A Novel Decision Making Approach for Benchmarking the Service Quality of Smart Community Health Centers

HAO LI\textsuperscript{1,2}, JINLIN LI\textsuperscript{1}, AND HELMUT DIETL\textsuperscript{2}
\textsuperscript{1}School of Management and Economics, Beijing Institute of Technology, Beijing 100081, China
\textsuperscript{2}Department of Business Administration, University of Zurich, 8032 Zürich, Switzerland
Corresponding author: Jinlin Li (lijinlin_bit@126.com)

This work was supported in part by the National Natural Science Foundation of China under Grant 71432002 and Grant 71972012, and in part by the Chinese Government Scholarship of China Scholarship Committee under Grant 201906030126.

ABSTRACT The purpose of this research is to develop a novel approach to benchmark smart community health centers in order to achieve continuous improvement of service quality. Three methods are presented: the fuzzy DEMATEL method is used to determine the criteria weights, the fuzzy ELECTRE III method is employed to obtain the ranking of smart community health centers, and IPA (Importance-Performance Analysis) is employed to formulate improvement strategies. The proposed approach clearly identifies the strengths and weakness of each smart community health center by ranking its performance with respect to a system of five service quality criteria. In addition, IPA is able to develop the most effective improvement strategies for each smart community health center. The proposed approach was applied to five smart community health centers in Beijing and service strengths and weakness are discussed. The proposed approach has three notable advantages. First, the novel approach can address ambiguity and uncertainty in the process of decision making. Second, interdependent relationships among the evaluation criteria are analyzed by the fuzzy DEMATEL method, so that the weights obtained are more in line with reality. Third, the fuzzy ELECTRE III method considers non-compensatory behavior for service quality comparisons among smart community health centers. The novel fuzzy-based approach presented in this article is a powerful and highly effective tool to benchmark smart community health centers and develop successful improvement strategies of service quality.

INDEX TERMS Quality of service, quality management, fuzzy set theory, decision making.

I. INTRODUCTION
Community health centers are an important part of the healthcare delivery system. China has a three-tiered health care delivery system, with community health centers at the bottom, secondary hospitals in the middle, and tertiary hospitals at the top [1], [2]. In recent years, China began to develop smart community health centers (SCHCs). Due to the rapid development of IT in China, the application of information system technology plays an important role in smart community health centers. It has four significant characteristics: online appointment, service information on website/App, telemedicine for diagnosis and information management system. Different from other countries, patients in China are free to choose any kind of medical institution as their first recourse for treatment [3]. Many patients with common diseases prefer to pursue treatment in hospitals rather than smart community health centers. This preference aggravates the difficulty and expensiveness of getting effective medical treatments and goes against the fundamental principle of the three-tiered health care delivery system [4], [5]. In an attempt to address the access and cost of healthcare delivery problems, in April 2009, China launched a broad and complex health reform plan that pledged to provide all citizens with equal access to primary care with reasonable quality and sufficient financial risk protection by 2020 [6]. The health reform plan aimed at strengthening smart community-based primary care delivery to improve population health and increase public satisfaction [7]. Community health service could attract and guide residents to seek the first treatment in SCHC.
Although China has developed the network of smart community health centers for ten years, due to the service quality of SCHCs, they fall far short of meeting public expectations as the nation’s primary care providers [8]. How to benchmark the service quality of smart community health centers so as to establish a process of continuous improvement is a question that urgently needs to be answered.

In this article, the benchmarking process focuses on the service quality of Chinese smart community health centers, which is especially appropriate for the three fundamental aspects. First, the Chinese government is eager to improve service quality of smart community health centers by initiating an effective benchmarking process. Second, smart community health centers in China have similar organization structures, management modes, and service contents. Under such conditions, it is likely to be simpler and more effective to implement the benchmarking process. Third, the operating cost of smart community health centers is provided by public funding, which limits competition. Benchmarking could generate positive aspects of self-effort, career motivation, and continuous improvement [9]. Previous research indicates that the introduction of incentive mechanisms and honor awards based on best practices could compensate for inefficiencies caused by the lack of competition in the public health sector. Angst et al. [10] highlighted how public hospitals compete for their reputation by improving operational efficiency and service quality. To exploit advantages from peer comparisons, it is crucial for SCHCs to implement reliable and detailed collaborative benchmarking processes combined with continuous self-assessment activities [11]. Therefore, it is crucial for smart community health centers in China to develop a novel approach to implement benchmarking processes in order to maintain continuous improvement of service quality.

Based on the problem to be addressed, numerous approaches could be applied to perform benchmarking. In this article, a novel fuzzy-based approach is proposed to compare the service quality performance of smart community health centers in the context of China. The fuzzy-based method can address the uncertainty, subjectivity, and vagueness of experts in assessing the criteria of health service quality performance [12]. The fuzzy-DEMATEL method is proposed to determine the weights which capture causal relationships between evaluation criteria [13]. The fuzzy-ELECTRE III method is developed to compare service quality performance of smart community health centers. Criteria weights and discrepancies in performance scores among smart community health centers are employed to formulate service quality improvement strategies by the IPA method. The IPA method allows the decision makers to visually identify gaps between criteria importance and actual performance. We apply the proposed fuzzy-based approach to five smart community health centers located in Beijing, China.

This article has two main contributions. First, to the best of the authors’ knowledge, fuzzy-ELECTRE III method is employed for the first time in service quality performance comparisons of smart community health centers.

Two essential characteristics of the ELECTRE III method make it very different from other methods: (1) ELECTRE III is based on pseudo criteria by the introduction of indifference threshold, preference threshold, and veto threshold. (2) ELECTRE III is a non-compensatory method, namely a very bad score of an alternative against a criterion cannot be compensated by good scores against other criteria [14]. For example, clean environment of smart community health centers cannot compensate for the lack of highly-skilled general practitioners or advanced information technology. Second, based on criteria weights and discrepancies, improvement strategies for smart community health centers are formulated by the IPA method.

II. LITERATURE REVIEW

Limited healthcare resources pose a challenge to community health services in China because of the aging population and the prevalence of chronic diseases. MCDM methods are commonly employed to model the complex decision making problems. AHP, TOPSIS, and VIKOR are some of the most common MCDM methods. The application of these methods in the healthcare field over the last ten years can be classified into eight categories [15]: service quality, supplier selection, mHealth application, factor identification, technology evaluation, disease diagnosis, treatment risk, and patient satisfaction. Despite their wide application, AHP, TOPSIS, and VIKOR have two obvious drawbacks. Due to their compensatory characteristic, they are not very suitable for service quality performance comparison of smart community health centers. In addition, they cannot address the uncertainty and vagueness in the decision-making process.

In recent years, fuzzy-based MCDM methods have been considered more effective to deal with an uncertain environment. To address uncertainty in the problems of healthcare performance comparison [16], an increasing number of fuzzy-based MCDM methods have been successfully applied to performance comparison in the healthcare field. For example, Yucesan and Gulb [17] studied hospital service quality by using Pythagorean fuzzy AHP and fuzzy TOPSIS, and Liao et al. [18] developed a hesitant fuzzy linguistic best worst method to study hospital performance evaluation. Gul [19] employed the fuzzy DEMATEL-focused two-stage methodology to evaluate the ergonomic design of emergency departments. The fuzzy-based methods have proven to be suitable for evaluating service quality in the healthcare field.

In a fuzzy environment, the DEMATEL method can be extended to calculate the weights of evaluation criteria. A majority of the existing methods neglect the independent relationships among the evaluation criteria, but the hypothesis that all these evaluation criteria are independent does not match the actual conditions [20]. The DEMATEL method is capable of analyzing the total relations among the evaluation criteria and visualizing the structure of complex systems [21] so that the criteria weights determined by the DEMATEL method are more accurate. ELECTRE III has been widely
applied to various fields, but its application in health service quality is still quite rare.

III. METHODS

The scheme of the proposed approach in this article comprises four stages: the preliminary stage, the fuzzy DEMATEL method, the fuzzy ELECTRE III method and the IPA method.

A. PRELIMINARY STAGE

1) PROBLEM FORMULATION

Smart community health centers are an important way to provide primary care service, guarantee residents’ well-being and promote social equity. To achieve better performance and higher reputation, the decision makers of smart community health centers must spare no effort to improve service quality. Due to limited resources, decision makers must formulate the correct investment mix strategy to improve service quality of primary care.

In this article, benchmarking the service quality of primary care from various stakeholders’ perspective is considered. Specifically, five smart community health centers (SCHC1, SCHC2, SCHC3, SCHC4, SCHC5) in Beijing are analyzed by employing the proposed fuzzy-based approach. Due to their comparable and specialized structures, these five smart community health centers can be regarded as reference points not only for Beijing but also for other Chinese regions.

2) EVALUATION CRITERIA

In this article, the evaluation criteria system of service quality consists of three levels: objective, criteria and attribute. Based on literature analysis and expert interviews, the evaluation criteria system is presented in FIGURE 1. The literature references for each criterion is shown in TABLE 1. For the evaluation criteria system of service quality, the objective level refers to the improvement of stakeholders’ perceived service quality, five criteria closely related to the objective are considered at the second level, then nineteen attributes are presented at the third level.

Although the established evaluation criteria system of service quality is based on Beijing smart community health centers, it also can be applied to service quality benchmarking of smart community health centers in other Chinese regions.

3) FUZZY SET THEORY

The fuzzy set theory was initially introduced by Zadeh [22]. A fuzzy set is characterized by a membership function that maps objects between 0 and 1 [23]. The definitions of fuzzy set theory are described in the following section.

**Definition 1:** Let $\tilde{A}$ be a triangular fuzzy number (TFN). TFN $\tilde{A}$ is denoted by a triplet $(l, m, u)$. The membership function $\mu_{\tilde{A}}(x)$ to determine the membership degrees of elements $x \in R$ to $\tilde{A}$ is defined as:

$$
\mu_{\tilde{A}}(x) = \begin{cases} 
0 & \text{if } x < l \\
\frac{x - l}{m - l} & \text{if } l \leq x \leq m \\
\frac{u - x}{u - m} & \text{if } m \leq x \leq u \\
0 & \text{if } x > m
\end{cases}
$$

(1)

where $m$ refers to the center bound of $\tilde{A}$ and corresponds to the maximum value of $\mu_{\tilde{A}}(x)$. $l$ and $u$ are the lower and upper bounds of $\tilde{A}$, respectively.

**Definition 2:** TFN $\tilde{A}$ can be denoted by its confidence interval at the level $\alpha$ or $\alpha$ cut. The definition is as follows:

$$
\tilde{A}^\alpha = [l^\alpha; u^\alpha] = [l + (m - l) \cdot \alpha; u - (u - m) \cdot \alpha]
$$

(2)

where $l^\alpha$ and $u^\alpha$ refer to the lower and upper bounds of $\tilde{A}$, respectively.

![FIGURE 1. Service quality structure of smart community health centers in Beijing.](image-url)
TABLE 1. The literature references for each criterion.

| The attributes of each criterion | Supporting literature |
|----------------------------------|-----------------------|
| A11 Cleanliness of consulting room | Liao et al. (2019) [2], Wu et al. (2016) [6] |
| A12 Cleanliness of ward | Walsh et al. (2018) [8] |
| A13 Cleanliness of waiting room | Li et al. (2019) [5] |
| A14 Sustainability of medical equipment | Dong et al. (2014) [3], Li et al. (2019) [5] |
| A21 Online appointment | Wu et al. (2016) [4], Angst et al. (2014) [10] |
| A22 Service information on website/App | Li et al. (2019) [5], Rajak (2019) [12] |
| A23 Telemedicine for diagnosis | Wei et al. (2011) [1], Angst et al. (2014) [10] |
| A24 Information management system | Angst et al. (2014) [10], Rajak (2019) [12] |
| A31 Swiftness of appointment and admission | Akdag et al. (2014) [15] |
| A32 Waiting time for treatment of primary care | La et al. (2019) [11] |
| A33 Waiting time for test results | Yip et al. (2019) [6], Walsh et al. (2018) [8] |
| A34 Ability of transferring to big hospitals | Walsh et al. (2018) [8] |
| A41 Cooperation among healthcare staff | La et al. (2019) [11] |
| A42 General practitioner-patient relationship | Li et al. (2019) [5], Yucesan et al. (2019) [17] |
| A43 Personalized service for different patients | Wei et al. (2011) [1] |
| A44 Organization culture | Wu et al. (2016) [4], Meng et al. (2012) [7] |
| A51 Ability of general practitioner | Liao et al. (2019) [18] |
| A52 Ability of nurse | Meng et al. (2012) [7] |
| A53 Communication skill | Wei et al. (2011) [1], Liao et al. (2019) [18] |

**Definition 3:** Let $\tilde{A}_1 = (l_1, m_1, u_1)$ and $\tilde{A}_2 = (l_2, m_2, u_2)$ be two triangular fuzzy numbers. The arithmetic operations of two TFNs are as follows:

1) Addition of two TFNs:
$$\tilde{A}_1 + \tilde{A}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$ (3)

2) Subtraction of two TFNs:
$$\tilde{A}_1 - \tilde{A}_2 = (l_1 - l_2, m_1 - m_2, u_1 - u_2)$$ (4)

3) Multiplication of two TFNs:
$$\tilde{A}_1 \times \tilde{A}_2 = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2)$$ (5)

4) Division of two TFNs:
$$\tilde{A}_1 \div \tilde{A}_2 = (l_1 \div u_2, m_1 \div m_2, u_1 \div l_2)$$ (6)

**B. FUZZY DEMATEL METHOD**

DEMATEL method was originally developed by the Geneva Research Center in 1976. Given the complex nature of the evaluation criteria system for service quality of smart community health centers, the fuzzy DEMATEL method combining fuzzy set theory and DEMATEL method is established to determine the criteria weights. The steps of this method are presented as follows:

**TABLE 2. Influence measures using fuzzy linguistic terms.**

| Linguistic term          | Corresponding TFNs   |
|--------------------------|----------------------|
| No Influence (NO)        | (0.00, 0.00, 0.25)   |
| Very Low Influence (VL)  | (0.00, 0.25, 0.50)   |
| Low Influence (L)        | (0.25, 0.50, 0.75)   |
| High Influence (H)       | (0.50, 0.75, 1.00)   |
| Very High Influence (VH) | (0.75, 1.00, 1.00)   |

**Step 1:** Design the fuzzy linguistic scale (Table 2). This fuzzy linguistic scale was initially developed by Dalalah et al. [24]. In Table 2, the influence assessment for pairwise criteria include five levels, each triangle fuzzy number corresponds to a linguistic term.

**Step 2:** Develop the initial direct relation matrix $\tilde{Q}$. We suppose that there are $n$ criteria to be considered. The decision makers are asked to determine the influence level between each pair of criteria by using the triangle fuzzy numbers. $\tilde{q}_{ij}$ is a triangle fuzzy number, which refers to the influence of the $i$-th criterion on the $j$-th criterion (with $i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, n$) assessed by the $h$-th (with $h = 1, 2, \ldots, H$) decision maker. The direct relation matrix $\tilde{Q}^h$ determined by the $h$-th decision maker is shown in Eq. (7).

$$\tilde{Q}^h = \begin{bmatrix} 
q_{11}^h & q_{12}^h & \cdots & q_{1n}^h \\
q_{21}^h & q_{22}^h & \cdots & q_{2n}^h \\
\vdots & \vdots & \ddots & \vdots \\
q_{n1}^h & q_{n2}^h & \cdots & q_{nn}^h 
\end{bmatrix}$$

| Corresponding TFNs |
|--------------------|
| (0, 0, 0.25)       |
| (0, 0, 0.25)       |
| (0, 0, 0.25)       |
| (0, 0, 0.25)       |

Let TFN $\tilde{q}_{ij}$ denote the average influence level of the $i$-th criterion on the $j$-th criterion. TFN $\tilde{q}_{ij}$ is obtained as follows:

$$\tilde{q}_{ij} = (l_{ij}, m_{ij}, u_{ij}) = \left( \frac{l_{ij}^L + l_{ij}^H + \cdots + l_{ij}^H}{H}, \frac{m_{ij}^L + m_{ij}^M + \cdots + m_{ij}^H}{H}, \frac{u_{ij}^L + u_{ij}^M + \cdots + u_{ij}^H}{H} \right)$$ (8)
Then, the initial direct relation matrix $\tilde{Q}$ is expressed as follows:

$$
\tilde{Q} = \begin{bmatrix}
\tilde{q}_{11} & \tilde{q}_{12} & \cdots & \tilde{q}_{1n} \\
\tilde{q}_{21} & \tilde{q}_{22} & \cdots & \tilde{q}_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
\tilde{q}_{n1} & \tilde{q}_{n2} & \cdots & \tilde{q}_{nn}
\end{bmatrix}
$$

(9)

Step 3: Normalize the fuzzy direct relation matrix. The normalized fuzzy direct relation matrix $D$ can be obtained by Eqs. (10) – (11).

$$
\hat{D} = \left[\tilde{d}_{ij}\right]_{n \times n} = \left[\frac{d_{ij}^1, d_{ij}^2, d_{ij}^3}{s, s, s}\right]_{n \times n}
$$

(10)

$$
s = \max_{1 \leq i \leq n} \sum_{j=1}^{n} u_{ij}
$$

(11)

Step 4: Calculate the total relation matrix $T$. The total relation matrix $T$ can be obtained by summing the direct effects expressed in $\hat{D}$ and the indirect effects determined by raising $\hat{D}$ to different powers. Then, the total relation matrix $\tilde{T}$ can be obtained by Eqs. (12) and (13).

$$
\tilde{T} = \left[\tilde{t}_{ij}\right]_{n \times n} = \hat{D}^1 + \hat{D}^2 + \cdots + \hat{D}^p; \text{if } p \to \infty, \hat{D}^p = [0]_{n \times n}
$$

(12)

$$
\tilde{t}_{ij} = (t_{ij}^1, t_{ij}^2, t_{ij}^3)
$$

(13)

The three elements of $\tilde{t}_{ij}$ can be obtained by Eqs. (14) – (18).

$$
D_1 = \left[\tilde{d}_{ij}\right]_{n \times n}, \quad T_1 = \left[\tilde{t}_{ij}\right]_{n \times n} = D_1(I - D_1)^{-1}
$$

(14)

$$
D_2 = \left[\tilde{d}_{ij}\right]_{n \times n}, \quad T_2 = \left[\tilde{t}_{ij}\right]_{n \times n} = D_2(I - D_2)^{-1}
$$

(15)

$$
D_3 = \left[\tilde{d}_{ij}\right]_{n \times n}, \quad T_3 = \left[\tilde{t}_{ij}\right]_{n \times n} = D_3(I - D_3)^{-1}
$$

(16)

where $I$ refers to the identity matrix.

Let $\tilde{r}_i$ denote the total effect of the $i$-th criterion on other criteria, and let $\tilde{c}_j$ denote the total effect of other criteria on the $j$-th criterion. $\tilde{r}_i$ and $\tilde{c}_j$ can be obtained by Eq. (17) and (18), respectively.

$$
\tilde{r}_i = \sum_{j=1}^{n} \tilde{t}_{ij} = (r_i^1, r_i^2, r_i^3)
$$

(17)

$$
\tilde{c}_j = \sum_{i}^{n} \tilde{t}_{ij} = (c_j^1, c_j^2, c_j^3)
$$

(18)

If $i = j$, $r_i + c_i$ refers to the total effects with respect to the $i$-th criterion, and it can be regarded as the relative importance of the $i$-th criterion in the evaluation criteria system. $r_i - c_i$ refers to the net effect of the $i$-th criterion. It can be obtained by Eqs. (19) – (22).

$$
\tilde{r}_i + \tilde{c}_i = (r_i^1 + c_i^1, r_i^2 + c_i^2, r_i^3 + c_i^3)
$$

(19)

Figure 2. Nine-point linguistic evaluation figure.

$$
\tilde{r}_i - \tilde{c}_i = (r_i^1 - c_i^1, r_i^2 - c_i^2, r_i^3 - c_i^3)
$$

(20)

$$
r_i + c_i = \frac{(r_i^1 + c_i^1) + 2(r_i^2 + c_i^2) + (r_i^3 + c_i^3)}{4}
$$

(21)

$$
r_i - c_i = \frac{(r_i^1 - c_i^1) + 2(r_i^2 - c_i^2) + (r_i^3 - c_i^3)}{4}
$$

(22)

C. FUZZY ELECTRE III METHOD

ELECTRE III, which can reduce the compensation effect caused by large values or high weights, was initially developed by Roy. In this article, we develop a fuzzy ELECTRE III method to rank the smart community health centers in China. The steps in this method are presented as follows:

Step I: Design the linguistic evaluation scale. Each decision maker is asked to evaluate service quality attributes by using triangular fuzzy numbers. The nine-point linguistic evaluation figure (Fig. 2) is developed.

| Linguistic term | Corresponding TFNs |
|-----------------|--------------------|
| Very Low (VL)   | (1, 1, 3)          |
| Low (L)         | (1, 3, 5)          |
| Medium (M)      | (3, 5, 7)          |
| High (H)        | (5, 7, 9)          |
| Very High (VH)  | (7, 9, 9)          |

Accordingly, the fuzzy linguistic evaluation scale (Table 3) is designed. In Table 3, the fuzzy linguistic evaluation scale
for service quality attributes includes five levels and each triangle fuzzy number corresponds to a linguistic term.

Step 2: Calculate the score of each smart community health center against each criterion. Let $g$ be the investigated smart community health center (with $g = 1, 2, \ldots, G$) to be evaluated by $Z$ decision makers with respect to $l$ criteria. Let $(\hat{P}_i(k)_g) = (i_{l,k}, m_{i,k,z}, u_{i,k,z})_g$ be the triangle fuzzy number which indicates the perceived service quality of the $g$-th smart community service center assessed by the $z$-th decision maker with respect to the $k$-th attribute (with $k = 1, 2, \ldots, A_i$) of the $i$-th criterion. Let $S$ denote the pairwise comparison of alternatives [25]. Let $S$ be the investigated smart community health center (with $I = \{1, 2, \ldots, A_i\}$) of the $i$-th criterion. The TFN $(\hat{P}_i(k)_g)$ is obtained as follows (Eq. 25):

$$(\hat{P}_i(k)_g) = \left[ \left( i_{l,k} \right)_g, (m_{i,k,z})_g, (u_{i,k,z})_g \right] = \frac{1}{Z} \sum_{i=1}^{Z} \left[ \left( i_{l,k} \right)_g, (m_{i,k,z})_g, (u_{i,k,z})_g \right]$$

Then, $(P^\alpha_{i,k})_g$ is obtained by the introduction of a confidence level $\alpha$ and an optimism index $\beta$. If the decision maker is more confident in choosing a crisp value to represent his/her assessment, a larger confidence level $\alpha$ will be employed. Optimism index $\beta$ reflects the decision maker’s attitude toward possible risks on the fuzzy evaluation results. $(P^\alpha_{i,k})_g$ can be obtained after setting the confidence level $\alpha$ and optimism index $\beta$.

$$(P^\alpha_{i,k})_g = \beta \cdot (P^\alpha_{i,k})_g + (1 - \beta) \cdot (P^\alpha_{i,k})_g, \quad \alpha, \beta \in [0, 1]$$

where, $(u^\alpha_{i,k})_g$ and $(l^\alpha_{i,k})_g$ refer to the upper and lower bounds of the confidence level $\alpha$ of the TFN $(\hat{P}_i(k)_g)$, respectively.

Finally, the score of the $g$-th smart community health center against the $i$-th criterion $(P^\alpha_{i,k})_g$ is obtained by calculating the arithmetic mean of the related scores of the service quality attributes, which is shown as follows:

$$(P^\alpha_{i,k})_g = \frac{1}{A_i} \sum_{k=1}^{A_i} (P^\alpha_{i,k})_g, \quad \forall j = 1, 2, \ldots, J; \quad \forall g = 1, 2, \ldots, G$$

Step 3: Calculate the credibility index. The ELECTRE III method uses the concept of outranking relationship for pairwise comparison of alternatives [25]. Let $S$ denote the outranking relationship between each pair of smart community health centers. For example, “$g S d$” refers to “alternative $g$ is at least as good as alternative $d$”. Let $q_i$, $p_i$, $v_i$ denote indifference threshold, preference threshold and veto threshold, respectively. In general, $q_i \leq p_i < v_i$.

For indifference threshold $q_i$, if $| (b^{\alpha,\beta}_{i,k})_g - (b^{\alpha,\beta}_{j,k})_d | \leq q_i$, the relationship between alternative $g$ and alternative $d$ is indifferent with respect to criterion $i$. For preference threshold $p_i$, if $| (b^{\alpha,\beta}_{i,k})_g - (b^{\alpha,\beta}_{j,k})_d | \geq p_i$, alternative $g$ outranks alternative $d$ with respect to criterion $i$. For veto threshold $v_i$, if $| (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g | \geq v_i$, “$g S d$” should be refused. We suppose that $(b^{\alpha,\beta}_{i,k})_g$ has an increasing direction of preference, the partial concordance index $C(g, d)$ with respect to criterion $i$ can be obtained by Eq. (28).

$$C(g, d) = \begin{cases} \frac{1}{\sum_{i=1}^{I} w_i \cdot C_j(g, d)} & \text{if } (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g \leq q_i \\ \frac{p_i - q_i}{(b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g} & \text{if } q_i < (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g \leq p_i \\ 0 & \text{if } (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g \\ \end{cases} \quad (28)$$

Then, the global concordance index $C(g, d)$ for each pair of alternative community health centers is obtained by Eq. (29).

$$C(g, d) = \frac{1}{\sum_{i=1}^{I} w_i} \sum_{i=1}^{I} w_i \cdot C_j(g, d), \quad \forall i = 1, 2, \ldots, I$$

where $w_i$ refers to the weight of the $i$-th criterion.

Step 4: Calculate the discordance index and credibility index. The discordance index $D_i(g, d)$ can be obtained by Eq. (30).

$$D_i(g, d) = \begin{cases} 0 & \text{if } (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g \leq p_i \\ \frac{v_i - p_i}{(b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g} & \text{if } p_i < (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g < v_i \\ 1 & \text{if } (b^{\alpha,\beta}_{i,k})_d - (b^{\alpha,\beta}_{j,k})_g \geq v_i \end{cases} \quad (30)$$

Finally, the credibility index $S(g, d)$ is obtained by Eq. (31). In fact, the credibility index refers to the degree of outranking relationship.

$$S(g, d) = \begin{cases} C(g, d) & \text{if } D_i(g, d) \leq C(g, d), \forall i \in I \\ \frac{C(g, d) \times \prod_{i=1}^{I} 1 - D_i(g, d)}{1 - C(g, d)} & \text{otherwise} \end{cases} \quad (31)$$

Step 5: Complete the ranking of smart community health centers. Descending distillation procedure and ascending distillation procedure are used to rank the smart community health centers. Then, the new ranking combining the results obtained by descending distillation procedure and ascending distillation procedure leads to a unique final ranking.
The implementation of descending distillation procedure and ascending distillation procedure is shown as follows:

(a) Let $\lambda_0$ denote the maximum value of $S(g, d)$ which is obtained by Eq. (32).

$$\lambda_0 = \max_{g, d} S(g, d)$$  \hspace{1cm} (32)

(b) Let $S(\lambda_0)$ denote the discrimination threshold which is computed by Eq. (33).

$$S(\lambda_o) = 0.3 - 0.15\lambda_o$$  \hspace{1cm} (33)

(c) Let $\lambda_1$ denote the cutoff level of outranking relation which is computed by Eq. (34).

$$\lambda_1 = \max_{\{S(g, d) < \lambda_0 - S(\lambda_o)\} \in G} S(g, d)$$  \hspace{1cm} (34)

For a pair of alternative smart community health centers $(g, d)$, $g$ outranks $d$ if the following conditions of Eq. (35) are met simultaneously [25].

$$g \succ d \iff \begin{cases} S(g, d) > \lambda_1 \\ S(g, d) - S(d, g) > S(\lambda_0) \end{cases}$$  \hspace{1cm} (35)

For every time $g$ outranks $d$, $g$ is given a score of +1 (strength) and $d$ is given a score of -1 (weakness). For each alternative smart community health center, a final qualification score is obtained by summing the score of strength and weakness. Then, the final ranking can be obtained after implementing descending distillation procedure and ascending distillation procedure.

**FIGURE 3.** IPA matrix.

### D. IPA METHOD

The importance and performance of service quality criteria are analyzed by using the IPA method. The IPA matrix (Fig. 3) consists of four quadrants. Based on the IPA matrix, the best improvement strategy can be formulated. For Quadrant I, the best strategy is to keep up the good work. Quadrant II is a key quadrant in the IPA matrix because the criteria placed in Quadrant II are very important, but the performances are low, so the decision makers should put stronger improvement efforts into these criteria. Quadrant III is a low priority zone. It is efficient to allocate small amounts of resources to improve these criteria. For Quadrant IV, the decision makers should realize that the current efforts on these service quality criteria are excessive.

In this article, the importance refers to the criteria weights determined by the fuzzy DEMATEL method. The performance refers to discrepancies in scores between the investigated community health centers and the best smart community health center resulting from the fuzzy ELECTRE III method. The scores of the best smart community health center are regarded as the reference point. In addition, Quadrant III consists of three areas namely red, yellow and green areas. They are used to find priorities of possible improvement efforts. Criteria placed in red areas need to be improved first, because the discrepancy is higher than the related veto threshold, which means that the gaps are unacceptable for the decision makers. Criteria placed in yellow areas need to be improved second, because the discrepancy is higher than the related indifference threshold but lower than the related veto threshold. Criteria placed in green areas need to be improved last, because the discrepancy is lower than the related indifference threshold.

**TABLE 4.** The weights of each criterion.

| Criterion 1 | Criterion 2 | Criterion 3 | Criterion 4 | Criterion 5 |
|------------|-------------|-------------|-------------|-------------|
| $r_i + c_i$ | (2.025, 2.62 | (2.861, 1.72 | (3.095, 1.82 | (4.948, 1.72 | (5.802, 1.35 |
| 2.5366)    | 8.4849)     | 3.5549)     | 5.4883)     | 5.5413)     |
| $r_i - c_i$ | (-0.846, 0.328, 0.8160 | (-1.871, 0.250, 0.979) | (-2.857, 0.267, 0.659) | (-3.914, 0.295, 0.675) | (-5.512, 1.140, 1.274) |
| 2.859 | 2.792 | 3.148 | 3.320 | 3.612 |
| $r_i - c_i$ | 0.155 | -0.194 | -0.416 | -0.662 | -2.633 | 0.001 |
| 2.863 | 2.798 | 3.175 | 3.386 | 0.247 |

### IV. RESULTS AND DISCUSSION

#### A. CALCULATE THE WEIGHTS OF CRITERIA

The fuzzy DEMATEL method is employed to determine the weights of the criteria. First, eight experts are asked to assess the influence levels between each pair of criteria by using Table 3. These eight experts have systematic knowledge and rich experience in service quality of smart community health centers. The experts consist of one policy maker, one senior hospital manager, two general practitioners, one nurse, two out-patients and one in-patient. Second, the initial direct relation matrix is obtained by using Eqs. (7) – (9) and the result is shown in Table A1. Third, the normalized fuzzy direct relation matrix is calculated by using Eqs. (10) – (11) and the result is shown in Table A2. Fourth, the total relation matrix (Table A3) is obtained by using Eqs. (12) – (16). Finally, the weights of the criteria (Table 4) are calculated.
by using Eqs. (17) – (24). The weights of criteria namely *Tangible, Information technology, Convenience, Relationship* and *Healthcare staff* are equal to 0.176, 0.172, 0.196, 0.209, and 0.247, respectively.

### B. DETERMINE THE RANKING OF ALTERNATIVES

After calculating the weights, we employ the fuzzy ELECTRE III method to determine the ranking order of the investigated smart community health centers. First, fifteen experts are asked to assess the service attributes of each smart community health center by using the fuzzy linguistic evaluation scale (Table 3). These fifteen experts are representatives of the fundamental stakeholders. Among them, three experts are out-patients, three experts are in-patients, three experts are general practitioners, two experts are nurses, two experts are policy makers and two experts are senior hospital managers. Second, in Eq. (26) we assume that the confidence level \( \alpha \) and optimism index \( \beta \) are equal to 0.5, respectively. Third, the crisp values of each criteria are calculated using Eqs. (25) - (27) and the results are shown in Fig. A4. Next, given the realistic conditions of smart community health centers, indifference threshold, preference threshold and veto threshold are set at 1, 2 and 3, respectively. The threshold values are subjectively determined by the experts familiar with the ELECTRE method based on the actual context of the research case. Finally, the ranking (Fig. 4) is obtained by the descending procedure and ascending procedure.

![FIGURE 4. The ranking results of fuzzy ELECTRE III.](image)

Finally, we perform a sensitivity analysis to verify the robustness of the ranking results obtained by the fuzzy ELECTRE III method. Specially, we consider different scenarios by varying the confidence level \( \alpha(\alpha = 0.1, 0.5, 0.9) \) and optimism index \( \beta(\beta = 0.1, 0.5, 0.9) \). The results of this sensitivity analysis are shown in Table A5.

*SCHC*\(_1\) is the best smart community health center with respect to primary care service quality, followed by *SCHC*\(_2\), *SCHC*\(_5\), *SCHC*\(_3\), *SCHC*\(_4\) in the descending order.

### C. IPA RESULTS

After calculating the criteria weights and discrepancies, we employ the IPA method to obtain the results and formulate the improvement strategies. The discrepancies are obtained by calculating the difference between the scores of the investigated community health centers and the reference point. In this research, *SCHC*\(_1\) is identified as best practice, so the scores of *SCHC*\(_1\) are considered as the reference point. The median values of weights and discrepancies are used to place the reference axes of the IPA matrices. The IPA matrices are shown in Fig. 5.

![FIGURE 5. IPA matrices.](image)

According to the IPA results, we can recommend some improvement strategies.

1. The criteria *Convenience* (C\(_3\)) for *SCHC*\(_3\) and *Relationship* (C\(_4\)) for *SCHC*\(_4\) are placed in Quadrant I. Therefore, these two smart community health centers should keep up the good work with respect to these criteria.

2. The criterion *Healthcare staff* (C\(_5\)) for *SCHC*\(_4\) is placed in the red area of Quadrant II, indicating that the discrepancy score is higher than the related veto threshold. This gap is intolerable for the stakeholders of *SCHC*\(_4\), so improving the criterion *Healthcare staff* (C\(_5\)) has the highest priority for *SCHC*\(_4\). The criteria *Relationship* (C\(_4\)) and *Healthcare staff* (C\(_5\)) for *SCHC*\(_3\) and *SCHC*\(_5\), and *Convenience* (C\(_3\)) for *SCHC*\(_4\) are placed in the yellow area of Quadrant II, indicating that the related discrepancy scores are between the related indifference thresholds and veto thresholds. Therefore, improving these criteria has the second highest priority. The criteria *Relationship* (C\(_4\)) and *Healthcare staff* (C\(_5\)) for *SCHC*\(_1\) are placed in the green area of Quadrant II, which reflects that the related discrepancy scores are lower than the indifference thresholds. Therefore, improving these criteria has the lowest priority for *SCHC*\(_2\).

3. The criterion *Tangible* (C\(_1\)) for *SCHC*\(_2\), *SCHC*\(_3\), *SCHC*\(_4\), and *SCHC*\(_4\), and the criterion *Information*
technology ($C_2$) for SCHC$_2$ are placed in Quadrant IV. The investigated stakeholders are satisfied with the current performances, but the respective criteria are not important. In other words, the current efforts on the Tangible and Information technology criteria are excessive, the decision makers should reallocate resources to improve criteria which have a higher priority.

D. DISCUSSION

In China, the benchmarking process is important for smart community health centers to implement continuous service quality improvement. The benchmarking results not only provide accurate information with respect to primary care service quality of smart community health centers, but also reflect the stakeholders’ satisfaction with current service quality. Primary care service quality represents a deep sense of responsibility and commitment of smart community health centers. Continuous improvement is helpful to attract, guide and channel residents to seek initial treatment in community health centers. The best smart community health center can be regarded as “the best practice” which can encourage other smart community health centers to make continuous efforts to achieve better service quality. Improvement strategy is also analyzed in the research. In particular, higher equity of primary care service can be reached by dealing with the discrepancies of related criteria. In addition, although the proposed approach in this article is employed to study service quality benchmarking of smart community health centers in China, its application can be extended to healthcare industries in other countries.

This study has found three significant managerial implications. First, the fuzzy DEMATEL method can not only determine the weights, but also analyze the type of causal relationship. The type of causal relationship for each criterion allows the decision makers to decide which criterion is more influential. Second, the ranking order is obtained by using the fuzzy ELECTRE III method, then the best practice is determined, which can form an incentive effect for other smart community health centers. Third, the IPA method allows the decision makers to visually identify gaps between criteria importance and actual performance. This study can help decision makers to formulate the improvement strategies of service quality.

Finally, we showed the benchmarking results of investigated smart community health centers to related experts, including three out-patients, three in-patients, three general practitioners, two nurses, two policy makers and two managers. All agreed with our benchmarking results. The policy makers and managers of the investigated smart community health centers are convinced that our results are useful to formulate improvement strategies of primary care service quality.

V. CONCLUSION

Benchmarking is a valuable tool to encourage continuous improvement with respect to primary care service quality among smart community health centers in China. In this article, a novel fuzzy-based approach combining DEMATEL, ELECTRE III and IPA is developed to implement a benchmarking process. Specifically, the fuzzy DEMATEL method is used to determine the criteria weights, the fuzzy ELECTRE III method considers non-compensatory behavior for service quality comparisons among smart community health centers. Finally, the proposed approach was applied to five smart community health centers in Beijing and service strengths and weaknesses are discussed.

The proposed approach has three notable strengths. First, the novel approach can address ambiguity and uncertainty in the process of decision making. Second, interdependent relationships among the evaluation criteria are analyzed by the fuzzy DEMATEL method, so that the weights obtained are more in line with reality. Third, the fuzzy ELECTRE III method considers non-compensatory behavior for service quality comparisons among smart community health centers. In addition, there are some limitations in this study.

### TABLE 5. The initial direct relation matrix.

| Criterion | Criterion 1 | Criterion 2 | Criterion 3 | Criterion 4 | Criterion 5 |
|-----------|-------------|-------------|-------------|-------------|-------------|
| 1         | 0.000, 0.000 | 0.125, 0.18  | 0.078, 0.14  | 0.086, 0.14  | 0.133, 0.19 |
| 0.250, 0.242 | 1.020, 1.020 | 0.807, 0.807 | 0.807, 0.807 | 0.807, 0.807 |
| 2         | 0.102, 0.171 | 0.063, 0.103 | 0.063, 0.103 | 0.125, 0.18  | 0.125, 0.18  |
| 0.211, 0.211 | 0.120, 0.120 | 0.102, 0.102 | 0.102, 0.102 | 0.102, 0.102 |
| 3         | 0.094, 0.181 | 0.063, 0.127 | 0.063, 0.127 | 0.117, 0.17  | 0.117, 0.17  |
| 48.020, 0.203 | 0.120, 0.120 | 0.102, 0.102 | 0.102, 0.102 | 0.102, 0.102 |
| 4         | 0.102, 0.211 | 0.055, 0.08  | 0.109, 0.16  | 0.094, 0.14  | 0.094, 0.14  |
| 56.021, 0.148 | 0.063, 0.063 | 0.063, 0.063 | 0.063, 0.063 | 0.063, 0.063 |
| 5         | 0.013, 0.026 | 0.007, 0.01  | 0.014, 0.02  | 0.000, 0.00  | 0.000, 0.00  |
| 20.026, 0.262 | 0.007, 0.007 | 0.007, 0.007 | 0.007, 0.007 | 0.007, 0.007 |

### TABLE 6. The normalized fuzzy direct relation matrix.

| Criterion | Criterion 1 | Criterion 2 | Criterion 3 | Criterion 4 | Criterion 5 |
|-----------|-------------|-------------|-------------|-------------|-------------|
| 1         | 0.000, 0.000 | 0.125, 0.18  | 0.078, 0.14  | 0.086, 0.14  | 0.133, 0.19 |
| 0.250, 0.242 | 1.020, 1.020 | 0.807, 0.807 | 0.807, 0.807 | 0.807, 0.807 |
| 2         | 0.102, 0.171 | 0.063, 0.103 | 0.063, 0.103 | 0.125, 0.18  | 0.125, 0.18  |
| 0.211, 0.211 | 0.120, 0.120 | 0.102, 0.102 | 0.102, 0.102 | 0.102, 0.102 |
| 3         | 0.094, 0.181 | 0.063, 0.127 | 0.063, 0.127 | 0.117, 0.17  | 0.117, 0.17  |
| 48.020, 0.203 | 0.120, 0.120 | 0.102, 0.102 | 0.102, 0.102 | 0.102, 0.102 |
| 4         | 0.102, 0.211 | 0.055, 0.08  | 0.109, 0.16  | 0.094, 0.14  | 0.094, 0.14  |
| 56.021, 0.148 | 0.063, 0.063 | 0.063, 0.063 | 0.063, 0.063 | 0.063, 0.063 |
| 5         | 0.013, 0.026 | 0.007, 0.01  | 0.014, 0.02  | 0.000, 0.00  | 0.000, 0.00  |
| 20.026, 0.262 | 0.007, 0.007 | 0.007, 0.007 | 0.007, 0.007 | 0.007, 0.007 |
system of interrelated criteria and the fuzzy ELECTRE III method is more applicable to performance comparison under non-compensatory behavior. For theoretical background, the determination of the threshold values is subjectively judged by the expert, so the accuracy is affected by the expert’s ability and experience.

DECLARATION OF CONFLICT OF INTEREST
None.

APPENDIX
See Tables 5–9.

REFERENCES
[1] X. Wei, G. Zou, H. Zhang, J. Walley, Z. Liu, J. Newell, Q. Sun, and R. Li, “Implementation of the chinese national microscopy centre policy: Health facility survey in Shandong Province,” Tropical Med. Int. Health, vol. 16, no. 7, pp. 847–853, Jul. 2011.
[2] H. Liao, C. Zhang, L. Luo, Z. Xu, J. Yang, and D. Xu, “Distance-based intuitionistic multiplicative multiple criteria decision-making methods for healthcare management in west China hospital,” Expert Syst., vol. 37, no. 2, pp. 82-98, Apr. 2020.
[3] X. Dong, L. Liu, S. Cao, H. Yang, F. Song, C. Yang, Y. Geng, Y. Wang, X. Yin, X. Xu, J. Xie, Y. Sun, and Z. Lu, “Focus on vulnerable populations and promoting equity in health service utilization—An analysis of visitor characteristics and service utilization of the Chinese community health service,” BMC Public Health, vol. 14, no. 1, pp. 503-5102, Dec. 2014.
[4] J. Wu, S. Zhang, H. Chen, Y. Lin, X. Dong, X. Yin, Z. Lu, and S. Cao, “Patient satisfaction with community health service centers as gatekeepers and the influencing factors: A cross-sectional study in Shenzhen, China,” PLoS ONE, vol. 11, no. 8, Aug. 2016, Art. no. e0161683.
[5] H. Li, J. Li, and J. Zhu, “Intervention mechanism of healthcare service goods based on social welfare maximization in China,” PLoS ONE, vol. 14, no. 3, Mar. 2019, Art. no. e0214655.
[6] W. Yip, H. Fu, A. T. Chen, T. Zhai, R. Xu, J. Pan, M. Hu, Z. Zhou, Q. Chen, W. Mao, Q. Sun, and W. Chen, “10 years of health-care reform in China: Progress and gaps in universal health coverage,” Lancet, vol. 394, no. 10204, pp. 1192–1204, Sep. 2019.
[7] Q. Meng, L. Xu, Y. Zhang, J. Qian, M. Cai, Y. Xin, J. Gao, K. Xu, J. T. Boerma, and S. L. Barber, “Trends in access to health services and financial protection in China between 2003 and 2011: A cross-sectional study,” Lancet, vol. 379, no. 9818, pp. 805–814, Mar. 2012.
[8] M. Walsh, M. G. Kittler, and D. Mahal, “Towards a new paradigm of healthcare: Addressing challenges to professional identities through community operational research,” Eur. J. Oper. Res., vol. 268, no. 3, pp. 1125–1138, Aug. 2018.
[9] A. Ranerup and L. Norén, “How are citizens’ public service choices supported in quasi-markets?” Int. J. Inf. Manage., vol. 35, no. 5, pp. 527–537, Oct. 2015.
[10] C. Angst, R. Agarwal, G. Gao, J. Khuntia, and J. S. McCullough, “Information technology and voluntary quality disclosure by hospitals,” Decis. Support Syst., vol. 57, pp. 367–375, Jan. 2014.
[11] C. M. La Fata, T. Lupo, and T. Piazza, “Service quality benchmarking via a novel approach based on fuzzy ELECTRE III and IPA: An empirical case involving the Italian public healthcare context,” Health Care Manage. Sci., vol. 22, no. 1, pp. 106–120, Mar. 2019.
[12] M. Rajak and K. Shaw, “Evaluation and selection of mobile health (mHealth) applications using AHP and fuzzy TOPSIS,” Technol. Soc., vol. 59, Nov. 2019, Art. no. 101186.
[13] F. Acuña-Carvajal, L. Pinto-Tarazona, H. Lopez-Ospina, R. Barros-Castro, L. Quezada, and K. Palacio, “An integrated method to plan, structure and validate a business strategy using fuzzy DEMATEL and the balanced scorecard,” Expert Syst. Appl., vol. 122, pp. 351–368, May 2019.
[14] A. Certa, M. Enea, and T. Lupo, “ELECTRE III to dynamically support the decision maker about the periodic replacements configurations for a multi-component system,” Decis. Support Syst., vol. 55, no. 1, pp. 126–134, Apr. 2013.
[15] H. Akdag, T. Kalayc, S. Karagöz, H. Zülfikar, and D. Giz, “The evaluation of hospital service quality by fuzzy MCDM,” Appl. Soft Comput., vol. 23, pp. 239–248, Oct. 2014.

both from applicability and theoretical background of fuzzy DEMATEL and fuzzy ELECTRE III methods. For applicability, the fuzzy DEMATEL method is more applicable to the
[16] K. Ahmadi and M. Ebrahimi, “A novel algorithm based on information diffusion and fuzzy MADM methods for analysis of damages caused by diabetes crisis,” *Appl. Soft Comput.*, vol. 76, pp. 205–220, Mar. 2019.

[17] M. Yucsesan and M. Gul, “Hospital service quality evaluation: An integrated model based on pythagorean fuzzy AHP and fuzzy TOPSIS,” *Soft Comput.*, vol. 24, no. 5, pp. 3237–3255, Mar. 2020.

[18] H. Liao, X. Mi, Q. Yu, and L. Luo, “Hospital performance evaluation by a hesitant fuzzy linguistic best worst method with inconsistency repairing.” *J. Cleaner Prod.*, vol. 232, pp. 657–671, Sep. 2019.

[19] M. Gul, “Emergency department ergonomic design evaluation: A case study using fuzzy DEMATEL-focused two-stage methodology,” *Health Policy Technol.*, vol. 8, no. 4, pp. 365–376, Dec. 2019.

[20] Z. Wang, J. Ren, M. E. Goodsite, and G. Xu, “Waste-to-energy, municipal solid waste treatment, and best available technology: Comprehensive evaluation by an interval-valued fuzzy multi-criteria decision making method,” *J. Cleaner Prod.*, vol. 172, pp. 887–899, Jan. 2018.

[21] H. Li, J. Li, Z. Zhang, X. Cao, J. Zhu, and W. Chen, “Establishing an interval-valued fuzzy decision-making method for sustainable selection of healthcare waste treatment technologies in the emerging economies,” *J. Mater. Cycles Waste Manage.*, vol. 22, no. 2, pp. 501–514, Mar. 2020.

[22] C. Virgil Negoita, “Fuzzy sets,” *Fuzzy Sets Syst.*, vol. 133, no. 2, p. 275, Jan. 2003.

[23] A. A. Khan, M. Shameem, R. R. Kumar, S. Hussain, and X. Yan, “Fuzzy AHP based prioritization and taxonomy of software process improvement success factors in global software development,” *Appl. Soft Comput.*, vol. 83, Oct. 2019, Art. no. 105648.

[24] D. Dalalah, M. Hayajneh, and F. Batieha, “A fuzzy multi-criteria decision making model for supplier selection,” *Expert Syst. Appl.*, vol. 38, no. 7, pp. 8384–8391, Jul. 2011.

[25] S. S. Hashemi, S. H. R. Hajiagha, E. K. Zavadskas, and H. A. Mahdiraji, “Multicriteria group decision making with ELECTRE III method based on interval-valued intuitionistic fuzzy information,” *Appl. Math. Model.*, vol. 40, no. 2, pp. 1554–1564, Jan. 2016.

**HAO LI** received the M.Sc. degree in management from Shanghai University in 2017. He is currently pursuing the Ph.D. degree with the School of Management and Economics, Beijing Institute of Technology, China. He received the Chinese Government Scholarship to do his research in services and operations management at the University of Zürich from 2019 to 2020. His research focuses on operation management of community health centers, health policy assessment, and healthcare intervention mechanism. In 2019, he presented his research article at the 2019 INFORMS Healthcare Conference at Massachusetts Institute of Technology, USA.

**JINLIN LI** is currently Professor of management science and engineering with the School of Management and Economics, Beijing Institute of Technology, China, where he is also the Chairman of the Center of System Risk Management. He is also Chairman of the Business Management Committee of the Chinese Academy of Management Sciences. His research focuses on healthcare operations management, revenue management theory and application, project risk management, and decision making methods. He serves on the editorial board of several Chinese journals.

**HELMUT DIETL** is currently a Professor of services and operations management with the Department of Business Administration, University of Zürich, Switzerland, where he is also the Chairman of the Board of Directors of the Center for Research in Sports Administration. His research focuses on sports economics, sports management, services and operations management, and the economics of organization. He is an Associate Editor of the *Journal of Sports Economics*. **© 2020 IEEE**