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Comprehensive evaluation of the implementation of close-type county medical alliance in Shandong Province using entropy weight TOPSIS method and non-integer rank sum ratio method

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Abstract

Background To improve the capacity of county medical and health services, China encourages all localities to pilot the close-type county medical alliance. In Shandong Province, medical alliances have been piloted in 47 counties, ranking first in the country. The objective of this study is to comprehensively evaluate the implementation of close-type county medical alliance in Shandong Province, identify the differences between different county regions, and analyze the reasons, so as to provide a reference for the construction of a new county medical and health service system with clear goals, powers and responsibilities, and division of labor.

Methods The implementation of the close-type county medical alliance was comprehensively evaluated in 47 national pilot counties in Shandong Province using entropy weight TOPSIS method and non-integer rank sum ratio method. Variance analysis was used for comparison of the comprehensive evaluation results.

Results The weight coefficient of evaluation indicators was highest for information interconnection, at 18.06%, and lowest for orderly referral of patients, at 3.64%. There was no difference in results of the comprehensive evaluation of entropy weight TOPSIS method and non-integer rank sum ratio method. Comprehensively order the implementation status of each pilot county according to the relative paste progress, 13 counties Y_5, Y_{11}, Y_{14}, Y_{16}, Y_{20}, Y_{25}, Y_{26}, Y_{27}, Y_{28}, Y_{32}, Y_{33}, Y_{40} and Y_{42} were ranked highest, whereas county Y_{37} was ranked lowest. Non-integer rank sum ratio method graded counties into three grades: excellent, good and average. Kruskal-Wallis nonparametric test showed that the difference between the grades was statistically significant ($H=37.099$, $p<0.001$). Variance analysis based on comprehensive evaluation results showed that implementation status was not correlated with the county economic development level, the level of health resources input and the medical service ability of the lead hospital.

Conclusions Our findings indicated that the implementation of the close-type county medical alliance is significantly different between pilot counties, with a marked differentiation within the same urban area. Therefore,

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effective measures are recommended to reduce this gap, including promoting informatization empowerment of the county medical community, strengthening government responsibility and improving policy effectiveness.

Keywords Close-type county medical alliance, Entropy weight TOPSIS method, Non-integer rank sum ratio method, Comprehensive evaluation

Background

Accompanied by the rapid growth of household income, demand for better healthcare services has been increasing in China [1]. Therefore, it is necessary to improve the medical service capacity. The county is the most basic social management unit in China, and construction of a county medical alliance is an important factor in improving the county medical service capacity [2]. In China, close-type county medical alliance is a community or group of medical institutions in the county, composed of county-level hospitals as the leader and township health centers, village health centers and other medical institutions as members [3]. This hierarchical medical system has been officially implemented nationwide since 2019, with the purpose of deeply integrating county medical and health resources, which has strong practical feasibility in building a county-wide high-quality and efficient medical and health service system [4]. In May 2022, the average Office of the State Council issued the "Key Work Tasks for Deepening the Reform of the Medical and Health System in 2022 ", which clearly pointed out the necessity to further promote the construction of close-type county medical alliances and reform institutional mechanisms, promote the implementation of administrative, personnel, financial, business, drug, information systems and other overall management within the medical alliance, strengthen monitoring and evaluation, and strengthen the application of evaluation results [5]. However, foreign countries focus on the research of integrated medical and health services, but have not put forward the concept of close-type county medical alliance, and there is a lack of relevant research based on county.

Shandong Province has the largest number of pilot counties of the close-type county medical alliance nationally. In total, 500 medical personnel are deployed to grassroots frontline service every year and more than 12,000 personnel are dispatched to empower county and grassroots construction [6] Currently, there are 47 national pilot counties implementing the close-type county medical alliance, including Jinan, Qingdao, Zibo and other cities where some positive results have been achieved. However, as the construction of county medical alliance is still in the initial stage of development, some challenges have been encountered, such as loose structure, uneven interests, weak implementation mechanisms, and poor integration with medical prevention [7–9]. Therefore, there is an urgent need to review and improve relevant policies and systems to strengthen the capacity of county medical and health services.

Currently, research on close-type county medical alliance mostly focuses on perceived problems in the process of building county medical alliance [10]. Other studies have analyzed the implementation effect of the construction of a single county medical alliance [11], conducted a case study of typical county medical alliance model [12–14], or evaluated the reform progress of the national county medical alliance [15]. However, few studies have explored the specific implementation of a provincial county medical alliance, and specifically no study has comprehensively evaluated the progress of close-type county medical alliance in Shandong Province, and the results are mixed. Therefore, this study is based on the hypothesis that there are differences in the implementation of close-type county medical alliance in each pilot county, Shandong Province was selected as the research site to comprehensively evaluate the implementation status of the county medical alliance, clarify the differences between different pilot counties, and analyze factors influencing the construction of a close-type county medical alliance to provide suggestions for accelerating this process. As far as we know, this study is the first to explore and evaluate the implementation status of the county medical alliance in Shandong Province. On the one hand, this study is helpful to provide reference for other related studies; On the other hand, it is helpful to better promote the perfect implementation of the close-type county medical alliance.

Methods

Subjects of study

The data were derived from the county medical alliance monitoring data of Shandong Province from 2018 to 2020. In total, 47 national pilot counties in Shandong Province were selected for a survey on the implementation status of close-type county medical alliance from 2018 to 2020. These included two counties in Jinan City (Y_1-Y_2), six counties in Qingdao City (Y_3-Y_8), six counties and districts in Zibo City (Y_9-Y_{14}), one county in Zaozhuang City (Y_{15}) three counties in Dongying City (Y_{16}-Y_{18}), one county in Yantai City (Y_{19}), one county in Weifang City (Y_{20}), three counties and districts in Jining City (Y_{21}-Y_{23}), two counties and districts in Tai'an City (Y_{24}- Y_{25}), three counties and districts in Weihai City (Y_{26}-Y_{28}), and four counties and districts in Rizhao City (Y_{29}-Y_{32}), one county in Linyi City in (Y_{33}), one county in

Dezhou City (Y_{34}), five counties in Liaocheng City (Y_{35}-Y_{39}), seven counties in Binzhou City (Y_{40}-Y_{46}), and one county in Heze City (Y_{47}).

Indicator determination

Using the evaluation standards in the "Evaluation Standards and Monitoring indicators System for the Construction of close-type county medical alliance (Trial)" issued by the National Health Commission, the National Medical Insurance Bureau, and the State Administration of Traditional Chinese Medicine, 11 indicators in 4 dimensions were selected to comprehensively evaluate the implementation of county medical alliance in Shandong Province. These included leadership of the party committee and government (X_1), medical community has decision-making power (X_2), effective assessment of the medical community (X_3), overall management of personnel (X_4), unified financial management (X_5), unified management of drugs (X_6), orderly referral of patients (X_7), interconnection of information (X_8), integration of medical prevention (X_9), unified income management (X_{10}) and medical insurance management reform (X_{11}). All 11 factors are positive indicators, that is, the higher the indicators value, the better the implementation effect. All secondary indicators under the four dimensions of the community of responsibility (Z_1), community of management (Z_2), community of service (Z_3) and community of interests (Z_4) were assigned indicators values. For example, for the leadership of the party committee and government (X_1) indicator, "there is a clear institutional arrangement and has been implemented", "there is a clear institutional arrangement but is still in preparation, not yet landed", and "there is no institutional arrangement and is not ready to be implemented" were assigned a value of 2, 1, and 0, respectively.

Statistical analysis

The entropy weight TOPSIS method and the non-integer rank sum ratio method are a comprehensive evaluation approaches commonly used in the field of health statistics and health management decision-making and evaluation, some studies have proved their superiority in comprehensive evaluation research [16], which can be completed using Excel and SPSS software, respectively. Here, we used these two methods to comprehensively evaluate the implementation status of the close-type county medical alliance in Shandong Province. By combining the two methods, we aimed to exploit the advantages of the two methods and effectively compensate for TOPSIS method's inability to classify and RSR method's loss of raw data information in the conversion process [17] to obtain more objective and accurate evaluation results.

Building and standardization of raw data matrix

Supposing m number of evaluation objects, where each m corresponds to n evaluation Dear Editor, thank you for your suggestion. indicators, the original data matrix can be established as $A=(a_{ij})_{m\times n}$, where i=1, 2, ..., m; j=1, 2, ..., n.

For different types of indicators, different data standardization processing needs to be adopted to obtain a normalized matrix: $B=(b_{ij})_{m\times n}$, where i=1, 2, ..., m; j=1, 2, ..., n. Since the indicators selected by this study were all positive indicators, the following processing formula was used: $b_{ij}=\frac{a_{ij}-min(a_j)}{max(a_j)-min(a_j)}$. To ensure the validity of the values, a valid value of 0.0001 was added to each value after dimensionlessness.

Calculation of weights of evaluation indicators using entropy weight method

The calculation of weights of evaluation indicators involves four steps. First, the entropy weight method is used to calculate the contribution degree of the i evaluation object under the j indicators as $p_{ij}=\frac{b_{ij}}{\sum_{i=1}^{m}b_{ij}}$, i=1, 2, ..., m; j=1, 2, ..., n. Second, the entropy value of the j indicators is calculated as $e_i=-\frac{1}{lnn}\sum_{i=1}^{m}p_{ij}ln(p_{ij})$, where $0\leq e_j\leq 1$. The smaller the entropy value, the greater the degree of variation. Third, the difference coefficient of the j indicators is calculated as $g_j=1-e_j$. Finally, the weight coefficient of the j indicators was determined as $w_j=\frac{g_j}{\sum_{j=1}^{n}g_j}$, where $\sum_{j=1}^{n}w_j=1$. The greater the difference coefficient, indicating a significant difference between the indicators, the greater the weight coefficient [18].

Establishment of a weighted standardization matrix

The weighted matrix can be calculated from the normalized raw data matrix and the weight coefficients as $c_{ij}=b_{ij}\times w_j$, where i=1, 2, ..., m; j=1, 2, ..., n.

Determination of positive and negative ideal solutions and calculation of the distance from each evaluation object to the positive and negative ideal solutions

To determine the positive ideal solutions c_j^+ and negative ideal solutions c_j^- from the weighted normalized matrix, the distance from the evaluation object a_j to the positive ideal solution is calculated as $d_i^+=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^+)^2}$, where $i=1, 2, \ldots, m$. The distance from the evaluation object to the negative a_j ideal solution is then calculated as $d_i^-=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^-)^2}$, $i=1, 2, \ldots, m$.s

Calculation of relative progress of each evaluation object and optimal solution

According to the distance from the evaluation object a_j to the positive and negative ideal solution, the relative paste progress of the evaluation object is finally calculated as $f_i = \frac{d_i^-}{d_i^- + d_i^+}$, $i = 1, 2, \ldots\ldots, m$. The greater the progress of the i relative paste, indicating that the evaluation object is closer to the ideal solution, the better the evaluation result [19].

Non-integer rank sum ratio analysis

For each group, RSR value is calculated using the non-integer rank sum ratio method and arranged from small to large. The frequency, cumulative frequency, RSR rank and average rank of each group are then determined. The "percentage and probability unit comparison table" is queried according to the cumulative frequency to obtain the probability unit Probit value. With the probability unit Probit value as the independent variable and the RSR value as the dependent variable, the estimated value of RSR is calculated according to the regression equation $RSR = a + b \times Probit$. Finally, according to the RSR reasonable number of bins Table [20], and the number of files is determined, which, in this study is three.

Results

The basic situation of the pilot counties

The 47 national pilot counties in Shandong Province are spread across 16 cities in Shandong Province. Of these, 35 (74.47%) have met the standards of close-type county medical alliances, whereas 12 (25.53%) have not. There are 17 pilot counties (36.17%) with no more than 1 lead hospital, 26 (55.32%) with 2–3 lead hospitals, and only 4 (8.51%) with 4 or more lead hospitals. There are 11 (23.40%) counties with less than 4 beds per 1,000 population, 27 (57.45%) with 4–6 beds, and only 9 (19.15%) with more than 6 beds. There are 10 pilot counties (21.28%) with less than 5 health technicians, 22 (46.81%) with 5–7 technicians, and 15 (31.91%) with more than 7 technicians.

Table 1 Calculate the results of various indicators weights in the counties using entropy weight method

First-level indicators	Secondary indicators	e_i	g_j	w_j (%)	Total sort
Z_1(31.96%)	X_1	0.9769	0.0231	8.61	5
	X_2	0.9582	0.0418	15.61	2
	X_3	0.9793	0.0207	7.74	6
Z_2(24.96%)	X_4	0.9799	0.0201	7.49	7
	X_5	0.9739	0.0261	9.73	4
	X_6	0.9793	0.0207	7.74	6
Z_3(25.63%)	X_7	0.9903	0.0097	3.64	9
	X_8	0.9516	0.0484	18.06	1
	X_9	0.9895	0.0105	3.93	8
Z_4(17.45%)	X_{10}	0.9799	0.0201	7.49	7
	X_{11}	0.9733	0.0267	9.96	3

e_i means the entropy value, g_i means the difference coefficient, w_i means the weight coefficient

Calculate the results of various indicators weights in the counties using entropy weight method

Following the calculation steps of the entropy weight method, the weight coefficients of each indicators, as detailed in (Table 1), was calculated. Among first-level indicators, the weight coefficient of the community of responsibility (Z_1), community of management (Z_2), community of service (Z_3) and community of interests (Z_4) was 31.96%, 24.96%, 25.63%, and 17.45%, respectively. Among secondary indicators, information interconnection (X_8) had the highest weight coefficient and orderly referral of patients (X_7) the lowest. Therefore, the degree of variation in information interconnection was the highest whereas that of orderly referral of patients was the lowest.

Comprehensive evaluation results of the pilot counties using entropy weight TOPSIS method

The entropy weight TOPSIS method was used to analyze 47 pilot counties in Shandong Province. In addition, the positive and negative ideal solutions were determined from the weighted standardization matrix to calculate the distance from each evaluation object to the positive and negative ideal solution. This distance was then used to calculate the relative paste progress, and comprehensively order the implementation status of the close-type county medical alliance in each pilot county according to the relative paste progress. In this ranking, the larger the relative paste progress, the better the implementation status of the close-type county medical alliance in the county. From the results, the implementation of close-type county medical alliance in 13 counties of Y_5, Y_{11}, Y_{14}, Y_{16}, Y_{20}, Y_{25}, Y_{26}, Y_{27}, Y_{28}, Y_{32}, Y_{33}, Y_{40} and Y_{42} was relatively good. These were all ranked first with a relative paste progress of 1. In contrast, the implementation status of the close-type county medical alliance in five counties of Y_{15}, Y_{19}, Y_{36}, Y_{39} and Y_{37} was relatively poor. These were ranked as the bottom five counties in that order, with a relative paste progress of 0. The relative paste progress values of the top five and bottom five pilot counties was were significantly different, indicating that the close-type county medical alliance is implemented at dissimilar rates in the pilot counties in Shandong Province (Table 2; Fig. 1).

RSR value distribution levels in different pilot counties

Based on RSR values, the implementation status of the close-type county medical alliance in 47 pilot counties in Shandong Province was divided into three levels: excellent, good and average, corresponding to a grading of 3,

Table 2 Comprehensive evaluation results of the pilot counties using entropy weight TOPSIS method

Pilot counties	d_i^+	d_i^-	f_i	Sort the results	Pilot counties	d_i^+	d_i^-	f_i	Sort the results
Y_5	0.000	0.331	1.000	1	Y_{12}	0.063	0.313	0.832	25
Y_{11}	0.000	0.331	1.000	1	Y_{23}	0.063	0.313	0.832	25
Y_{14}	0.000	0.331	1.000	1	Y_{35}	0.063	0.313	0.832	25
Y_{16}	0.000	0.331	1.000	1	Y_{46}	0.063	0.313	0.832	25
Y_{20}	0.000	0.331	1.000	1	Y_{22}	0.072	0.307	0.810	29
Y_{25}	0.000	0.331	1.000	1	Y_{24}	0.073	0.306	0.807	30
Y_{26}	0.000	0.331	1.000	1	Y_4	0.074	0.306	0.805	31
Y_{27}	0.000	0.331	1.000	1	Y_{44}	0.074	0.306	0.805	31
Y_{28}	0.000	0.331	1.000	1	Y_{21}	0.079	0.302	0.795	33
Y_{32}	0.000	0.331	1.000	1	Y_9	0.079	0.302	0.792	34
Y_{33}	0.000	0.331	1.000	1	Y_{10}	0.080	0.301	0.791	35
Y_{40}	0.000	0.331	1.000	1	Y_{43}	0.098	0.285	0.745	36
Y_{42}	0.000	0.331	1.000	1	Y_{29}	0.133	0.275	0.674	37
Y_6	0.039	0.325	0.893	14	Y_{45}	0.179	0.250	0.583	38
Y_2	0.050	0.320	0.865	15	Y_1	0.188	0.262	0.582	39
Y_3	0.050	0.320	0.865	15	Y_{34}	0.191	0.256	0.572	40
Y_{13}	0.050	0.320	0.865	15	Y_{47}	0.194	0.250	0.564	41
Y_{17}	0.050	0.320	0.865	15	Y_{41}	0.189	0.227	0.545	42
Y_{18}	0.050	0.320	0.865	15	Y_{15}	0.261	0.137	0.344	43
Y_{30}	0.050	0.320	0.865	15	Y_{19}	0.275	0.111	0.288	44
Y_{38}	0.050	0.320	0.865	15	Y_{36}	0.275	0.107	0.279	45
Y_7	0.054	0.318	0.855	22	Y_{39}	0.328	0.027	0.075	46
Y_8	0.062	0.313	0.834	23	Y_{37}	0.331	0.000	0.000	47
Y_{31}	0.062	0.313	0.834	23					

d_i^+ means the positive ideal solutions, d_i^- means the negative ideal solutions, f_i means the relative paste progress

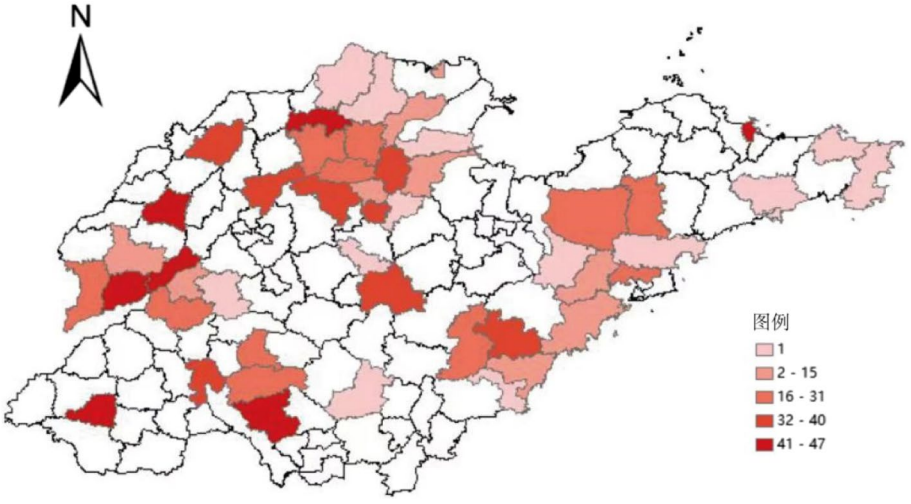

Fig. 1 Ranking of the comprehensive evaluation results of 47 pilot counties in Shandong Province

2 and 1, respectively. The evaluation results of the pilot counties under the non-integer rank sum ratio method were basically consistent with those of the entropy weight TOPSIS method. Among the 47 pilot counties, 7 (Y_{47}, Y_{41}, Y_{15}, Y_{19}, Y_{36}, Y_{39}, and Y_{37}) were graded as average, 27 (Y_6, Y_2, Y_3, Y_{13}, Y_{17}, Y_{18}, Y_{30}, Y_{38}, Y_7, Y_8, Y_{31}, Y_{12}, Y_{23}, Y_{35}, Y_{46}, Y_{22}, Y_{24}, Y_4, Y_{44}, Y_{21}, Y_9, Y_{10}, Y_{43}, Y_{29}, Y_{45}, Y_1, and Y_{34}) and as good and 13 (Y_5, Y_{11}, Y_{14}, Y_{16}, Y_{20}, Y_{25}, Y_{26}, Y_{27}, Y_{28}, Y_{32}, Y_{33}, Y_{40}, and Y_{42}) as excellent (Tables 3 and 4). The Kruskal-Wallis nonparametric test showed statistically significant differences between grades ($H=37.099$, $p<0.001$).

Table 3 Pilot counties graded according to the results of the file

Grade	Percentile threshold	Probit	RSR Critical value	Bin results
Average	< 15.866	< 4	< 0.599	Y_{47}, Y_{41}, Y_{15}, Y_{19}, Y_{36}, Y_{39}, Y_{37}
Good	15.866~84.134	4~6	0.599~1.082	Y_6, Y_2, Y_3, Y_{13}, Y_{17}, Y_{18}, Y_{30}, Y_{38}, Y_7, Y_8, Y_{31}, Y_{12}, Y_{23}, Y_{35}, Y_{46}, Y_{22}, Y_{24}, Y_4, Y_{44}, Y_{21}, Y_9, Y_{10}, Y_{43}, Y_{29}, Y_{45}, Y_1, Y_{34}
Excellent	> 84.134	> 6	> 1.082	Y_5, Y_{11}, Y_{14}, Y_{16}, Y_{20}, Y_{25}, Y_{26}, Y_{27}, Y_{28}, Y_{32}, Y_{33}, Y_{40}, Y_{42}

RSR means rank sum ratio, Probit means the probability unit

Analysis of factors influencing the implementation status of close-type county medical alliances in different counties

The 47 counties were first divided into three levels: excellent, good and average. Variance analysis was carried out to explore the impact of the level of county economic development, the level of health resources input and the medical service capacity of the lead hospital on the implementation status of the close-type county medical alliance. In this analysis, the per capita GDP in the county represented the level of economic development of the county, the number of health technicians per thousand people and the number of beds per thousand people in the county represented the level of health resources input [19], and the proportion of discharged patients with tertiary and fourth-level surgeries represented the medical service capacity of the lead hospital [21]. The results revealed no significant differences in per capita GDP (H=3.346, p=0.188), number of health technicians per thousand population (H=2.688, p=0.261), number of beds per thousand population (H= 0.781, p=0.677) and proportion of discharged patients (F=0.162, p=0.851) among the pilot counties at different levels (Table 5).

Discussion

Content differences in the close-type county medical alliance implemented

The weight results of 11 indicators in 4 dimensions calculated using the entropy weight method revealed significant differences in the degree of variation between the indicators in each pilot county. Among them, information interconnection showed the highest degree of variation, with a weight coefficient of 18.06%, whereas orderly referral of patients showed the least, with a weight coefficient of 3.64%, which is slightly higher than the value obtained by Zhang [15] in the analysis of county medical alliance nationally. Information interconnection in each pilot county requires the information system to be associated with the original information network. Our results show that the pilot counties in Shandong Province differ significantly in information interconnection, which may be attributed to the large gap in the foundation of information construction between regions and imperfect construction of city and county information platforms [22]. Construction of efficient information platforms requires equipment and talents and major investment [8], which differ depending on actual payment ability of each county, resulting in large variations between counties. The results also show that the difference in the orderly referral of patients in the pilot counties is small. This is because each county has actively explored its services and continuously improved since the hierarchical diagnosis and treatment system was proposed. In addition, the hierarchical diagnosis and treatment system was only established recently in 2020 in line with national conditions, thus differences will become significant after more years of implementation [23]. However, currently, the "number of transfers" in all counties is much higher than the "number of downward referrals" [24, 25], suggesting the need for efforts to promote two-way referrals to minimize the degree of variation.

Regional differences in the implementation of close-type county medical alliance

The comprehensive evaluation results of the entropy weight TOPSIS showed that relative paste progress of 13 counties (Y_5, Y_{11}, Y_{14}, Y_{16}, Y_{20}, Y_{25}, Y_{26}, Y_{27}, Y_{28}, Y_{32}, Y_{33}, Y_{40} and Y_{42}) was 1, indicating a relatively good implementation status. In contrast, the relative paste progress of the five counties (Y_{15}, Y_{19}, Y_{36}, Y_{39} and Y_{37}) was less than 1 low. County Y_{37} had a relative paste progress of 0, indicating a relatively poor implementation status and suggesting further improvement. Overall, the relative paste progress varied markedly between counties, indicating large differences in the implementation status of the close-type county medical alliance in the 47 pilot counties in Shandong Province. The difference between counties in the same urban area was also significant.

Analysis of factors influencing the close-type county medical alliance

From the results of the non-integral rank sum ratio binning and variance analysis results, the comprehensive evaluation results of the RSR method were averagely consistent with those of entropy weight TOPSIS method. In both analyses, 47 national pilot counties in Shandong Province were divided into three grades: excellent, good and average. This shows the objectivity of the indicators weight calculated using the entropy weight TOPSIS method [26, 27] and the RSR method result binning. It also shows that the original data used in the study had

Table 4 RSR value distribution levels in different pilot counties

Pilot counties	TOPSIS sorts the results	RSR value	RSR sort results	Probit value	Level	Pilot counties	TOPSIS sorts the results	RSR value	RSR sort results	Probit value	Level
Y_5	1	1.000	1	7.554	3	Y_{12}	25	0.913	25	4.839	2
Y_{11}	1	1.000	1	7.554	3	Y_{23}	25	0.913	25	4.839	2
Y_{14}	1	1.000	1	7.554	3	Y_{35}	25	0.913	25	4.947	2
Y_{16}	1	1.000	1	7.554	3	Y_{46}	25	0.913	25	4.947	2
Y_{20}	1	1.000	1	7.554	3	Y_{22}	29	0.879	29	4.758	2
Y_{25}	1	1.000	1	7.554	3	Y_{24}	30	0.877	30	4.702	2
Y_{26}	1	1.000	1	7.554	3	Y_4	31	0.875	31	4.618	2
Y_{27}	1	1.000	1	7.554	3	Y_{44}	31	0.875	31	4.618	2
Y_{28}	1	1.000	1	7.554	3	Y_{21}	33	0.867	33	4.469	2
Y_{32}	1	1.000	1	7.554	3	Y_9	34	0.867	34	4.530	2
Y_{33}	1	1.000	1	7.554	3	Y_{10}	35	0.866	35	4.407	2
Y_{40}	1	1.000	1	7.554	3	Y_{43}	36	0.773	36	4.342	2
Y_{42}	1	1.000	1	7.554	3	Y_{29}	37	0.707	40	4.274	2
Y_6	14	0.962	14	5.593	2	Y_{45}	38	0.678	41	4.203	1
Y_2	15	0.951	15	5.354	2	Y_1	39	0.757	37	4.128	2
Y_3	15	0.951	15	5.354	2	Y_{34}	40	0.737	38	4.047	2
Y_{13}	15	0.951	15	5.354	2	Y_{47}	41	0.727	39	3.959	2
Y_{17}	15	0.951	15	5.354	2	Y_{41}	42	0.565	42	3.862	1
Y_{18}	15	0.951	15	5.354	2	Y_{15}	43	0.388	43	3.754	1
Y_{30}	15	0.951	15	5.354	2	Y_{19}	44	0.322	44	3.628	1
Y_{38}	15	0.951	15	5.354	2	Y_{36}	45	0.304	45	3.477	1
Y_7	22	0.925	22	5.134	2	Y_{39}	46	0.058	46	3.278	1
Y_8	23	0.915	23	5.053	2	Y_{37}	47	0.021	47	2.972	1
Y_{31}	23	0.915	23	5.053	2						

RSR means rank sum ratio, Probit means the probability unit

Table 5 Analysis of factors influencing the implementation status of compact medical communities in different counties

Grade	Pilot counties	GDP per capita	Number of health technicians in 1,000 population	Number of beds per thousand people	Proportion of discharged patients with grade 3 and 4 surgeries (%)	Grade	Pilot counties	GDP per capita	Number of health technicians in 1,000 population	Number of beds per thousand people	Proportion of discharged patients with grade 3 and 4 surgeries (%)
Excellent	Y_5	10.24	6.01	4.37	46.2	Good	Y_{12}	5.06	5.14	3.96	34.94
	Y_{11}	5	10.94	9.43	55.75		Y_{23}	5.62	6.71	5.44	49.91
	Y_{14}	11.88	7.27	6.06	60.06		Y_{35}	2.28	3.13	3.67	37.82
	Y_{16}	8.3	6.27	3.72	42.46		Y_{46}	3.16	5.52	5.01	51.89
	Y_{20}	5.55	4.73	5.85	32.79		Y_{22}	7.13	9.45	5.88	39.08
	Y_{25}	7.46	6.07	5.18	30.97		Y_{24}	2.85	7.03	4.3	45.3
	Y_{26}	14.47	7.84	6.4	48.35		Y_4	14.23	3.4	2.63	47.66
	Y_{27}	5.17	5.49	4.1	68.33		Y_{44}	7.15	6.83	2.2	19.85
	Y_{28}	10.58	10.28	3.66	54.69		Y_{21}	4.68	7.55	6.43	61.36
	Y_{32}	12.49	4.39	2.8	43.41		Y_9	5.27	6.55	4.03	42.54
	Y_{33}	5.09	5.24	4.71	53.74		Y_{10}	9.61	8.4	3.37	32.57
	Y_{40}	5.79	5.09	4.44	22.51		Y_{43}	7.49	6.2	4.69	48.56
	Y_{42}	4.43	5.12	4.38	60.45		Y_{29}	3.95	3.65	4.78	57.49
Good	Y_6	13.51	9.1	6.81	54.6		Y_1	7.3	7.05	3.43	31.75
	Y_2	6.48	6.38	6.41	50.66		Y_{34}	5.02	5.01	4.15	45.37
	Y_3	23.14	9.31	5.49	45.39		Y_{47}	4.13	4.74	5.67	47.99
	Y_{13}	12.02	8.08	8.29	58.86	Average	Y_{45}	3.87	5.87	4.36	43.1
	Y_{17}	12.94	6.08	3.72	47.14		Y_{41}	5.03	4.25	4.38	12.9
	Y_{18}	7.88	5.15	3.7	45.12		Y_{15}	4.63	6.91	5.55	47.8
	Y_{30}	6.91	12.29	8.41	62.81		Y_{19}	40.26	6.59	3.94	62.67
	Y_{38}	5.2	16.6	4.85	51.65		Y_{36}	3.48	4.36	4.48	51.92
	Y_7	6.9	6.72	6.24	46.22		Y_{39}	2.97	4.44	4.02	44.56
	Y_8	5.19	5.73	5.23	60.84		Y_{37}	3.8	4.37	4.08	62.35
	Y_{31}	0	7.77	5.27	57.74						

GDP means gross domestic product

fewer outliers. The combination of the two methods to comprehensively evaluate the implementation status of the close-type county medical alliance is more scientific and reasonable [28]. The results of variance analysis showed that the comprehensive evaluation level of the implementation status of the close-type county medical alliance in different counties was not related to the county's economic development level (per capita GDP), the level of health resources input (the number of health technicians and beds per thousand population) and the medical service capacity of the lead hospital (the proportion of tertiary and fourth-level operations of discharged patients), which was basically consistent with the results of Zhao's [19] comprehensive evaluation of basic public health service projects. This result could be explained in two ways. First, due to the limitation of human and material resources and other conditions, this study only investigated 47 pilot counties, excluding non-pilot counties in Shandong Province, which may not fully represent the actual situation in Shandong Province. Second, close-type county medical alliance is still in its initial stage of development having only been officially implemented since 2019, and thus, the degree of attention paid to the county medical alliance by county is different [19], which results in certain differences between pilot counties. Therefore, to bridge this disparity, all counties should prioritize the construction of a close-type county medical alliance, increase the input level of health resources in the county, and improve the service capacity of the lead hospital.

Limitations of this study

First, the entropy-weighted TOPSIS method and the non-integral rank sum ratio (RSR) method were used to objectively empower the indicators [29, 30], which ignored the importance of the original data and the evaluation indicators itself to a certain extent, creating some bias. However, the combined use of the two methods will avoid this influence to a certain extent. Second, this study only investigated 47 national pilot counties in Shandong Province, and did not conduct comparative studies with non-pilot counties, and thus our sample may fully represent the overall situation in Shandong Province. In the future, the research society will further expand the scope of evaluation and conduct two-way comparison between pilot counties and non-pilot counties.

Conclusions

Through the analysis of the implementation of close-type county medical alliance in Shandong Province, we find that there were large differences in different pilot counties, and the differentiation between counties within the same urban area was also more serious. Therefore, three suggestions are proposed for reference. First, it is necessary to promote the construction of a close-type county medical alliance, enhance information empowerment in grassroots counties, organize and carry out personnel training, integrate modern information technology into the grassroots medical service delivery, and expand the information system of county medical alliance [15]. These measures will improve not only the service capacity of grassroots medical institutions, but also the efficiency of the operation and management of the medical alliance, significantly benefiting the medical alliance [31], Second, the county's medical service capacity should be improved by sending experts to counties [32–34], strengthening the training of county medical personnel, strengthening the leadership role of the leading hospital, improving the accuracy of initial diagnosis, establishing a green channel for up-down referral, building linkages between upper and lower levels, and strictly regulating approvals for external referrals [35, 36] to promote two-way referrals. Third, the government should play its leadership role, strengthen its responsibility in running hospitals, regularly monitor the implementation of policies and the effectiveness of the construction of the medical alliance, and improve "decentralization, management and service" [37]. This will require fully mandating the lead hospital to manage member units, clarify the goals and responsibilities of both sides, implement refined management, and then enforce effective policies [21].

Abbreviations

RSR Rank Sum Ratio
GDP Gross Domestic Product

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Authors' contributions

DG conceptualized the article and its design; HZL and SSJ conducted data collection; QZ drafted the manuscript; LW was responsible for the overall article, guidance, improvement, supervision and management. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study protoco was approved and organized by Health Commission of Shandong Province. This study was reviewed and approved by the

Institutional Review Board (Academic Research Ethics Committee) of Shandong University of Traditional Chinese Medicine School of Health Management. All procedures were in accordance with the ethical standards of the Helsinki Declaration. All participants in the study provided written informed consent to participate in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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