Chapter 2
A Multi-Granularity Triangular Fuzzy Approach for Diabetes Blood Glucometer Selection Using PROMETHEE and Three-Way Decision

Liyin Wang
Shanxi University, China

Xueqing Fan
Shanxi University, China

Yuting Cheng
Shanxi University, China

Anna Wang
https://orcid.org/0009-0001-5196-9132
Shanxi University, China

Hansen Zhao
Georgia Institute of Technology, USA

ABSTRACT

This chapter focuses on the issue of selecting a blood glucose meter for diabetic patients. To address this problem, the authors have developed a comprehensive evaluation model that combines triangular fuzzy (TF) logic, multi-granularity (MG), three-way decision (TWD), and rough set theory. The evaluation model takes into consideration the performance indicators of the blood glucose meter and user requirements. The authors utilize TF logic to model the indicators and determine their weights, while integrating the TWD method to handle incomplete and uncertain information. Subsequently, they introduce the PROMETHEE method to comprehensively evaluate and rank various alternatives. Finally, within this evaluation model, they select the optimal choice based on its score. Experimental results demonstrate the effectiveness of our proposed method in resolving the blood glucose meter selection problem and providing personalized recommendations for diabetic patients.

DOI: 10.4018/979-8-3693-1582-8.ch002

INTRODUCTION

Problem Background

The advancement of modern medical technology has significantly improved the ability of diabetes patients to manage and monitor their blood glucose levels (Domingo-Lopez, 2022). Glucometers, being convenient medical devices, are extensively utilized in both home and clinical environments. Nonetheless, the market is saturated with a wide array of glucometer models and brands, which presents a challenge for patients in selecting the most suitable one. Factors such as accuracy, quality, after-sales support, and pain sensation must be taken into consideration. Patients must carefully evaluate these factors to choose a glucometer that aligns with their specific needs and preferences. Consequently, in order to aid patients in making well-informed decisions, it is essential to thoroughly comprehend the challenges associated with selecting a glucometer and provide corresponding solutions. Such research endeavors contribute to enhancing the effectiveness of diabetes management, improving patients' quality of life, and guiding medical device manufacturers in meeting the needs and expectations of patients, thus fostering product improvement and innovation.

When selecting a glucometer, patients must take into account various factors, including price, accuracy, and convenience. However, these factors introduce a level of ambiguity and uncertainty that complicates the decision-making process. In order to tackle these challenges, this study presents a comprehensive model that integrates triangular fuzzy sets (TFSs), the TWD, and the PROMETHEE multi-attribute decision-making method to improve the efficiency and accuracy of selecting glucometers.

A Brief Review of TFSs

In 1965, Zadeh (Zadeh, 1965) introduced the concept of fuzzy sets, expanding the representation of uncertain information beyond binary values in real-life scenarios. Fuzzy sets improve the accuracy and reliability of decision-making and have played a vital role in the advancement of fuzzy mathematics. Nevertheless, fuzzy sets also possess certain limitations. For instance, there is often difficulty in setting and selecting appropriate membership functions, and dealing with large datasets and complex problems can result in computational complexity.

To address these limitations, several generalizations of fuzzy sets have been proposed, such as intuitionistic fuzzy sets (Atanassov, 1986), hesitant fuzzy sets (Torra, 2010), and others (Turksen, 1986; Peng & Selvachandran, 2019; Zhang et al., 2019). These generalizations broaden the scope of fuzzy mathematics and offer additional approaches to handle uncertainty. These generalizations have found extensive application across diverse fields and problem domains. Ecer (2022) introduced a novel extension of the MAIRCA framework, namely intuitionistic fuzzy MAIRCA, designed to assess coronavirus vaccines according to specific evaluation criteria. Mishra et al. (2022) proposed a multi-attribute decision making method based on hesitant fuzzy sets and the modified VIKOR method, which effectively addresses the limitations of existing MADM methods. Chai et al. (2023) combined intuitionistic fuzzy sets, interval-valued fuzzy sets, and cumulative prospect theory to propose a novel fuzzy multi-attribute decision making method for selecting the most sustainable supplier. Wang et al. (2022) proposed a novel method for measuring the entropy of Pythagorean fuzzy set, considering both the Pythagorean fuzziness entropy based on membership and non-membership degrees, and the Pythagorean hesitation entropy based on the degree of hesitation. Zhang et al. (2021a, 2022a) introduced q-ROFSs into the framework