TOPSIS Framework for Community Home-Based Elderly Care Services Quality Evaluation for Disabled Elderly People With Probabilistic Simplified Neutrosophic Sets

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ABSTRACT

Currently, compared to the situation of aging population and the demand for elderly care services from the people, the overall quality and level of development of elderly care services in China are not high. The community home-based elderly care services quality evaluation for disabled elderly people could be looked as the multiple-attribute decision-making (MADM). The TOPSIS technique is a useful technique to put up with the MADM. The probabilistic simplified Neutrosophic set (PSNSs) is easy to express uncertain information during community home-based elderly care services quality evaluation for disabled elderly people. In this study, CRITIC technique is put forward to obtain the attribute weights and the probabilistic simplified neutrosophic number TOPSIS (PSNN-TOPSIS) technique is put forward for MADM. Finally, numerical example for community home-based elderly care services quality evaluation for disabled elderly people is employed to verify the PSNN-TOPSIS technique with comparative analysis.

KEYWORDS

Multiple-Attributes Decision-Making (MADM), Probabilistic Simplified Neutrosophic Sets (PSNSs), TOPSIS Technique, Elderly Care Services Quality Evaluation

INTRODUCTION

In the context of global population aging, the current aging of China's population has become the norm of population development, and the speed of population aging is significantly accelerating, with the degree continuing to deepen (D. Chen, 2019; Huang et al., 2019; J. L. Liu, 2019; D. Wang et al., 2018). With the acceleration of population aging, the scale of disabled elderly population in China continues to increase (Gu, Li et al.2020; Gu, Yuan et al., 2020; Luan et al., 2021). According to the results of the fourth survey on the living conditions of elderly people in urban and rural areas of China, the number of elderly people in a disabled or semi-disabled state in the country is as high as 40.63 million, accounting for 18.3% of the total elderly population (Bouzid et al., 2022; Cheng et al., 2022; Yang, Wang, & Dai, 2021; Yang, Wang, Di et al., 2021). Disabled elderly people, due to impaired daily activity abilities, are prone to emotional depression and other types of depression, leading to the development of depressive emotions and a decrease in life satisfaction (Marmamula et al., 2022; Sakboonyarat et al., 2022; Shao et al., 2022). Therefore, it is particularly important to

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pay attention to the mental health issues of disabled elderly people. The notice on comprehensively strengthening elderly health services issued in 2021 pointed out that promoting healthy aging, attaching importance to the mental health of the elderly, and paying attention to and promoting the mental health work of the elderly are important elements in implementing the national strategy of actively responding to population aging (He et al., 2023; Jiang & Liu, 2023; Q. X. Wang et al., 2022; Zhang et al., 2022). At present, research on the mental health of disabled elderly people is mostly focused on individual characteristics and family structure, with less attention paid to the impact of community home-based elderly care services on the mental health of disabled elderly people (Kwok et al., 2023; Marmamula et al., 2023; Meng et al., 2023). Since 2016, China has established a national-level pilot program for the integration of medical and elderly care, promoting the active integration of medical and health services with elderly care services and exploring the continuous extension of medical and elderly care integration services to communities and families. Community home-based elderly care services may have a significant impact on the mental health of disabled elderly people. In summary, studying the impact of community home-based elderly care services on the mental health of disabled elderly people is beneficial for promoting the active integration of socialized elderly care services and elderly health, and it is of great significance for preventing the risk of depression and promoting mental health. Firstly, steps are taken to increase the publicity efforts of community home-based elderly care services and strengthen the reasonable guidance for disabled elderly people to use community home-based elderly care services (Qin et al., 2023; Ren et al., 2023; Schönemann-Gieck et al., 2023). The advantage of popularizing community home-based elderly care services among the disabled elderly population is to weaken the social elderly care cognitive bias of the disabled elderly population. Secondly, steps are taken to develop and improve community-based home-based elderly care services that meet the actual basic needs of the elderly. Continuously summarizing the common laws of the actual elderly care needs of disabled elderly people in elderly care practice, providing community home-based elderly care services that meet the universal needs of disabled elderly people, and meeting their service needs in the actual elderly care process are also important steps. Thirdly, steps are taken to enhance the diversified supply quality of community home-based elderly care services (Gao & Tang, 2024; Zhou et al., 2023). On the basis of providing common services, it is important to improve the precision and personalization of the supply of community home-based elderly care services (Guo et al., 2024; Qin et al., 2024).

Multiple-attribute decision-making (MADM) is a decision-making process that prioritizes alternative solutions in alignment with existing decision information through specific methodologies (Garg, Ali et al., 2023; Garg, Ullah et al., 2023; Pamucar, Duran-Romero et al., 2023; Pamucar, Gokasar et al., 2023; Pamucar, Torkayesh et al., 2023). Its theories and models are extensively utilized across various domains, such as venture-capital decision-making, project evaluation, and industrial sector development evaluation (Akram et al., 2021a; Akram, 2021b; Ye, Sun, Bao et al., 2023; Ye, Sun, Chu, Zhan, Bao et al., 2023; Ye, Sun, Chu, Zhan, & Cai, 2023). In recent decades, MADM has seen broad applications in various fields, including engineering, economics, technology, and the military (Garg, Ullah et al., 2023; B. Li et al., 2018; L. Li et al., 2018; Li et al., 2020; Sang, 2018; Sirbiladze et al., 2023; Wan & Chen, 2020; Xu et al., 2018). The evaluation of community home-based elderly care services quality for disabled elderly individuals constitutes an MADM. Recently, the technique for order preference by similarity to ideal solution (TOPSIS) model (C. T. Chen, 2000; Lai et al., 1994; Polireddi & Sekhar, 2023; Sadeghi ett al., 2023; Sun et al., 2023) has been employed to enhance MADM. Probabilistic simplified neutrosophic sets (PSNSs) (Altun et al., 2020) are used as a technique to characterize uncertain information during the evaluation of community home-based elderly care services quality for disabled elderly individuals. In this study, the criteria importance through intercriteria correlation (CRITIC) technique (Diakoulaki et al., 1995) is proposed to obtain attribute weights under PSNSs, and the probabilistic simplified neutrosophic number (PSNN)-TOPSIS model is introduced to address MADM with PSNSs. Finally, a numerical study on the evaluation of community home-based elderly care services quality for disabled elderly individuals is conducted to validate the PSNN-TOPSIS model. The primary research motivations of this study are as follows: (1) the extension of the TOPSIS model to PSNSs; (2) the application of the CRITIC technique to obtain attribute weights; (3) the introduction of the PSNN-TOPSIS model to solve MADM with PSNSs; and (4) a numerical study to validate the PSNN-TOPSIS technique with comparative analysis.

The overall structure is put forward: The PSNSs are conducted in section 2. The PSNN-TOPSIS model is put forward with MADM in section 3. A numerical example of community home-based elderly care services quality evaluation for disabled elderly people is employed to prove the PSNN-TOPSIS technique in section 4, with comparative analysis. Section 5 ends with a conclusion.

PRELIMINARIES

H. Wang et al. (2010) put forward the SVNSs.

Definition 1 (H. Wang et al., 2010)

The SVNSs is put forward:

$$FF = \{(\theta, FT(\theta), FI(\theta), FF(\theta)) | \theta \in \Theta\}, \tag{1}$$

where $FT(\theta), FI(\theta), FF(\theta)$ is membership, indeterminacy-membership, and falsity-membership, $FT(\theta), FI(\theta), FF(\theta) \in [0,1]$, and $0 \leq FT(\theta) + FI(\theta) + FF(\theta) \leq 3$.

Altun et al. (2020) put forward the PSNSs.

Definition 2 (Altun et al., 2020)

The PSNSs are put forward:

$$PF = \left\{ \begin{pmatrix} \theta, FT(\theta)(PFT(\theta)), \\ FI(\theta)(PFI(\theta)), \\ FF(\theta)(PFF(\theta)) \end{pmatrix} | \theta \in \Theta \right\}, \tag{2}$$

where $FT(\theta), FI(\theta), FF(\theta)$ is truth-membership, indeterminacy-membership, and falsity-membership, $FT(\theta), FI(\theta), FF(\theta) \in [0,1], 0 \leq FT(\theta) + FI(\theta) + FF(\theta) \leq 3, 0 \leq PFT(\theta), PFI(\theta), PFF(\theta) \leq 1$, and $PFT(\theta), PFI(\theta), PFF(\theta)$ is the possibility values of $FT(\theta), FI(\theta), FF(\theta)$. The PSNN is listed as $PF = (FT(PFT), FI(PFI), FF(PFF))$.

Definition 3 (Altun et al., 2020)

Let $PF_1 = \left(FT_1(PFT_1), FI_1(PFI_1), FF_1(PFF_1)\right), PF_2 = \left(FT_2(PFT_2), FI_2(PFI_2), FF_2(PFF_2)\right)$, and the basic operations are put forward:

(1) $PF_1 \oplus PF_2 = \begin{pmatrix} FT_1 + FT_2 - FT_1 \cdot FT_2\left(2!\frac{PFT_1 \cdot PFT_2}{PFT_1 + PFT_2}\right), \\ FI_1 \cdot FI_2\left(2!\frac{PFI_1 \cdot PFI_2}{PFI_1 + PFI_2}\right), FF_1 \cdot FF_2\left(2!\frac{PFF_1 \cdot PFF_2}{PFF_1 + PFF_2}\right) \end{pmatrix}$;

(2) $PF_1 \otimes PF_2 = \begin{pmatrix} FT_1 \cdot FT_2\left(2!\frac{PFT_1 \cdot PFT_2}{PFT_1 + PFT_2}\right), \\ FI_1 + FI_2 - FI_1 \cdot FI_2\left(2!\frac{PFI_1 \cdot PFI_2}{PFI_1 + PFI_2}\right), FF_1 + FF_2 - FF_1 \cdot FF_2\left(2!\frac{PFF_1 \cdot PFF_2}{PFF_1 + PFF_2}\right) \end{pmatrix}$;

(3) $\lambda PF = (1 - (1 - FT)^{\lambda}(PFT), (FI)^{\lambda}(PFI), (FF)^{\lambda}(PFF)), \lambda > 0$;

(4) $(PF)^{\lambda} = ((FT)^{\lambda}(PFT), 1 - (1 - FI)^{\lambda}(PFI), 1 - (1 - FF)^{\lambda}(PFF)), \lambda > 0.$

Definition 4 (Altun et al., 2020)

Let $PF_1 = \left(FT_1(PFT_1), FI_1(PFI_1), FF_1(PFF_1)\right)$, $PF_2 = \left(FT_2(PFT_2), FI_2(PFI_2), FF_2(PFF_2)\right)$, and the PSNN logarithmic distance (PSNNLD) and PSNN Hamming distance (PSNNHD) between PF_1 and PF_2 is constructed:

$$PSNNLD(PF_1, PF_2) = \frac{1}{3}, \begin{pmatrix} (FT_1 \times PFT_1)\log \frac{(FT_1 \times PFT_1)}{\frac{(FT_1 \times PFT_1) + (FT_2 \times PFT_2)}{2}} \\ +(FT_2 \times PFT_2)\log \frac{(FT_2 \times PFT_2)}{\frac{(FT_1 \times PFT_1) + (FT_2 \times PFT_2)}{2}} \\ +(FI_1 \times PFI_1)\log \frac{(FI_1 \times PFI_1)}{\frac{(FI_1 \times PFI_1) + (FI_2 \times PFI_2)}{2}} \\ +(FI_2 \times PFI_2)\log \frac{(FI_2 \times PFI_2)}{\frac{(FI_1 \times PFI_1) + (FI_2 \times PFI_2)}{2}} \\ +(FF_1 \times PFF_1)\log \frac{(FF_1 \times PFF_1)}{\frac{(FF_1 \times PFF_1) + (FF_2 \times PFF_2)}{2}} \\ +(FF_2 \times PFF_2)\log \frac{2(FF_2 \times PFF_2)}{\frac{(FF_1 \times PFF_1) + (FF_2 \times PFF_2)}{2}} \end{pmatrix} \tag{3a}$$

$$PSNNHD(PF_1, PF_2) = \frac{1}{3}\begin{pmatrix} |FT_1 \cdot PFT_1 - FT_2 \cdot PFT_2| \\ +|FI_1 \cdot PFI_1 - FI_2 \cdot PFI_2| \\ +|FF_1 \cdot PFF_1 - FF_2 \cdot PFF_2| \end{pmatrix} \tag{3b}$$

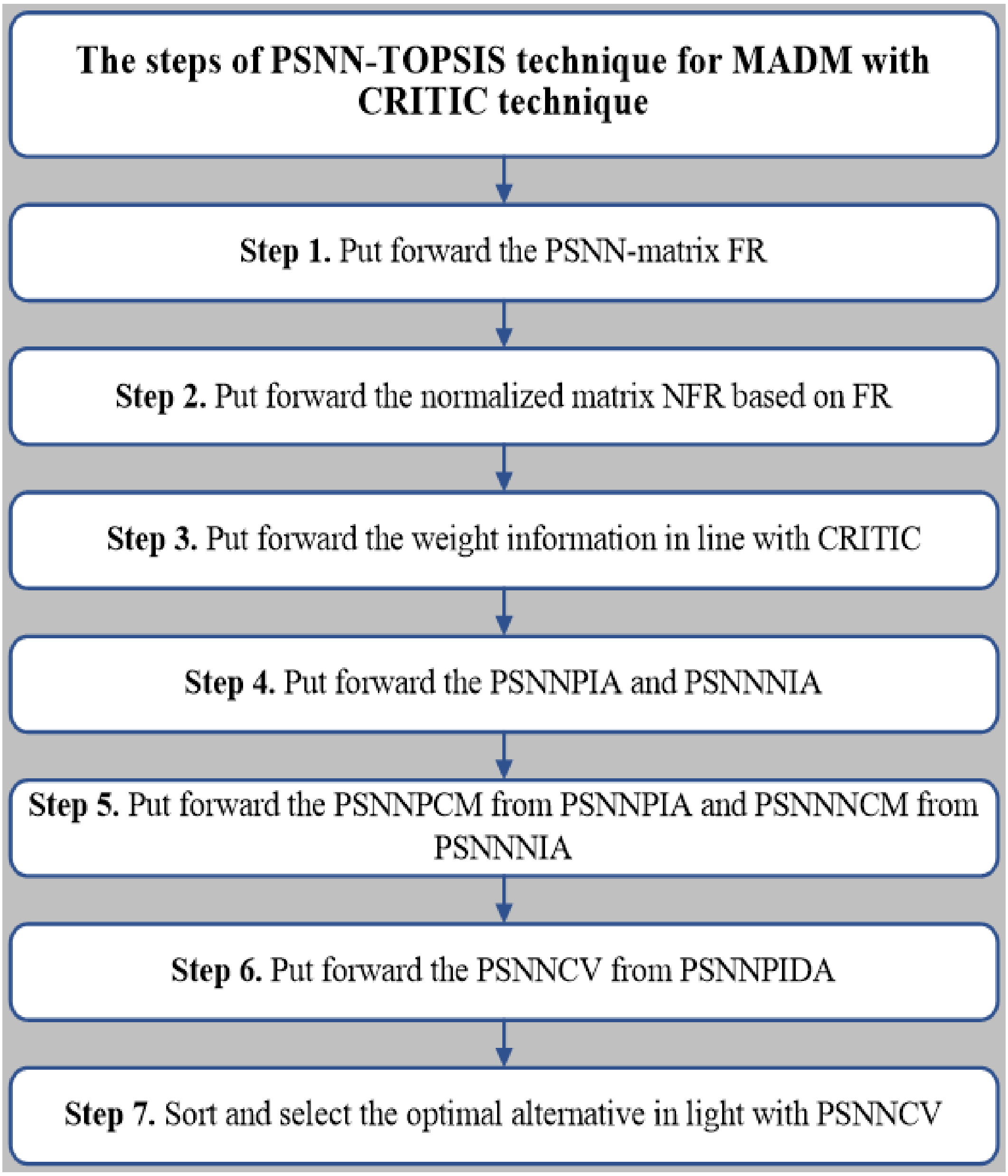
PSNN-TOPSIS TECHNIQUE FOR MADM PROBLEM WITH CRITIC

The PSNN-TOPSIS is put forward for MADM under PSNSs with completely unknown weight. Let $FA = \{FA_1, FA_2, \cdots, FA_m\}$ be alternatives, and $FG = \{FG_1, FG_2, \cdots, FG_n\}$ be attributes with weight cw, where $fw_j \in [0,1]$, $\sum_{j=1}^{n} fw_j = 1$. Suppose that the decision information is depicted with PSNNs

$$FR = \left(FR_{ij}\right)_{m \times n} = \begin{pmatrix} FT_{ij}\left(PFT_{ij}\right), \\ FI_{ij}\left(PFI_{ij}\right), FF_{ij}\left(PFF_{ij}\right) \end{pmatrix}_{m \times n}.$$

Then, PSNN-TOPSIS technique is put forward as MADM with CRITIC technique (see Figure 1).

Figure 1. PSNN-TOPSIS framework for MADM with CRITIC technique



Step 1: Put forward the PSNN-matrix

$$FR = \left(FR_{ij}\right)_{m\times n} = \begin{pmatrix} FT_{ij}\left(PFT_{ij}\right), \\ FI_{ij}\left(PFI_{ij}\right), FF_{ij}\left(PFF_{ij}\right) \end{pmatrix}_{m\times n}.$$

Step 2: Put forward the normalized matrix $NFR = \left[NFR_{ij}\right]_{m\times n}$ based on $FR = \left(FR_{ij}\right)_{m\times n}$.

$$NFR_{ij} = \left(FT_{ij}^{N}\left(PFT_{ij}^{N}\right), FI_{ij}^{N}\left(PFI_{ij}^{N}\right), FF_{ij}^{N}\left(PFF_{ij}^{N}\right)\right) = \begin{cases} \left(FT_{ij}\left(PFT_{ij}\right), FI_{ij}\left(PFI_{ij}\right), FF_{ij}\left(PFF_{ij}\right)\right), FG_{j} \text{ is benefit attributes} \\ \left(FF_{ij}\left(PFF_{ij}\right), 1 - FI_{ij}\left(1 - PFI_{ij}\right), FT_{ij}\left(PFT_{ij}\right)\right), FG_{j} \text{ is cost attributes} \end{cases}. \quad (4)$$

Step 3: Put forward the weight information in line with CRITIC.

The CRITIC technique (Diakoulaki, Mavrotas, & Papayannakis, 1995) is utilized to put forward the weight information. The compute steps of CRITIC technique are then designed (C. Liu, 2023).

1. Depending on PSNN-matrix $NFR = \left[NFR_{ij}\right]_{m\times n}$, the PSNN correlation coefficient (PSNNCC) for attributes is put forward.

$$PSNNCC_{jt} = \frac{\sum_{i=1}^{m}\left(SV\left(NFR_{ij}\right) - SV\left(NFR_{j}\right)\right)\left(SV\left(NFR_{it}\right) - SV\left(NFR_{t}\right)\right)}{\sqrt{\sum_{i=1}^{m}\left(SV\left(NFR_{ij}\right) - SV\left(NFR_{j}\right)\right)^{2}}\sqrt{\sum_{i=1}^{m}\left(SV\left(NFR_{it}\right) - SV\left(NFR_{t}\right)\right)^{2}}}, j,t = 1,2,\ldots,n, \quad (5)$$

where

$$SV\left(NFR_{j}\right) = \tfrac{1}{m}\sum_{i=1}^{m} SV\left(NFR_{ij}\right) = \frac{FT_{ij}^{N}\cdot PFT_{ij}^{N} + 2FI_{ij}^{N}\cdot PFI_{ij}^{N} + FF_{ij}^{N}\cdot PFF_{ij}^{N}}{4m}.$$

and

$$SV\left(NFR_{it}\right) = \tfrac{1}{m}\sum_{i=1}^{m} SV\left(NFR_{it}\right) = \frac{FT_{it}^{N}\cdot PFT_{it}^{N} + 2FI_{it}^{N}\cdot PFI_{it}^{N} + FF_{it}^{N}\cdot PFF_{it}^{N}}{4m}.$$

2. Put forward the PSNN standard deviation (PSNNSD).

$$PSNNSD_{j} = \sqrt{\frac{1}{m-1}\sum_{i=1}^{m}\left(SV\left(NFR_{ij}\right) - SV\left(NFR_{j}\right)\right)^{2}}, \quad (6)$$

where $SV\left(NFR_{j}\right) = \tfrac{1}{m}\sum_{i=1}^{m} SV\left(NFR_{ij}\right)$.

3. Put forward the weight information.

$$fw_{j} = \frac{PSNNSD_{j}\sum_{t=1}^{n}\left(1 - PSNNCC_{jt}\right)}{\sum_{j=1}^{n}\left(PSNNSD_{j}\sum_{t=1}^{n}\left(1 - PSNNCC_{jt}\right)\right)}, \quad (7)$$

where $fw_{j} \in [0,1]$ and $\sum_{j=1}^{n} fw_{j} = 1$.

Step 4: Put forward the PSNN positive ideal alternative (PSNNPIA) and PSNN negative ideal alternative (PSNNNIA) (C. Liu, 2023):

$$PSNNPIA = \left\{PSNNPIA_{j}\right\}, j = 1,2,\ldots,n. \quad (8)$$

$$PSNNNIA = \left\{PSNNNIA_{j}\right\}, j = 1,2,\ldots,n. \quad (9)$$

$$PSNNPIA_j = \begin{pmatrix} FT_j^{+N}\left(PFT_j^{+N}\right), \\ FI_j^{+N}\left(PFI_j^{+N}\right), FF_j^{+N}\left(PFF_j^{+N}\right) \end{pmatrix}, j = 1, 2, \ldots, n. \tag{10}$$

$$PSNNNIA_j = \begin{pmatrix} FT_j^{-N}\left(PFT_j^{-N}\right), \\ FI_j^{-N}\left(PFI_j^{-N}\right), FF_j^{-N}\left(PFF_j^{-N}\right) \end{pmatrix}, j = 1, 2, \ldots, n. \tag{11}$$

$$\begin{aligned} &SV\left(FT_j^{+N}\left(PFT_j^{+N}\right), FI_j^{+N}\left(PFI_j^{+N}\right), FF_j^{+N}\left(PFF_j^{+N}\right)\right) = \\ &\max_i SV\left(FT_{ij}^N\left(PFT_{ij}^N\right), FI_{ij}^N\left(PFI_{ij}^N\right), FF_{ij}^N\left(PFF_{ij}^N\right)\right), \end{aligned} \tag{12}$$

$$\begin{aligned} &SV\left(FT_j^{-N}\left(PFT_j^{-N}\right), FI_j^{-N}\left(PFI_j^{-N}\right), FF_j^{-N}\left(PFF_j^{-N}\right)\right) = \\ &\min_i SV\left(FT_{ij}^N\left(PFT_{ij}^N\right), FI_{ij}^N\left(PFI_{ij}^N\right), FF_{ij}^N\left(PFF_{ij}^N\right)\right), \end{aligned} \tag{13}$$

where

$$\begin{aligned} &SV\left(FT_j^{+N}\left(PFT_j^{+N}\right), FI_j^{+N}\left(PFI_j^{+N}\right), FF_j^{+N}\left(PFF_j^{+N}\right)\right) = \\ &\frac{FT_j^{+N} \cdot PFT_j^{+N} + 2FI_j^{+N} \cdot PFI_j^{+N} + FF_j^{+N} \cdot PFF_j^{+N}}{4}, \end{aligned} \tag{14}$$

$$\begin{aligned} &SV\left(FT_j^{-N}\left(PFT_j^{-N}\right), FI_j^{-N}\left(PFI_j^{-N}\right), FF_j^{-N}\left(PFF_j^{-N}\right)\right) = \\ &\frac{FT_j^{-N} \cdot PFT_j^{-N} + 2FI_j^{-N} \cdot PFI_j^{-N} + FF_j^{-N} \cdot PFF_j^{-N}}{4}, \end{aligned} \tag{15}$$

$$SV\left(FT_{ij}^N\left(PFT_{ij}^N\right), FI_{ij}^N\left(PFI_{ij}^N\right), FF_{ij}^N\left(PFF_{ij}^N\right)\right) = \frac{FT_{ij}^N \cdot PFT_{ij}^N + 2FI_{ij}^N \cdot PFI_{ij}^N + FF_{ij}^N \cdot PFF_{ij}^N}{4}. \tag{16}$$

Step 5: Put forward the PSNN positive combined distance (PSNNPCM) from the PSNNPIA and PSNN negative combined distance (PSNNNCM) from the PSNNNIA:

$$\begin{aligned} &PSNNPCM(FA_i, PSNNPIA) = \\ &\frac{1}{2}\sum_{j=1}^{n} fw_j\left(PSNNLD\left(FA_i, PSNNPIA_j\right) + PSNNHD\left(FA_i, PSNNPIA_j\right)\right) \end{aligned} \tag{17}$$

$$\begin{aligned} &PSNNNCM(FA_i, PSNNNIA) = \\ &\frac{1}{2}\sum_{j=1}^{n} fw_j\left(PSNNLD\left(FA_i, PSNNNIA_j\right) + PSNNHD\left(FA_i, PSNNNIA_j\right)\right) \end{aligned} \tag{18}$$

Step 6: Put forward the PSNN close values (PSNNCV) from the PSNNPIA.

$$\begin{aligned} &PSNNCV(FA_i, PSNNPIA) \\ &= \frac{PSNNPCM(FA_i, PSNNNIA)}{\begin{pmatrix} PSNNPCM(FA_i, PSNNNIA) \\ +PSNNPCM(FA_i, PSNNPIA) \end{pmatrix}} \end{aligned} \tag{19}$$

Step 7: In line with the $PSNNCV(FA_i, PSNNPIA)$, the larger $PSNNCV(FA_i, PSNNPIA)$ is a better alternative.

NUMERICAL STUDY AND COMPARATIVE ANALYSIS

Numerical Study

The guidance issued during the 20th National Congress of the Communist Party of China emphasizes the national imperative of proactively addressing the challenges of an aging population by enhancing the elderly care sector, refining services for solitary seniors, and ensuring that fundamental elderly care is accessible to all. This directive serves as a crucial benchmark for advancing the quality of elderly care services across China. Elderly care is deeply intertwined with the public's welfare and constitutes a crucial sector impacting countless households. The development of an integrated elderly care framework that amalgamates home-based, community, and medical services is essential for fostering high-quality elderly care and is a foundational initiative in embracing a people-oriented development approach in the face of demographic aging. Demographic aging represents a significant trend in contemporary societal evolution and remains a persistent national reality for China in the foreseeable future. The pace at which China's elderly population is growing is quickening, with the number of seniors increasing steadily. By the end of 2023, China had 29.697 million people aged 60 and above, making up 21.1% of the total populace. Of these, 21.676 million were 65 or older, accounting for 15.4% of the population. The escalating aging demographic poses serious challenges, amplifying the burdens of social and familial elderly care, increasing the strain on social security funds, and exacerbating the mismatch between the demand for and supply of elderly care services—key issues that hinder the high-quality growth of the economy and society. Since the 18th National Congress of the Communist Party of China, the elderly care sector has seen rapid advancements, with significant strides made in strategic planning, infrastructure development, functional enhancement, and service delivery. The elderly care system, which integrates community-based services with healthcare, is swiftly taking shape. By the end of 2023, through the execution of the Home and Community Basic Elderly Care Service Improvement Action Project, 235,000 family care beds had been established, providing in-home care for 418,000 elderly individuals and addressing the needs of 1.4828 million households requiring elderly care. As of the third quarter of 2023, there were 400,000 elderly care facilities nationwide, with 8.206 million beds available. Among these, 41,000 are dedicated elderly care facilities, with 5.121 million beds; the remaining 359,000 are community elderly care services, with 3.085 million beds. Community-based elderly care services now substantially cover urban areas and over half of rural communities, with innovative models, like family care beds, senior dining programs, and time banks, increasingly emerging. Community home-based elderly care services necessitate the collaboration of multiple sectors, including civil affairs, health, medical insurance, finance, and social security, and rely on the concerted efforts of local communities, medical institutions, and health services. This constitutes a complex system requiring multi-party involvement and comprehensive policy implementation. The complexity of coordinating these services at the grassroots level often complicates the creation of effective synergy. The integration and optimization of elderly care resources have yet to be fully realized, and tracking, monitoring, supervising, and evaluating the effectiveness of elderly care policies poses significant challenges. Additionally, certain preferential policies involving land allocation, financial aid, and medical insurance settlements are spread across multiple departments, complicating the implementation process. The community home-based elderly care services quality evaluation for disabled elderly people is MADM. In this work, the PSNN-TOPSIS is put forward as a community home-based elderly care services quality evaluation for disabled elderly people. Five community home-based elderly care services centers, $FA_i(i = 1,2,3,4,5)$, are assessed with four attributes (Table 1).

Table 1. Four attributes for community home-based elderly care services quality evaluation

Attribute name	Attribute Description	Measurement Method Description
Accessibility-FG_1	Measures how easily services can be accessed, including convenience of location, suitability of service hours, and affordability.	Evaluated by assessing the density of service points, service hours, and the ratio of service fees to average regional income.
Quality of Service-FG_2	Focuses on the professionalism, safety, and person-centeredness of the service, as well as the consistency and reliability of the services provided.	Measured through satisfaction surveys of service recipients, compliance with standard operating procedures, and improvements in service outcomes.
Staff Qualification and Training-FG_3	Assesses the professional qualifications, level of training, and continuing education of the caregiving staff.	Includes the certifications held by the staff, the proportion participating in regular training, and the results of skills assessments of the staff.
Continuity and Integration-FG_4	Continuity refers to the long-term and stability of service provision; integration refers to the coordination and cooperation between different service components.	Evaluated by assessing the duration of consistent services received by the elderly, the frequency of service interruptions, and the effectiveness of coordination mechanisms among various services.

Then, the PSNN-TOPSIS is put forward as a community home-based elderly care services quality evaluation for disabled elderly people with PSNSs.

Step 1: Put forward the PSNS-matrix. The evaluation result is conducted in Table 2.

Table 2. The PSNN information

Alternative	FG_1	FG_2
FA_1	{0.32(0.4), 0.45(0.3), 0.23(0.3)}	{0.51(0.5), 0.33(0.2), 0.16(0.3)}
FA_2	{0.41(0.3), 0.29(0.4), 0.30(0.3)}	{0.38(0.4), 0.22(0.3), 0.40(0.3)}
FA_3	{0.48(0.4), 0.35(0.3), 0.17(0.3)}	{0.29(0.3), 0.42(0.4), 0.29(0.3)}
FA_4	{0.37(0.3), 0.28(0.5), 0.35(0.2)}	{0.42(0.4), 0.31(0.3), 0.27(0.3)}
FA_5	{0.30(0.4), 0.45(0.3), 0.25(0.3)}	{0.34(0.3), 0.41(0.4), 0.25(0.3)}
Alternative	FG_3	FG_4
FA_1	{0.27(0.3), 0.54(0.4), 0.19(0.3)}	{0.42(0.2), 0.37(0.5), 0.21(0.3)}
FA_2	{0.56(0.5), 0.24(0.2), 0.20(0.3)}	{0.33(0.3), 0.51(0.4), 0.16(0.3)}
FA_3	{0.39(0.2), 0.47(0.5), 0.14(0.3)}	{0.36(0.3), 0.53(0.4), 0.11(0.3)}
FA_4	{0.46(0.5), 0.21(0.2), 0.33(0.3)}	{0.39(0.3), 0.44(0.4), 0.17(0.3)}
FA_5	{0.49(0.4), 0.28(0.3), 0.23(0.3)}	{0.40(0.3), 0.46(0.5), 0.14(0.2)}

Step 2: Put forward the normalized matrix $NFR = [NFR_{ij}]_{5\times4}$ (see Table 3).

Table 3. The normalized PSNN-matrix through PSNNs

Alternative	FG_1	FG_2
FA_1	{0.32(0.4), 0.45(0.3), 0.23(0.3)}	{0.51(0.5), 0.33(0.2), 0.16(0.3)}
FA_2	{0.41(0.3), 0.29(0.4), 0.30(0.3)}	{0.38(0.4), 0.22(0.3), 0.40(0.3)}
FA_3	{0.48(0.4), 0.35(0.3), 0.17(0.3)}	{0.29(0.3), 0.42(0.4), 0.29(0.3)}
FA_4	{0.37(0.3), 0.28(0.5), 0.35(0.2)}	{0.42(0.4), 0.31(0.3), 0.27(0.3)}
FA_5	{0.30(0.4), 0.45(0.3), 0.25(0.3)}	{0.34(0.3), 0.41(0.4), 0.25(0.3)}
Alternative	FG_3	FG_4
FA_1	{0.27(0.3), 0.54(0.4), 0.19(0.3)}	{0.42(0.2), 0.37(0.5), 0.21(0.3)}
FA_2	{0.56(0.5), 0.24(0.2), 0.20(0.3)}	{0.33(0.3), 0.51(0.4), 0.16(0.3)}
FA_3	{0.39(0.2), 0.47(0.5), 0.14(0.3)}	{0.36(0.3), 0.53(0.4), 0.11(0.3)}
FA_4	{0.46(0.5), 0.21(0.2), 0.33(0.3)}	{0.39(0.3), 0.44(0.4), 0.17(0.3)}
FA_5	{0.49(0.4), 0.28(0.3), 0.23(0.3)}	{0.40(0.3), 0.46(0.5), 0.14(0.2)}

Step 3: Put forward the weight with CRITIC (Table 4).

Table 4. Weight values

	FG_1	FG_2	FG_3	FG_4
Weight	0.1982	0.3559	0.2629	0.1930

Step 4: Obtain PSNNPIA and PSNNNIA (Table 5).

Table 5. The PSNNPIA and PSNNNIA

	FG_1	FG_2
PSNNPIA	{0.48(0.4), 0.35(0.3), 0.17(0.3)}	{0.51(0.5), 0.33(0.2), 0.16(0.3)}
PSNNNIA	{0.30(0.4), 0.45(0.3), 0.25(0.3)}	{0.29(0.3), 0.42(0.4), 0.29(0.3)}
	FG_3	FG_4
PSNNPIA	{0.56(0.5), 0.24(0.2), 0.20(0.3)}	{0.42(0.2), 0.37(0.5), 0.21(0.3)}
PSNNNIA	{0.27(0.3), 0.54(0.4), 0.19(0.3)}	{0.33(0.3), 0.51(0.4), 0.16(0.3)}

Step 5: Put forward the PSNNPCM from the PSNNPIA and PSNNNCM from the PSNNNIA (see Table 6).

Table 6. The $PSNNPCM(FA_i, PSNNPIA)$ and $PSNNPCM(FA_i, PSNNNIA)$

	$PSNNPCM(FA_i, PSNNPIA)$	$PSNNPCM(FA_i, PSNNNIA)$
FA_1	0.5018	0.5580
FA_2	0.6381	0.6440
FA_3	0.8858	0.6430
FA_4	0.8865	0.6162
FA_5	0.5312	0.6219

Step 6: Put forward the PSNNCV from the PSNNPIA (see Table 7).

Table 7. The PSNNCV from the PSNNPIA

	PSNNCV
FA_1	0.5265
FA_2	0.5023
FA_3	0.4206
FA_4	0.4101
FA_5	0.5393

Step 7: From the PSNNCV, the order is $FA_5 > FA_1 > FA_2 > FA_3 > FA_4$, and FA_5 is the optimal community home-based elderly care services center (see Table 8).

Table 8. The order

	Order
FA_1	2
FA_2	3
FA_3	4
FA_4	5
FA_5	1

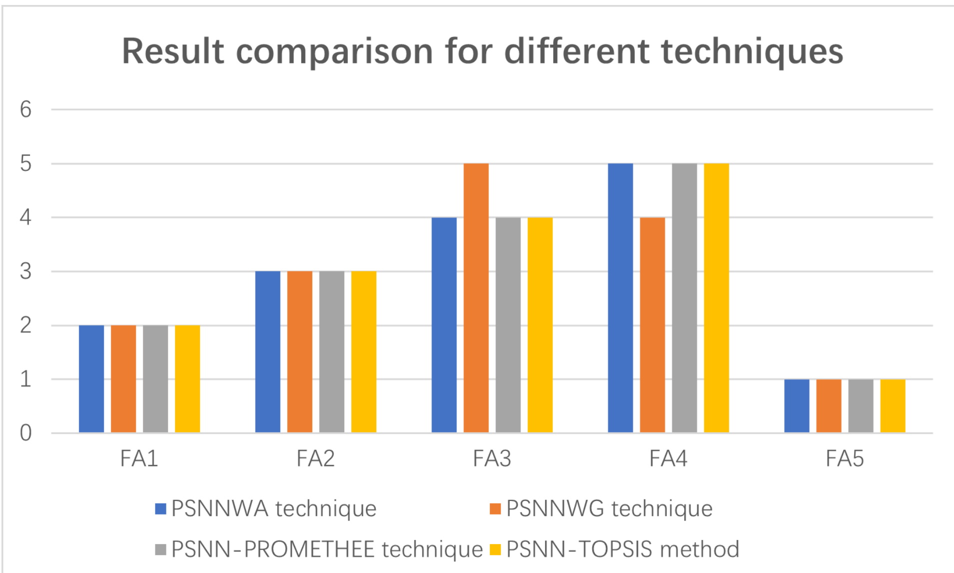
Comparative Analysis

The PSNN-TOPSIS is compared with the PSNNWA and PSNNWG technique (Altun et al., 2020), as well as the probabilistic Simplified Neutrosophic number (PSNN)-preference ranking organization method for enrichment evaluation (PROMETHEE) technique (Altun et al., 2020). The results are constructed in Table 9 and Figure 2.

Table 9. Order for different techniques

Techniques	Order	The Optimal Choice
PSNNWA technique (Altun et al., 2020)	$FA_5 > FA_1 > FA_2 > FA_3 > FA_4$	FA_5
PSNNWG technique (Altun et al., 2020)	$FA_5 > FA_1 > FA_3 > FA_2 > FA_4$	FA_5
PSNN-PROMETHEE (Altun et al., 2020)	$FA_5 > FA_1 > FA_2 > FA_3 > FA_4$	FA_5
PSNN-TOPSIS method	$FA_5 > FA_1 > FA_2 > FA_3 > FA_4$	FA_5

Figure 2. Order for different techniques



Thus, from Table 9, it is obvious that order of these models is slightly different, but these models have the same best community home-based elderly care services center and worst community home-based elderly care services center. This verifies the PSNN-TOPSIS technique is reasonable and effective.

In contrast to these existing methods, the PSNN-TOPSIS method proposed in this paper has the following three advantages:

1. **Enhanced ability to handle uncertainty**: The PSNN-TOPSIS, which combines PNN and TOPSIS, can more effectively process and evaluate uncertain information. This combination not only captures the inherent uncertainties in the data but also uses similarity to an ideal solution for decision ranking, making the results more reliable and scientific.
2. **Balanced computational efficiency and accuracy**: PSNN-TOPSIS achieves a balance between computational efficiency and accuracy through optimized computation processes. This makes the method suitable both for situations requiring high decision accuracy and for scenarios where computational speed is critical.

3. **Wide-ranging applicability**: The design of the PSNN-TOPSIS method considers different types of data and diverse application scenarios, enabling it to perform well in broader areas and with more complex issues.

In summary, through comparative analysis, we can see that the PSNN-TOPSIS method proposed in this paper has clear advantages in several key areas, especially in handling uncertainties, balancing computational efficiency with accuracy, and in overall applicability. These strengths make PSNN-TOPSIS a promising new tool worth widespread application.

CONCLUSIONS

Community home-based elderly care services in our country involve various departments, such as civil affairs, finance, social security, and health. The frequent mutual buck passing among these departments often results in management gaps. It is recommended to establish a dedicated project for elderly care services and incorporate it into the performance evaluation system to effectively oversee inter-departmental cooperation. Additionally, comprehensive quality management and third-party evaluation institutions should be introduced. This would not only enhance the government's quality audit supervision but also strengthen the oversight and management of other investment entities, self-supervision of (street) communities, and the supervision and feedback from elderly individuals and their families regarding community home-based elderly care services. Third-party professional evaluation institutions can be introduced to conduct professional evaluations of the quality of these services, forming an operational mechanism of "supervision, evaluation, feedback, and adjustment" to effectively improve service quality. The quality evaluation of community home-based elderly care services for disabled elderly people can be considered through the MADM approach. In this study, the CRITIC technique is proposed to determine attribute weights under PSNSs, and the PSNN-TOPSIS model is introduced to address the MADM with PSNSs. Finally, a numerical study for the quality evaluation of community home-based elderly care services for disabled elderly people is presented to validate the PSNN-TOPSIS model. The primary research motivations of this study are constructed: (1) extending the TOPSIS model to PSNSs; (2) proposing the CRITIC technique to obtain attribute weights; (3) introducing the PSNN-TOPSIS model to solve the MADM with PSNSs; and (4) conducting a numerical study to validate the PSNN-TOPSIS technique with comparative analysis.

The study in question has made some progress in improving the quality of community home care services for the elderly in China, particularly in developing methodologies for providing more precise services to disabled seniors. However, despite the innovative use of the PSNN-TOPSIS method to handle uncertainty in assessments, there are several notable shortcomings: Firstly, the limitations of the data might impact the comprehensiveness and accuracy of the evaluations. The data collection may not encompass all factors affecting the quality of community home care services, especially lacking representativeness among different regions and elderly people with different needs. Secondly, although the PSNN-TOPSIS method is theoretically effective, its universality and practicality still require further verification and improvement. The complexity of this method might also limit its application in institutions without the relevant technical background. Lastly, the absence of long-term effect tracking and evaluation in the study makes it difficult to determine the enduring impact of the proposed improvements in practical applications.

In light of these shortcomings, future research could delve deeper into three particular directions:

1. **Expanding data sources and sample diversity**: Future research should aim to broaden the sources of data, including different regions, economic conditions, and elderly groups with diverse needs. This would enhance the breadth and representativeness of the data, making the assessment model more precise and comprehensive.

2. **Comparing and developing various assessment models**: Exploring and comparing different assessment methods, such as fuzzy logic and artificial neural networks, would help to determine the most suitable models for evaluating and improving community home care services. Through comparative analysis of these models, more practical solutions can be found to enhance service quality and efficiency.
3. **Implementing long-term follow-up studies**: Designing and conducting long-term follow-up studies to monitor the impacts of policy changes, service innovations, and technological applications on the quality of life for the elderly. Such studies could not only assess the effects of improvement measures but also provide a basis for continuous refinement and adjustment for policymakers and service providers. Through these further research and explorations, the quality of community home care services can be more effectively enhanced, better meeting the growing needs of the elderly population.

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