization [17-18]. Therefore, Shenzhen should intensify program promotion efforts in the future, recommending more diverse and content-rich promotional activities combined with new-era, new-media communication methods implemented at national, provincial, municipal, district, and street levels to continuously improve residents' awareness and sense of access regarding national essential public health services.

4 Limitations

The comprehensive evaluation indicator system for essential public health services developed by our research team included as many as 54 indicators, which were theoretically collectible but deviated in practical implementation. This study collected as many indicators as possible based on the principle of maximizing data completeness, though some data remained unobtainable. Missing data for a few indicators may have introduced certain biases and limitations to the index results. To minimize bias, this study estimated missing data for partial years using average annual growth rates.

This study applied the effect-oriented comprehensive indicator system for essential public health service projects to conduct a retrospective evaluation of Shenzhen' s essential public health services from 2017 to 2022. The indicator collection process demonstrated certain feasibility for practical application, though some indicators reflecting population health outcomes still had low availability. The evaluation also revealed that information-based full-quantity assessment can solve data misreporting problems and improve project supervision efficiency. However, its promoting effect is limited when service coverage approaches saturation. Future essential public health services should aim to improve service quality and enhance population health benefits, with particular focus on awareness and satisfaction to continuously improve residents' sense of access.

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data cleaning, organization and verification, and manuscript revision; WANG Yiqian was responsible for data collection and quality control; LI Mengyu was responsible for data collection and organization; LIU Lu was responsible for chart preparation and manuscript revision; LIU Gang was responsible for research conceptualization, data provision and quality control; YOU Lili was responsible for study design, quality control and supervision, and overall manuscript responsibility.

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