ABSTRACT

This study aims to predict the age group most vulnerable to diabetes in the context of emerging viral threats. We employ and compare two decision-making techniques: Simple Additive Weighting (SAW) and Fuzzy Multiple Criteria Decision Making (MCDM) using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Real time data on age, glucose levels, blood pressure, skin thickness, insulin, body mass index and diabetes pedigree function are collected to identify susceptible individuals. The research evaluates the effectiveness of both techniques and recommends the most suitable approach for prediction. Finally, the study offers recommendations for diabetes management based on the finding.

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CHAPTER-I

1 INTRODUCTION

Fuzzy Logic, a concept introduced by Lotfi Zadeh in 1965, extends classical logic to handle the concept of partial truth—where the truth value may range between completely true and completely false. Unlike binary logic, which restricts expressions to strict yes or no values, fuzzy logic allows for a more flexible approach by accommodating varying degrees of truth. This makes it particularly useful for dealing with uncertainties and imprecise information, especially in decision-making processes.

MCDM is a branch of decision science that involves evaluating and ranking multiple alternatives based on a set of criteria. In real-world scenarios, decision-making often requires considering various conflicting criteria, and MCDM provides systematic methods to address this complexity. By using MCDM techniques, decision-makers can make informed and rational choices in situations where multiple factors need to be considered, such as resource allocation, project selection, and strategic planning.

One of the simplest and most commonly used MCDM methods is the SAW method. SAW is based on the principle of weighted summation, where each criterion is assigned a weight reflecting its importance. The method evaluates each alternative by calculating the weighted sum of its scores across all criteria. SAW is popular due to its simplicity and ease of implementation, making it a preferred choice for preliminary decision-making tasks.

By combining fuzzy logic with MCDM approaches like SAW, decision-makers can handle the inherent uncertainties in evaluating and ranking alternatives. This fusion allows for more robust and adaptable solutions in complex, real-world scenarios where precise data may not always be available.

1.1 PRELIMINARIES

MCDM [9]

It refers to a set of methods and processes used to evaluate and prioritize alternatives based on multiple, often conflicting, criteria. MCDM helps decision-makers identify the most suitable option among a set of alternatives by considering various factors simultaneously.

SAW IN MCDM [9]

It is a straightforward MCDM method used to evaluate and rank alternatives based on multiple criteria. It involves scoring each alternative on each criterion, then aggregating these scores using a weighted sum to produce an overall score for each alternative.

DECISION MATRIX [9]

1. **Define the Decision Matrix:** Let m be the number of alternatives and n be the number of criteria. The decision matrix D is defined as:

$$D = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

   where a_{ij}represents the performance of alternative i on criterion j.

2. **Normalize the Decision Matrix:** Normalize the matrix to bring all criteria to a comparable scale. For beneficial criteria, the normalization can be done as:

$$r_{ij} = \frac{a_{ij}}{max(a_j)}$$

   For non-beneficial criteria, it can be:

$$r_{ij} = \frac{min(a_j)}{a_{ij}}$$

3. **Weight the Normalized Values:** Let w_j be the weight assigned to criterion j (where $\sum_{j=1}^{n} w_j = 1$) the weighted normalized score is calculated as:

$$v_i = \sum_{j=1}^{n} w_j.r_{ij}$$

4. **Rank the Alternatives:** Finally, rank the alternatives based on their scores. The alternative with the highest score is considered the best option.

FUZZY SET [9]

A fuzzy set is defined by a membership function $\mu_a(x)$, which assigns a degree of membership to each element x. This value ranges between 0 and 1:

$$\mu_a(x)\text{=degree of membership of } x \text{ in set } A$$

MEMBERSHIP FUNCTION [9]

Common types of membership functions include:

- Triangular :$\mu_A(x) = max(0, \frac{z-a}{b-a}, \frac{c-x}{c-b})$
- Trapezoidal, Gaussian, etc

FUZZY RULES [9]

Fuzzy rules are expressed in the form of "If-Then" statements. For example:

- **Rule 1:** If the temperature is "high," then the fan speed is "fast."
- **Rule 2:** If the temperature is "medium," then the fan speed is "medium."

FUZZY INFERENCE [9]

Fuzzy inference combines fuzzy rules to determine the output based on input values. The most common methods are:

- **Mamdani:** Uses fuzzy sets for both inputs and outputs.
- **Sugeno:** Uses fuzzy sets for inputs and crisp functions for outputs.

Example Scenario: Determine fan speed based on temperature.

- **Input Temperature:** 30°C
- **Fuzzy Sets:**
  - Low: $\mu_{Low}(30) = 0.1$
  - Medium: $\mu_{Medium}(30) = 0.7$
  - High: $\mu_{High}(30) = 0.2$
- **Fuzzy Rules:**
  - If temperature is Low, then fan speed is Slow.
  - If temperature is Medium, then fan speed is Medium.
  - If temperature is High, then fan speed is Fast.

Decision making:

1. **Fuzzification:** Convert the crisp input into fuzzy values using the membership functions.
2. **Rule Evaluation:** Apply fuzzy rules to determine the degrees of output based on the input fuzzy values. For instance:
   - Output for Rule 1:$\mu_{Slow}(30) = 0.1$

- Output for Rule 2: $\mu_{Medium}(30) = 0.7$
- Output for Rule 3: $\mu_{High}(30) = 0.2$

3. **Aggregation:**Combine the outputs from all rules. For instance, the overall output membership for fan speed might be:

$$\mu_{Output} = max(\mu_{Slow}, \mu_{Medium}, \mu_{Fast}) = max(0.1, 0.7, 0.2) = 0.7$$

4. **Defuzzification:** Convert the fuzzy output back into a crisp value using methods like the centroid method:

$$\text{Fan Speed} = \frac{(\mu_i.x_i)}{\mu_i}$$

FUZZY NUMBERS [9]

A real fuzzy number A is described as any fuzzy subset of the real line R with membership function f_A which possesses the following properties where a, b, c, and d are real numbers:

- f_A is a continuous mapping from R to the closed interval $[0, 1]$.
- $f_A(x) = 0$, for all $x \in (-\infty, a]$.
- f_A is strictly increasing on $[a, b]$.
- $f_A(x) = 1$, for all $x \in [b, c]$.
- f_A is strictly decreasing on $[c, d]$.
- $f_A(x) = 0$, for all $x \in [d, \infty)$.

We may let $a = -\infty$, or $a = b$, or $b = c$, or $c = d$, or $d = +\infty$. Unless elsewhere specified, it is assumed that A is convex, normal and bounded, i.e. $-\infty < a, d < +\infty$.[1] The membership function f_A of the fuzzy number A can also be expressed as:

$$f_A(x) = \begin{cases} f_A^L(x) & \text{if } (a \leq x \leq b) \\ 1 & \text{if } (b \leq x \leq c) \\ f_A^R(x) & \text{if } (c \leq x \leq d) \\ 0 & \text{otherwise} \end{cases}$$

where $f_A^L(x)$ and $f_A^R(x)$ are the left and right membership functions of fuzzy number A, respectively

The fuzzy number A is a triangular fuzzy number if its membership function f_A is given by

$$f_A(x) = \begin{cases} \frac{(x-a)}{(b-a)} & \text{if } a \leq x \leq b \\ \frac{(x-c)}{(b-c)} & \text{if } b \leq x \leq c \\ 0 & \text{otherwise} \end{cases}$$

where a, b and c are real numbers.

TOPSIS [5]

It is a MCDM method that identifies the best alternative based on the shortest distance to an ideal solution and the farthest distance from an anti-ideal solution. The fundamental principle behind TOPSIS is that the chosen alternative should have the closest proximity to the ideal solution while being the farthest from the worst-case scenario.

FUZZY TOPSIS IN MCDM [5]

It is an extension of the traditional TOPSIS method that incorporates fuzzy logic to handle uncertainty and imprecision in decision-making. This approach is particularly useful when decision criteria are subjective or qualitative, allowing for a more detailed evaluation of alternatives.

1. **Fuzzy Decision Matrix:** The fuzzy decision matrix D is represented as:

$$D = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

where a_{ij}represents the performance of alternative i on criterion j.

2. **Normalization:** The normalized fuzzy decision matrix can be calculated as:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}}$$

3. **Weighted Normalized Decision Matrix:** The weighted normalized values are computed by multiplying each normalized value by the corresponding weight w_j:

$$v_{ij} = w_j.r_{ij}$$

4. **Ideal and Negative Ideal Solutions:** The positive ideal solution A^+ and negative ideal solution A^- are defined as:

$$A^+ = max(v_{ij})$$
$$A^- = min(v_{ij})$$

5. **Separation Measures:** The separation from the ideal and negative ideal solutions are calculated as:

$$S_i^+ = \sqrt{\int_{j=1}^{n}(v_{ij} - A^+)^2}$$
$$S_i^- = \sqrt{\int_{j=1}^{n}(v_{ij} - A^-)^2}$$

6. **Relative Closeness to the Ideal Solution:** The relative closeness of each alternative to the ideal solution is given by:

$$C_i = \frac{S_i}{S_i + S_j}$$

1.2 BOOLEAN LOGIC - FUZZY LOGIC

Boolean Logic [21]: It is a logic form of algebra where the values of the variables can only be true of false (1 or 0). It is based on binary values and uses logical operators such as AND, OR and NOT. The operations yield binary outcome, making it suitable for digital circuits and simple decision-making processes.

Fuzzy Logic [21]: It extends boolean logic by allowing for degrees of truth rather than a strict true/ false dichotomy. It uses membership functions to represent the degree to which a variable belongs to a set, allowing for a continuum of truth values ranging from 0 to 1. This makes fuzzy logic useful in situations where information is uncertain or imprecise.

1.3 FUZZY LOGIC

Fuzzy logic is a form of many-valued logic that deals with reasoning that is approximate rather than fixed and exact. Unlike classical Boolean logic, which works with binary values (true or false), fuzzy logic allows for degrees of truth, meaning values can range between 0 and 1 [23].

This approach is particularly useful for modeling complex systems where precise information is unavailable or where systems operate in a gray area rather than in black and white. Fuzzy logic uses fuzzy rules that incorporate degrees of membership. Concepts are expressed in terms of membership functions that define how much an element belongs to a fuzzy set. For example, fuzzy rules might include, “If the temperature is somewhat high, then the fan speed should be moderately high." Fuzzy operators handle the combination of these rules. Fuzzy logic plays a significant role in decision-making, particularly in scenarios where information is imprecise, uncertain, or incomplete. It enhances decision-making by offering a flexible, human-like approach to handling uncertainty and imprecision. Its ability to model complex, real-world scenarios with degrees of membership and rule-based reasoning makes it a powerful tool in a wide range of applications. Whether improving system performance, facilitating complex multi-criteria decisions, or enhancing user interaction, fuzzy logic significantly contributes to more effective and nuanced decision-making processes. This understanding of fuzzy logic's role in decision-making can be applied to various projects and industries, leveraging its strengths to address challenges and improve outcomes. In fuzzy logic, the concepts of black, white, and gray areas represent the spectrum of truth values:

- **Black Area (True/Yes):** This represents absolute truth, where a statement is completely true. For example, "The temperature is hot" might fall into this category if the temperature exceeds a specific threshold.

- **White Area (False/No):** This indicates absolute falsehood, where a statement is completely false. For instance, "The temperature is cold" might be in this area if the temperature is well above freezing.

- **Gray Area (Partial Truth):** This encompasses the range of values between true and false, where statements can be partially true or false. For example, "The temperature is warm" can have varying degrees of truth, depending on the context (e.g., 20°C might be considered warm by some but cool by others).

1.4 BASICS OF MATLAB

MATLAB [20] - "Matrix Laboratory," is a high-level programming language and interactive environment designed primarily for numerical computing, data analysis, and visualization. Developed by MathWorks, MATLAB is widely used in engineering, scientific research, and academia for its powerful computational capabilities and ease of use.

MATLAB is defined as a software platform that provides an integrated environment for algorithm development, data analysis, visualization, and numerical computation. Its core is based on matrices, making it particularly well-suited for tasks involving linear algebra, signal processing, control systems, and various other mathematical computations .

BASICS OF MATLAB

1. **Core Language:** MATLAB's syntax is designed to be intuitive and user-friendly, allowing users to write complex mathematical expressions with ease. Variables can be defined and manipulated in a straightforward manner, which facilitates rapid prototyping.

2. **Matrices and Arrays:** At its core, MATLAB operates primarily on matrices and arrays, allowing for efficient manipulation of large data sets. Users can perform a variety of operations, such as addition, multiplication, and inversion, directly on these structures.

3. **Built-in Functions:** MATLAB comes with a vast library of built-in functions for mathematical operations, statistical analysis, optimization, and more. This extensive collection enables users to implement complex algorithms without needing to code everything from scratch.

4. **Data Visualization:** One of MATLAB's strengths lies in its ability to create high-quality graphical representations of data. Users can generate plots, charts, and visualizations with simple commands, making it easy to analyze and interpret results.

5. **Toolboxes:** MATLAB offers numerous specialized toolboxes that extend its capabilities to specific domains such as signal processing, image processing, machine learning, and control systems. These toolboxes provide additional functions and tools tailored for particular applications.

6. **Simulink:** A companion product to MATLAB, Simulink allows users to model, simulate, and analyze dynamic systems using a graphical interface. It is particularly useful for control system design and simulation.

7. **Cross-Platform Compatibility:** MATLAB is available on various operating systems, including Windows, macOS, and Linux, which facilitates collaboration and sharing of MATLAB scripts across different environments.

1.5 BASICS OF PYTHON

Python is an open-source, high-level programming language that has gained immense popularity due to its versatility, ease of learning, and extensive library support. Created by Guido van Rossum and first released in 1991, Python emphasizes readability and simplicity, making it an ideal choice for beginners and experienced developers alike. Its design philosophy encourages code readability, which is reflected in its use of significant indentation [14].

FEATURES

1. **Simple Syntax:** Python's syntax closely resembles natural language, which allows developers to express concepts in fewer lines of code compared to languages like C++ or Java. This simplicity facilitates rapid application development and reduces the learning curve for new programmers.

2. **Interpreted Language:** As an interpreted language, Python executes code line-by-line, which aids in debugging and enhances flexibility during development. This feature allows developers to test small code snippets in real-time, making it easier to experiment and iterate.

3. **Dynamic Typing:** Python supports dynamic typing, meaning that variables do not require explicit declaration before they are used. This flexibility allows for quicker coding and reduces the overhead of type management.

4. **Extensive Libraries and Frameworks:** Python boasts a rich ecosystem of libraries and frameworks, such as NumPy for numerical computing, Pandas for data analysis, Flask and Django for web development, and TensorFlow and PyTorch for machine learning. These tools significantly accelerate development processes and enable developers to implement complex functionalities with ease.

5. **Cross-Platform Compatibility:** Python is a cross-platform language, which means that Python programs can run on various operating systems, including Windows, macOS, and Linux, without requiring modifications. This characteristic enhances its usability in diverse environments.

Python is a powerful and flexible programming language that caters to a wide range of applications, from web development and data analysis to automation and artificial intelligence. Its simple syntax, extensive libraries, and supportive community make it an excellent choice for both new and seasoned developers. As technology continues to evolve, Python's relevance in the programming landscape is likely to grow, making it a valuable skill for anyone looking to thrive in the digital age. Whether you are building a simple script or developing complex systems, Python offers the tools and capabilities needed to bring your ideas to life.

CHAPTER – II

2 LITERATURE REVIEW

2.1 HISTORY OF FUZZY

In many real-world situations, information is not precise or binary (true or false). Instead, it is often vague, uncertain, or imprecise. Traditional logic and mathematics struggle to handle such complexity effectively.

Early Foundations

- **Ancient and Philosophical Roots (Pre-20^{th} Century):** The concept of vagueness and imprecision has roots in ancient philosophy. Philosophers such as Aristotle explored ideas related to degrees of truth and gradations of qualities, though these were not formalized into a structured theory.

The Birth of Fuzzy Logic

- **1965: Lotfi Zadeh's Groundbreaking Work:** The formal foundation of fuzzy logic was laid by Lotfi A. Zadeh, a professor of computer science and electrical engineering at the University of California, Berkeley. In his seminal paper titled "Fuzzy Sets," Zadeh introduced the concept of fuzzy sets, which extend classical set theory to handle partial membership. Unlike classical sets, where an element either belongs or does not belong to a set, fuzzy sets allow for degrees of membership.

- **1966: Extension to Fuzzy Logic:** Following the introduction of fuzzy sets, Zadeh further developed fuzzy logic as a way to handle reasoning that is approximate rather than fixed and exact. This extension provided a framework to model human reasoning and decision-making processes that involve uncertainty and vagueness.

Early Applications and Development

- **1970s: Initial Applications:** The initial applications of fuzzy logic were in control systems. Early adopters began to apply fuzzy logic to problems where binary logic and classical control systems struggled, such as in the automotive and aerospace industries. One notable early application was the development of fuzzy logic controllers for appliances, such as washing machines and air conditioners, enhancing their performance and efficiency.

- **1980s: Expansion and Commercialization:** During the 1980s, fuzzy logic gained popularity and saw increased application in various fields. It was integrated into a variety of consumer products, including automotive systems (e.g., automatic transmission control) and industrial processes. This period also saw the emergence of commercial tools and software based on fuzzy logic, making it more accessible to engineers and researchers.

Modern Advancements

- **1990s: Theoretical and Practical Advances:** The 1990s marked significant advancements in both the theoretical aspects of fuzzy logic and its practical applications. Researchers developed more sophisticated algorithms and methods for fuzzy inference systems, and fuzzy logic was increasingly used in fields such as finance, medical diagnosis, and pattern recognition.

- **2000s: Integration with Other Technologies:** Fuzzy logic began to be integrated with other technologies, such as neural networks and genetic algorithms, leading to the development of hybrid systems that leverage the strengths of multiple methodologies. This integration allowed for more robust and flexible problem-solving approaches.

- **2010s and Beyond: Ubiquity and Emerging Trends:** In recent years, fuzzy logic has become an integral part of various advanced technologies. It is used in artificial intelligence (AI), robotics, and data science, particularly in handling uncertainties and imprecise data. Modern applications include smart home systems, autonomous vehicles, and complex decision-making systems.

Current State and Future Directions

- **Ongoing Research and Applications:** Today, fuzzy logic continues to evolve, with ongoing research exploring new applications and refinements. The integration with machine learning, deep learning, and other AI technologies is opening new avenues for its use in complex systems and real-time decision-making processes.

- **Future Prospects:** The future of fuzzy logic holds promise in areas such as the Internet of Things (IoT), big data analytics, and advanced control systems. As systems become increasingly complex and data-driven, fuzzy logic's ability to manage uncertainty and imprecision will likely become even more valuable [6].

2.2 AUTHORS AND THEIR RESEARCH WORKS

Fuzzy Set Ranking Methods and Multiple and Multiple Expert Decision Making, Professor Slobodan P. Simonovic, 2001 [23] explores the multi-criteria decision-making tool known as fuzzy compromise programming. The research compares various fuzzy set ranking techniques, essential for processing fuzzy information. A thorough sensitivity analysis of three water resource systems is conducted, considering decision-makers' risk preferences, leading to the identification of compromise solutions. One system underwent a weight sensitivity analysis to assess the impact of changing weights on rankings. The findings indicate that the method is resistant to variations in weights. Additionally, the study investigates how fuzzy compromise programming can be adapted for multiple decision-makers by integrating group decision-making approaches.

Ranking fuzzy numbers based on the areas on the left and the right sides of fuzzy number, Ali Mahmodi Nejada, Mashaallah Mashinchi, 2010 [15] propose a novel method for ranking fuzzy numbers based on their left and right sides. This approach addresses shortcomings in recent research that often leads to improper rankings. The authors present straightforward computations and provide numerical examples to contrast their method with existing techniques.

A Ranking Approach for Intuitionistic Fuzzy Numbers and its Application, Amit Kumar, Manjot Kaur, 2013 [10] discuss the limitations of currently used ranking methods for intuitionistic fuzzy (IF) numbers. They propose a new ranking technique aimed at addressing these limitations, facilitating the identification of optimal solutions to imbalanced minimum cost flow (MCF) problems where all parameters are represented by IF numbers.

Various Fuzzy Number and Their Various Ranking Approaches, Lavanya P, 2017 [12] reviews ranking formulas for various fuzzy numbers derived from recent research. The paper emphasizes the importance of fuzzy number concepts and associated ranking formulas, highlighting significant outcomes in fuzzy ranking applications.

Integrating Fuzzy TOPSIS and Genetic Algorithms for Multi-Criteria Decision Making, Zhang .L, 2019 [27] integrates Fuzzy TOPSIS with genetic algorithms to enhance decision-making in multi-criteria problems. The research aims to improve the robustness and adaptability of decision processes, utilizing simulation and comparisons with traditional decision-making techniques.

Fuzzy TOPSIS-Based Approach For Supplier Selection In Supply Chain Management, Singh .R, 2020 [24] examines the application of Fuzzy TOPSIS in supplier selection processes, evaluating criteria such as cost, quality, and delivery time under fuzzy conditions. The method effectively ranks suppliers based on multiple criteria, addressing uncertainty in decision-making.

Enhancing Multi-Criteria Decision Making Using Fuzzy TOPSIS in Sustainable Energy Planning, Akhter .M, 2021 [2] explores Fuzzy TOPSIS for evaluating sustainable energy options, investigating how fuzzy logic refines decision-making under uncertain conditions. The study compares Fuzzy TOPSIS with traditional methods and employs a case study to illustrate the methodology.

A Comparative Study Of Fuzzy TOPSIS And Fuzzy AHP For Multi-Criteria Decision Making, Zadeh .H, 2022 [26] compares the performance of Fuzzy TOPSIS with Fuzzy Analytic Hierarchy Process (AHP) in multi-criteria decision-making scenarios. The study evaluates how each method handles uncertainty and linguistic variables, aiming to identify the superior method for complex environments. Statistical analysis and case studies are employed to compare the results.

The Use Of Social Simulation Modelling To Understand Adherence To Diabetic Retinopathy Screening Programs, Andreia Penso Pereira, 2024 [19] demonstrates the potential to predict adherence rates to population-based screenings using agent-based models (ABMs). The research develops an ABM that accurately represents decision-making regarding screening adherence and explores the utility of combining ABMs with fuzzy logic in simulating human behavior.

Design Of A Model For Multistage Classification Of Diabetic Retinopathy And Glaucoma, Rupesh Goverdhan Mundada, 2024 [17] addresses the rising prevalence of diabetic retinopathy (DR) and glaucoma. The study proposes an innovative iterative Q-learning model integrated with fuzzy C-means clustering to enhance diagnostic accuracy and classification speed. The model improves upon traditional diagnostic frameworks, particularly in discerning complex retinal features.

Various Distance Between Generalized Diophantine Fuzzy Sets Using Multiple Criteria Decision Making And Their Real Life Applications, Simic Vladimir, 2024 [25] introduces generalized Diophantine fuzzy sets, expanding on both Diophantine fuzzy sets and Pythagorean fuzzy sets. The paper defines basic properties and distances related to these sets and presents new operators, including necessity and possibility functions. The research emphasizes real-world applications of intuitionistic fuzzy sets, highlighting the superiority of the proposed method.

Evaluation of energy economic optimization models using multi-criteria decision-making approach, Deveci Muhammet, 2024 [7] develops an integrated MCDM approach to evaluate and benchmark energy economic optimization (EEO) models. The methodology consists of three phases: identifying commonly used EEO models and evaluation criteria, applying the fuzzy-weighted zero-consistency method (FWZIC) for weight assignment, and integrating fuzzy decision-making techniques to benchmark the models based on acquired weights.

SUMMARY

The reviewed literature presents diverse approaches and advancements in fuzzy set ranking methods and MCDM. Key contributions include the exploration of fuzzy compromise programming for effective decision-making under uncertainty, with sensitivity analyses demonstrating robustness against weight variations. Innovations in ranking fuzzy numbers, such as methods focusing on left and right areas, address previous shortcomings and enhance computational simplicity.

Several studies integrate fuzzy logic with advanced algorithms like genetic algorithms and fuzzy TOPSIS to improve decision-making robustness in scenarios ranging from supplier selection to sustainable energy planning. Comparative analyses, such as those between fuzzy TOPSIS and fuzzy AHP, highlight the strengths of each method in handling uncertainty and linguistic variables, offering insights into their application in complex environments.

The management of diabetes requires a multifaceted approach, including lifestyle modifications, regular monitoring of blood glucose levels, and, when necessary, pharmacological interventions. Understanding the distinct causes of diabetes ranging from genetic predisposition to lifestyle factors is critical for developing effective prevention strategies. Furthermore, in addressing chronic health conditions like diabetes, MCDM methods play a pivotal role. The MCDM framework involves clearly defining problems, identifying criteria, generating alternatives, assigning weights, and applying decision-making techniques. Techniques such as TOPSIS facilitate a systematic evaluation of alternatives based on weighted criteria, allowing for more informed and strategic decision-making in healthcare settings.

Overall, these studies contribute significantly to the field by enhancing the adaptability, accuracy, and practicality of fuzzy-based MCDM tools across diverse domains.

Here we have applied fuzzy logic concept to one such application in helth-care, to make appropriate deccision in critical scenarios.

CHAPTER-III

3 MAIN WORK

3.1 DIABETIC AND IT'S TYPES

Diabetes, also known as diabetes mellitus, is a chronic condition that affects how the body processes blood sugar (glucose). Normally, glucose from food is used for energy and regulated by the hormone insulin, which is produced by the pancreas. In diabetes, this process is disrupted, leading to high blood sugar levels that can cause various health complications.

Types of Diabetes [16]

1. **Type 1 Diabetes:**

    - **Cause:** This autoimmune condition occurs when the immune system attacks and destroys insulin-producing beta cells in the pancreas. As a result, the body produces little or no insulin.
    - **Onset:** Typically develops in children or young adults but can occur at any age.
    - **Management:** Requires lifelong insulin therapy, either through injections or an insulin pump.

2. **Type 2 Diabetes:**

    - **Cause:** This type is primarily caused by insulin resistance, where the body's cells do not respond effectively to insulin. Over time, the pancreas cannot produce enough insulin to overcome this resistance.
    - **Onset:** More common in adults, though increasing in children due to rising obesity rates.
    - **Management:** Initially managed through lifestyle changes such as diet and exercise, but may also require oral medications or insulin as the disease progresses.

3. **Gestational Diabetes:**

    - **Cause:** This type is primarily Occurs during pregnancy when the body cannot produce enough insulin to meet the increased needs, leading to high blood sugar levels.
    - **Onset:** Typically develops in the second or third trimester of pregnancy.

- **Management:** Initially managed Managed through diet, exercise, and sometimes insulin. It usually resolves after childbirth but increases the risk of developing Type 2 diabetes later in life.

4. **Other Specific Types:**

   - **Secondary Diabetes:** Caused by other medical conditions or medications, such as cystic fibrosis or steroid use.
   - **Monogenic Diabetes:** Rare forms caused by genetic mutations affecting insulin production or function.

Causes of Diabetes

- **Genetics:** Family history can increase susceptibility, especially for Type 1 and Type 2 diabetes.

- **Lifestyle Factors:** Poor diet, physical inactivity, and obesity are significant risk factors for Type 2 diabetes

- **Autoimmune Reaction:** In Type 1 diabetes, the immune system mistakenly attacks insulin-producing cells.

- **Insulin Resistance:** In Type 2 diabetes, the body's cells become resistant to insulin, leading to higher blood sugar levels.

Affection of Diabetes in Body

- **Glucose Metabolism:** In a healthy body, insulin helps cells absorb glucose from the bloodstream. In diabetes, this process is impaired, leading to elevated blood sugar levels.

- **Cellular Impact:** High blood sugar can damage blood vessels and nerves, leading to complications such as heart disease, stroke, kidney damage, and nuropathy.

- **Spread in the Body:** The elevated glucose levels affect various organs and systems, causing widespread damage over time if not managed properly.

Managing diabetes involves monitoring blood sugar levels, adopting a healthy lifestyle, and, if necessary, using medications or insulin to maintain glucose levels within a target range and prevent complications.

3.2 SOLVING MCDM PROBLEM

To solve MCDM problems, start by clearly defining the problem and objectives that the decision-making process aims to address. Identify and define the criteria that will be used to evaluate the available alternatives, ensuring these criteria are relevant and measurable. Once the criteria are established, generate a comprehensive list of all possible alternatives that could address the problem or achieve the objectives, and gather relevant data for each option in relation to the criteria [11].

Next, assign weights to each criterion to reflect their relative importance, which can be achieved through methods like pairwise comparison or direct rating. Evaluate each alternative against the criteria, and if necessary, normalize the scores to ensure comparability across different scales. Apply a suitable MCDM method such as TOPSIS, AHP, PROMETHEE, or ELECTRE to rank the alternatives based on the weighted criteria.

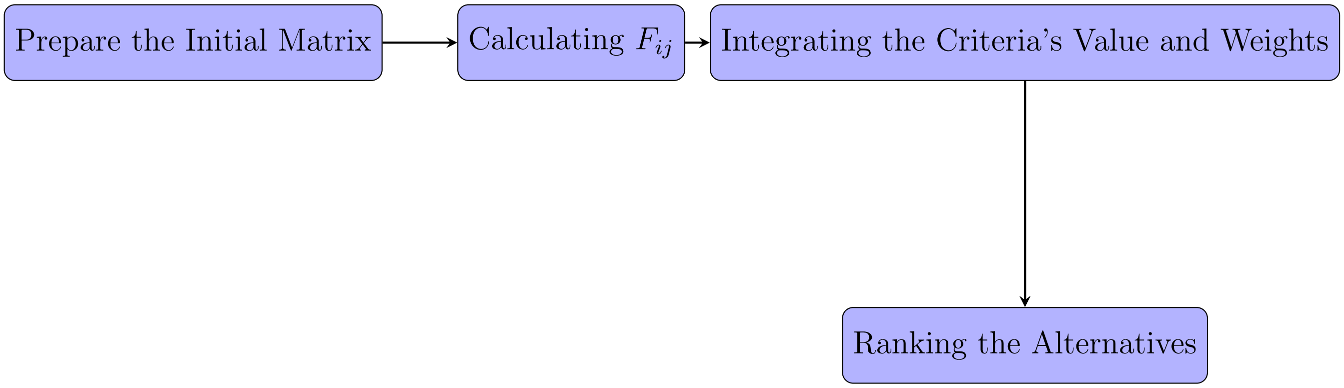
Analyze the results to determine the best options and conduct sensitivity analysis to see how changes in criteria weights or data impact the rankings. Make a decision based on the analysis, providing a clear rationale for the chosen alternative. Develop an implementation plan for the selected option and monitor its performance to ensure it meets the desired outcomes. Finally, review the results post-implementation, gather feedback, and document any lessons learned to improve future MCDM processes.

Working of MCDM method

Step 1: Identification of Goal
Step 2: Selection of Parameters
Step 3: Selection of Alternatives
Step 4: Weighting Method Selection of represent Importance
Step 5: Method of Aggregation
Step 6: Decision making base of Aggregation Results

3.3 STEPS FOR SOLVING SAW

The Simple Additive Weighting method is one of the most common MCDM methods. Finding the weighted sum of the performance ratings for each alternative considering all attributes is the basic concept of the SAW method. For this, normalized decision matrix must be prepared [19]. This normalization process results in a scale that makes comparing with all alternative ratings possible [8].



Step 1: This is an optional step that helps to conduct the following steps better.

The initial matrix is prepared based on the values for m∗n matrix r_{ij} is the value of the i^{th} criterion for j^{th} object where :

- i = 1,2,...,m;
- j = 1,2,...,n;

Another point is to determine the weights of the criteria (w_i) to show their importance. These weights can be considered as numbers between zero and one (or by percentages) and considering $\sum_{i=1}^{n} w_i = 1$

Step 2: Normalizing the Value of i^{th} Criterion for the j^{th} Alternative (Calculating $\overline{r_{ij}}$):

The $\overline{r_{ij}}$ is known as the normalized i^{th} criterion's value for j^{th} alternative/object. This value must be calculated in this step considering whether the problem is a cost or benefit type. The difference is that in the cost problems the object is minimizing, on the other hand maximizing is the object of a benefit problem. These differences reflect in the $\overline{r_{ij}}$ calculation as follows:

$$\begin{aligned}\overline{r_{ij}} &= \frac{\min(r_{ij})}{r_{ij}}; \text{if j is a cost attribute.}\\ \overline{r_{ij}} &= \frac{r_{ij}}{\max(r_{ij})}; \text{if j is a benefit/profit attribute.}\end{aligned}$$

where r_{ij} is the value of the i^{th} criterion for j^{th} object. The $min(r_{ij})$ is the largest value of the i^{th} criterion when all alternatives are compared, and in contrast, $min(r_{ij})$ is the smallest value for it. Therefore, $\overline{r_{ij}}$ is a normalized value for the i^{th} criterion and j^{th} alternative.

Step 3: Integrating the Values of the Criteria and Weights.

The integration of the criteria and weights helps to gain a single magnitude that is the final performance value for each alternative. For this, the following equation can be used for the j^{th} alternative/ object:

$$S_j = \sum_{n=1}^{n} w_i \overline{r_{ij}}$$

Step 4: Ranking the Alternatives to Choose the best One.

In the final step, the best alternative is chosen based on the largest performance value of the S_j maximizing criterion, and the smallest for the minimizing criterion. Numerical examples are provided in the literature.

Finally, there is another important consideration for the SAW method that is beneficial to be noted here:

The r_{ij} is this method should be positive. According to this requirement the negative values should be transferred to positive ones ($\overline{r}_{ij}$) using different methods. For example, the following formula can be used:

$$\overline{r}_{ij} = r_{ij} + |min(r_{ij})| + 1$$

3.4 APPLICATION AREA, MERITS, AND DEMERITS OF THE SAW

The SAW method possesses different application areas ranging from business to water management and financial studies. Different studies are conducted based on utilizing the SAW method for ranking and selection purposes [8]. This method can be also integrated with other MADM methods such as AHP, VIKOR, TOPSIS, and ELECTRE; some examples are as follows:

- Ranking the cloud render farm services;
- Evaluating the quality of urban life;
- Risk assessment in public-private partnership projects;
- Selecting the most efficient devices;
- Selecting sensors attached to the devices;
- Ranking the best resources at the local or lower level;

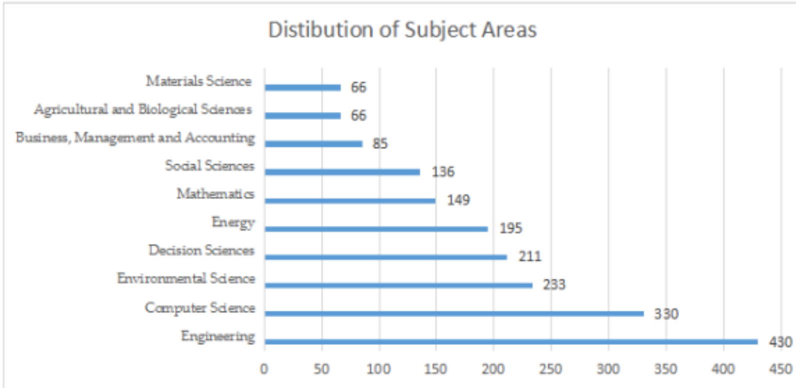


Figure 1: Distribution of subject areas used the SAW method.

Figure 1 is based on the SAW search term in the "ScienceDirect" database (conducted on 2022/06/2). The figure illustrates that according to the results this method is mostly used in the engineering, computer, environmental, and decision sciences subject areas.

3.5 THE BASICS OF THE TOPSIS METHOD AND PROBLEMS OF ITS FUZZY EXTENSION

The classical TOPSIS method is based on the idea that the best alternative should have the shortest distance from the positive ideal solution and the greatest distance from the negative one. It is assumed that if each local criterion is monotonically increasing or decreasing, then it is easy to define the ideal solution [18].

A positive ideal solution is composed of all the best achievable values of the local criteria, while a negative ideal solution is compose d of all the worst achievable values of the local criteria.

Suppose a MCDM problem is based on m alternatives $A_1, A_2, ..., A_m$ and n local criteria $C_1, C_2, ..., C_n$. Each alternative is evaluated with respect to the n criteria. All the ratings are assigned to alternatives and presented in the decision matrix $D[x_{ij}]_{m*n}$, where x_{ij} is the rating of alternative A_i with respect to the criterion C_j. Let $W = [w_1, w_2, ..., w_n]$ be the vector of local criteria weights satisfying $\sum\limits_{j=1}^{n} w_j = 1$

The TOPSIS method consists of the following steps :

1. **Normalize the decision matrix:**

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum\limits_{k=1}^{m} x_{kj}^2}}, \text{i=1,2,...,m; j=1,2,...,n;}$$

Multiply the columns of normalized decision matrix by the associated weights:

$$v_{ij} = w_i * r_{ij}\text{,i=1,2,...,m; j=1,2,...,n;}$$

2. **Determine the positive ideal and negative ideal solutions, respectively, as follows:**

$$A^+ = \{v_1^+, v_2^+, ..., v_n^+\} = \{(maxv_{ij}|j \in K_b)(minv_{ij}|j \in k_c)\}$$
$$A^- = \{v_1^-, v_2^-, ..., v_n^-\} = \{(minv_{ij}|j \in K_b)(maxv_{ij}|j \in k_c)\}$$

   where K_b is a set of benefit criteria and K_c is a set of cost criteria

3. **Obtain the distances of the existing alternatives from the positive ideal and negative ideal solutions:** two Euclidean distances for each alternatives are, respectively, calculated as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}\text{, i= 1,2,...,m}$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}\text{, i= 1,2,...,m}$$

4. **Calculate the relative closeness to the ideal alternatives:**

$$RC_i = \frac{S_i^-}{S_i^+ + S_i^-} \text{ ;i= 1, 2, ... , m; } 0 \leq RC_i \leq 1$$

5. **Rank the alternatives according to their relative closeness to the ideal alternatives:** The bigger RC_i, the better alternative A_i. Let us consider a formal fuzzy extension of the classical TOPSIS method in a form which is free of the simplifications and limitations associated with the known fuzzy TOPSIS methods analyzed in the previous section.[1] It is important that such an approach makes it possible to present the fuzzy TOPSIS method in the form of a weighted sum aggregation of the local criteria. Suppose a MCDM problem is based on m alternatives $A_1, A_2, ..., A_m$and n criteria $C_1, C_2, ..., C_n$. Let $D[\overline{x_{ij}}]_{m*n}$ be a fuzzy decision matrix, where $\overline{x_{ij}} = (a_{ij}, b_{ij}, c_{ij})$ is a triangular fuzzy value representing the rating of alternative A_i with respect to the criterion C_j. Let $W = [w_1, w_2, ..., w_n]$ be the vector of real-valued local criteria weights satisfying $\sum_{j=1}^{n} w_j = 1$

   The method of formal fuzzy extension of TOPSIS method consists of the following steps:

   (a) Normalizing the decision matrix.
   An appropriate and methodologically justified method for normalization of fuzzy decision matrices was developed in as follows:

$$\overline{r_{ij}} = (r_{ij}^L, r_{ij}^M, r_{ij}^U) = (\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+});\text{i=1,...,m};j \in K_b,$$

where $c_j^+ = max_i(c_{ij}); j \in K_b$.

$$\overline{r_{ij}} = (r_{ij}^L, r_{ij}^M, r_{ij}^U) = (\frac{a_{ij}}{c_j^-}, \frac{b_{ij}}{c_j^-}, \frac{c_{ij}}{c_j^-});\text{i=1,...,m};j \in K_c,$$

where $a_j^+ = min_i(a_{ij}); j \in K_c$. This normalization guarantees that $\overline{r_{ij}} \subset [0,1]$ for all i and j.

(b) The positive and negative ideal solutions are obtained as follows:

$$A_+ = \{\overline{r_1^+}, \overline{r_2^+}, ..., \overline{r_n^+}\} = \{max\{(r_{ij}^L, r_{ij}^M, r_{ij}^U)\}|j \in K_b, min\{(r_{ij}^L, r_{ij}^M, r_{ij}^U)\}|j \in K_c\},$$
$$A_- = \{\overline{r_1^-}, \overline{r_2^-}, ..., \overline{r_n^-}\} = \{min\{(r_{ij}^L, r_{ij}^M, r_{ij}^U)\}|j \in K_b, max\{(r_{ij}^L, r_{ij}^M, r_{ij}^U)\}|j \in K_c\},$$

(c) Calculation of separation of each alternative from the positive and negative ideal solutions.

$$\begin{aligned}
\overline{r_j^+} &\geq \overline{r_{ij}}, i = 1, 2...m, j \in K_b \\
\overline{r_{ij}} &\geq \overline{r_j^+}, i = 1, 2...m, j \in K_c \\
\overline{r_{ij}} &\geq \overline{r_j^-}, i = 1, 2...m, j \in K_b \\
\overline{r_j^-} &\geq \overline{r_{ij}}, i = 1, 2...m, j \in K_c
\end{aligned}$$

Therefore, there is no need to use n-dimensional Euclidean or Hamming distances for obtaining $S_i^+$and S_i^- i = 1, 2,..., m, as they can be calculated as follows:

$$\begin{aligned}
S_i^+ &= \sum_{j \in K_b} w_j(\overline{r_j^+} - \overline{r_{ij}}) + \sum_{j \in K_c} w_j(\overline{r_{ij}} - \overline{r_j^+}) \\
S_i^- &= \sum_{j \in K_b} w_j(\overline{r_{ij}} - \overline{r_j^-}) + \sum_{j \in K_c} w_j(\overline{r_j^-} - \overline{r_{ij}})
\end{aligned}$$

These expressions make it possible to look at the problem from another point of view. We can see that the expressions

$$\begin{aligned}
&\overline{r_j^+} - \overline{r_{ij}}, i = 1, 2...m, j \in K_b \\
&\overline{r_{ij}} - \overline{r_j^+}, i = 1, 2...m, j \in K_c \\
&\overline{r_{ij}} - \overline{r_j^-}, i = 1, 2...m, j \in K_b \\
&\overline{r_j^-} - \overline{r_{ij}}, i = 1, 2...m, j \in K_c
\end{aligned}$$

may be treated as modified values of local criteria based on the initial ones. Therefore, expressions may be considered as the weighted sum aggregation s of local criteria. Nevertheless, this aggregation cannot be treated as unique nor as the best one within the framework of the fuzzy TOPSIS method in all case

An important property of weighted sum aggregation is that the small values of some local criteria may be counterbalanced by large values of other ones in the final assessment. For example, a high percent of goods of low quality in most cases cannot be counterbalanced by low production costs, just as the low professional qualifications of medical staff usually cannot be compensated for by high quality diagnostic equipment and so on. Since this compensation property of weighted sum aggregation is in many applications undesirable, a decision maker may prefer to use, e.g., weighted geometric aggregation and a more cautious decision maker may prefer aggregation based on the "principle of maximal pessimism".

The problem of selecting an appropriate aggregation method is of perennial interest, because of its direct relevance to practical decision making.[4] Generally, the choice of aggregation mode is a context dependent problem. Therefore, in different applications of the TOPSIS method, different aggregation modes may be used to obtain S^{+} and S^{-}. Of course, currently the most popular aggregating mode is the weighted sum. It is used in many well known decision making models, but often without any critical analysis. On the other hand, in some fields, e.g., in ecological modelling, the weighted sum is not used for aggregation. The reason behind this is that in practice there are cases when if any local criterion is totally dissatisfied then the considered alternative should be rejected from the consideration completely. Nevertheless, when dealing with a complex task characterized by a great number of local criteria, it seems reasonable to use all those types of aggregation relevant to this task. If the results obtained by using different aggregation modes are similar, this fact may be considered as good confirmation of their optimality.

In the opposite case, additional analysis of local criteria and their ranking is usually advised. In addition to the weighted sum, we propose to use other types of aggregations in the fuzzy TOPSIS method. Since different aggregation modes may provide different final rankings of alternatives, to obtain a compromise result, we propose a new method for generalizing the aggregation modes within the framework of the fuzzy TOPSIS method. This method is based on an adaptation of the approach developed, which is based on the synthesis of Type 2 and Level 2 fuzzy sets To calculate the fuzzy values we shall use the a-cut representation of fuzzy values. This means that there are no restrictions on the form of the fuzzy values in our approach and we use triangular fuzzy values in the above definitions only to make the presentation of the developed approach more transferable. Of course, when the fuzzy values have regular triangular or trapezoidal forms, the solution to a MCDM problem with the use of the TOPSIS method can be reduced in its consideration to only the lowest and highest α-cuts, practically without any loss of accuracy.

3.6 APPLICATION AREA, MERITS AND DEMERITS OF THE FUZZY TOPSIS

APPLICATION AREA [13]:

1. **Healthcare:** Evaluating treatment options, hospital performance, and patient care services, considering multiple criteria such as cost, efficacy, and patient satisfaction.

2. **Supply Chain Management:** Selecting suppliers based on criteria like quality, delivery time, and cost, accommodating the uncertainty in supplier performance.

3. **Environmental Management:** Assessing environmental impact, sustainability practices, and resource allocation, where data can be uncertain or imprecise.

4. **Finance: Portfolio** selection, investment analysis, and risk assessment, integrating various economic indicators and qualitative judgments.

5. **Manufacturing:** Evaluating production processes, machinery selection, and quality control by considering multiple conflicting criteria.

6. **Manufacturing:** Evaluating production processes, machinery selection, and quality control by considering multiple conflicting criteria.

MERITS:

1. **Handling Uncertainty:** Fuzzy TOPSIS effectively manages uncertainty and imprecision in decision-making by allowing for degrees of membership rather than binary outcomes.

2. **Comprehensive Evaluation:** It enables the integration of both qualitative and quantitative criteria, providing a holistic view of the alternatives.

3. **Ranking Alternatives:** The method facilitates a clear ranking of options, making it easier for decision-makers to identify the best choice.

4. **Flexibility:** It can be adapted to various domains and decision-making scenarios, making it versatile for different applications.

5. **User-Friendly:** The approach is intuitive and can be implemented with relative ease, allowing decision-makers from non-technical backgrounds to use it effectively.

DEMERITS:

1. **Complexity in Data Collection:** Gathering fuzzy data and defining membership functions can be challenging and may require expert input, which can be subjective.

2. **Parameter Sensitivity:** The results can be sensitive to the chosen membership functions and the weight assigned to different criteria, potentially leading to biased outcomes.

3. **Computationally Intensive:** For large datasets or complex problems, the computational load may become significant, requiring advanced software or longer processing times.

4. **Lack of Standardization:** There is no universally accepted methodology for defining fuzzy sets and membership functions, which can lead to inconsistencies in application.

5. **Interpretation Challenges:** The results may be difficult to interpret for stakeholders unfamiliar with fuzzy logic concepts, potentially complicating the decision-making process.

CHAPTER – IV

4 APPLICATION

The TOPSIS method involves the following key techniques:

1. **Normalization** of data to bring it to a comparable scale.
2. **Weighting** of normalized data to reflect the importance of each criterion.
3. **Identification** of ideal and negative-ideal solutions for comparison.
4. **Calculation** of distances from the ideal and negative-ideal solutions.
5. **Computation** of the closeness coefficient to rank alternatives.

These steps help in evaluating and selecting alternatives that are closest to the ideal solution while being farthest from the negative-ideal solution, thus facilitating informed decision-making [22]. The paper also included a dataset on diabetes in which the scale point was fixed using linguistic values some beneficial and non-beneficial attributes are mentioned according to the weightage. The ranking result was eventually discovered, and visualization was displayed using the MATLAB programming language. The major contribution of this paper as follows,

- Using the average approach, the acquired dataset is categorized by age wise.
- For the impacted diabetes patient's dataset, linguistic values are provided.
- The scale point is fixed based on linguistic values, and the weighting of beneficial and non-beneficial value is fixed based on the dataset.
- With the use of the TOPSIS approach, the dataset's final ranking is established.
- Using MATLAB the visualization result is determined.

There are five steps of algorithms to solve our problem
Step 1: Data collection
Step 2: Data categorize to simplify the dataset
Step 3: Fixing scale point with respect to linguistic values
Step 4: Fixing the weightage, beneficial and non-beneficial of the simplified dataset
Step 5: Find ranking using Multi Criteria decision method of TOPSIS method.

4.1 DATASET WITH OUTCOME

Age	Gender	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function	Outcome
21	Female	89	66	23	94	28.1	0.167	0
21	Female	97	66	15	140	23.2	0.487	0
21	Female	76	62	0	0	34	0.391	0
21	Male	88	58	11	54	24.8	0.267	0
21	Male	95	85	25	36	37.4	0.247	1
21	Male	171	72	33	135	33.3	0.199	1
22	Female	154	62	31	284	32.8	0.237	0
22	Female	102	75	23	0	0	0.572	0
22	Female	129	110	46	130	67.1	0.319	1
22	Male	92	92	0	0	19.9	0.188	0
22	Male	71	70	27	0	28	0.586	0
22	Male	101	50	15	36	24.2	0.526	0
23	Female	109	64	44	99	34.8	0.905	1
23	Female	105	64	41	142	41.5	0.173	0
23	Female	84	0	0	0	0	0.304	0
23	Male	107	62	13	48	22.9	0.678	1
23	Male	103	80	11	82	19.4	0.491	0
23	Male	92	62	28	0	31.6	0.13	0
24	Female	71	48	18	76	20.4	0.323	0
24	Female	93	50	30	64	28.7	0.356	0
24	Female	105	0	0	0	0	0.305	0
24	Male	87	0	23	0	28.9	0.773	0
24	Male	95	66	13	38	19.6	0.334	0
24	Male	146	85	27	100	28.9	0.189	0
25	Female	100	66	20	90	32.9	0.867	1
25	Female	139	64	35	140	28.6	0.411	0
25	Female	158	84	41	210	39.4	0.395	1
25	Male	105	58	0	0	24.3	0.187	0
25	Male	180	66	39	0	42	1.893	1
25	Male	119	64	18	92	34.9	0.725	0

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Figure 2

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26	Female	0	74	20	23	27.7	0.299	0
26	Female	73	60	0	0	26.8	0.268	0
26	Female	111	62	0	0	22.6	0.142	0
26	Male	180	64	25	70	34	0.271	0
26	Male	148	60	27	318	30.9	0.15	1
26	Male	113	80	16	0	31	0.874	0
27	Female	90	68	42	0	38.2	0.503	1
27	Female	177	60	29	478	34.6	1.072	1
27	Female	96	64	27	87	33.2	0.289	0
27	Male	126	88	41	235	39.3	0.704	0
27	Male	95	72	33	0	37.7	0.37	0
27	Male	131	0	0	0	43.2	0.27	1
28	Female	112	66	22	0	25	0.307	0
28	Female	113	44	13	0	22.4	0.14	0
28	Female	74	0	0	0	0	0.102	0
28	Male	99	52	15	94	24.6	0.637	0
28	Male	109	56	21	135	25.2	0.833	0
28	Male	88	74	19	53	29	0.229	0
29	Female	78	50	32	88	31	0.248	1
29	Female	146	56	0	0	29.7	0.564	0
29	Female	122	68	0	0	35	0.394	0
29	Male	74	68	28	45	29.7	0.293	0
29	Male	162	52	38	0	37.2	0.652	1
29	Male	119	80	35	0	29	0.263	1
30	Female	100	70	52	57	40.5	0.677	0
30	Female	106	60	24	0	26.5	0.296	1
30	Female	104	64	23	116	27.8	0.454	0
30	Male	116	74	0	0	25.6	0.201	0
30	Male	120	70	30	135	42.9	0.452	0
30	Male	118	58	36	94	33.3	0.261	0

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Figure 3

31	Female	85	66	29	0	26.6		0.351	0
31	Female	108	62	10	278	25.3		0.881	0
31	Female	118	84	47	230	45.8		0.551	1
31	Male	96	56	17	49	20.8		0.34	0
31	Male	107	74	0	0	29.6		0.254	1
31	Male	78	88	29	40	36.9		0.434	0
32	Female	183	64	0	0	23.3		0.672	1
32	Female	113	76	0	0	33.3		0.278	1
32	Female	88	30	42	99	55		0.496	1
32	Male	115	70	30	96	34.6		0.529	1
32	Male	77	82	41	42	35.8		0.156	0
32	Male	100	0	0	0	30		0.484	1
33	Female	137	40	35	168	43.1		2.288	1
33	Female	103	30	38	83	43.3		0.183	0
33	Female	78	48	0	0	33.7		0.654	0
33	Male	97	60	23	0	28.2		0.443	0
33	Male	99	76	15	51	23.2		0.223	0
33	Male	162	76	56	100	53.2		0.759	1
34	Female	111	64	39	0	34.2		0.26	0
34	Female	107	74	30	100	33.6		0.404	0
34	Female	168	74	0	0	38		0.537	1
34	Male	173	70	14	168	29.7		0.361	1
34	Male	122	56	0	0	33.3		1.114	1
34	Male	170	64	37	225	34.5		0.356	1
35	Female	84	74	31	0	38.3		0.457	0
35	Female	96	68	13	49	21.1		0.647	0
35	Female	125	60	20	140	33.8		0.088	0
35	Male	100	70	26	50	30.8		0.597	0
35	Male	93	60	25	92	28.7		0.532	0
35	Male	129	80	0	0	31.2		0.703	0

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Figure 4

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36	Female	138	0	0	0	36.3	0.933	1
36	Female	128	64	42	0	40	1.101	0
36	Female	102	52	0	0	25.1	0.078	0
36	Male	161	68	23	132	25.5	0.326	1
36	Male	137	68	14	148	24.8	0.143	0
36	Male	128	68	19	180	30.5	1.391	1
37	Female	124	68	28	205	32.9	0.875	1
37	Female	80	66	30	0	26.2	0.313	0
37	Female	106	70	37	148	39.4	0.605	0
37	Male	155	74	17	96	26.6	0.433	1
37	Male	113	50	10	85	29.5	0.626	0
37	Male	109	80	31	0	35.9	1.127	1
38	Female	112	68	22	94	34.1	0.315	0
38	Female	99	80	11	64	19.3	0.284	0
38	Female	182	74	0	0	30.5	0.345	1
38	Male	115	66	39	140	38.1	0.15	0
38	Male	194	78	0	0	23.5	0.129	1
38	Male	129	60	12	231	27.5	0.527	0
39	Female	112	74	30	0	31.6	0.197	1
39	Female	124	70	20	0	27.4	0.254	1
39	Female	152	90	33	29	26.8	0.731	1
39	Male	112	75	32	0	35.7	0.148	0
39	Male	157	72	21	168	25.6	0.123	0
39	Male	122	64	32	156	35.1	0.692	1
40	Female	179	70	0	0	35.1	0.2	0
40	Female	102	86	36	120	45.5	0.127	1
40	Female	105	70	32	68	30.8	0.122	0
40	Male	118	72	19	0	23.1	1.476	0
40	Male	87	58	16	52	32.7	0.166	0
40	Male	95	60	18	58	23.9	0.26	0

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Figure 5

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41	Female	165	76	43	255	47.9	0.259	0
41	Female	115	76	0	0	31.2	0.343	1
41	Female	152	78	34	171	34.2	0.893	1
41	Male	178	84	0	0	39.9	0.331	1
41	Male	125	70	26	115	31.1	0.205	1
41	Male	0	80	32	0	41	0.346	1
42	Female	92	80	0	0	42.2	0.237	0
42	Female	137	84	0	0	31.2	0.252	0
42	Female	61	82	28	0	34.4	0.243	0
42	Male	90	62	12	43	27.2	0.58	0
42	Male	90	78	0	0	42.7	0.559	0
42	Male	165	88	0	0	30.4	0.302	1
43	Female	125	50	40	167	33.3	0.962	1
43	Female	129	0	30	0	39.9	0.569	1
43	Female	88	74	40	54	35.3	0.378	0
43	Male	196	76	36	249	36.5	0.875	1
43	Male	189	64	33	325	31.2	0.583	1
43	Male	158	70	0	0	29.8	0.207	0
44	Female	146	78	0	0	38.5	0.52	1
44	Female	147	74	25	293	34.9	0.385	0
44	Female	99	54	28	83	34	0.499	0
44	Male	124	72	0	0	27.6	0.368	1
44	Male	101	64	17	0	21	0.252	0
44	Male	81	86	16	66	27.5	0.306	0
45	Female	133	102	28	140	32.8	0.234	1
45	Female	173	82	48	465	38.4	2.137	1
45	Female	118	64	23	89	0	1.731	0
45	Male	84	64	22	66	35.8	0.545	0
45	Male	105	58	40	94	34.9	0.225	0
45	Male	122	52	43	158	36.2	0.816	0

SHRI GANESH LABORATORY Tirupattur

18/9/202

Figure 6

Shri Ganesh Laboratory

Multi Speciality Health Care Lab, Digital X-Ray & ECG

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TIRUPATTUR & DT. 635 601.
Phone : 04179 - 230366 Cell : 9894019983
Email :shriganeshlab@gmail.com

46	Female	140	82	43	325	39.2	0.528	1
46	Female	98	82	15	84	25.2	0.299	0
46	Female	87	60	37	75	37.2	0.509	0
46	Male	156	75	0	0	48.3	0.238	1
46	Male	93	100	39	72	43.4	1.021	0
46	Male	107	72	30	82	30.8	0.821	0
47	Female	125	70	24	110	24.3	0.221	0
47	Female	119	54	13	50	22.3	0.205	0
47	Female	116	74	29	0	32.3	0.66	1
47	Male	105	100	36	0	43.3	0.239	1
47	Male	144	82	26	285	32	0.452	1
47	Male	100	68	23	81	31.6	0.949	0
48	Female	100	66	29	196	32	0.444	0
48	Female	166	76	0	0	45.7	0.34	1
48	Female	131	64	14	415	23.7	0.389	0
48	Male	116	72	12	87	22.1	0.463	0
48	Male	143	84	23	310	42.4	1.076	0
48	Male	143	74	22	61	26.2	0.256	0
49	Female	138	60	35	167	34.6	0.534	1
49	Female	173	84	33	474	35.7	0.258	1
49	Female	97	68	21	0	27.2	1.095	0
49	Male	144	82	32	0	38.5	0.554	1
49	Male	83	68	0	0	18.2	0.624	0
49	Male	129	64	29	115	26.4	0.219	1
50	Female	148	72	35	0	33.6	0.627	1
50	Female	99	84	0	0	35.4	0.388	0
50	Female	151	78	32	210	42.9	0.516	1
50	Male	184	78	39	277	37	0.264	1
50	Male	94	0	0	0	0	0.256	0
50	Male	181	64	30	180	34.1	0.328	1

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18/9/2024

Figure 7

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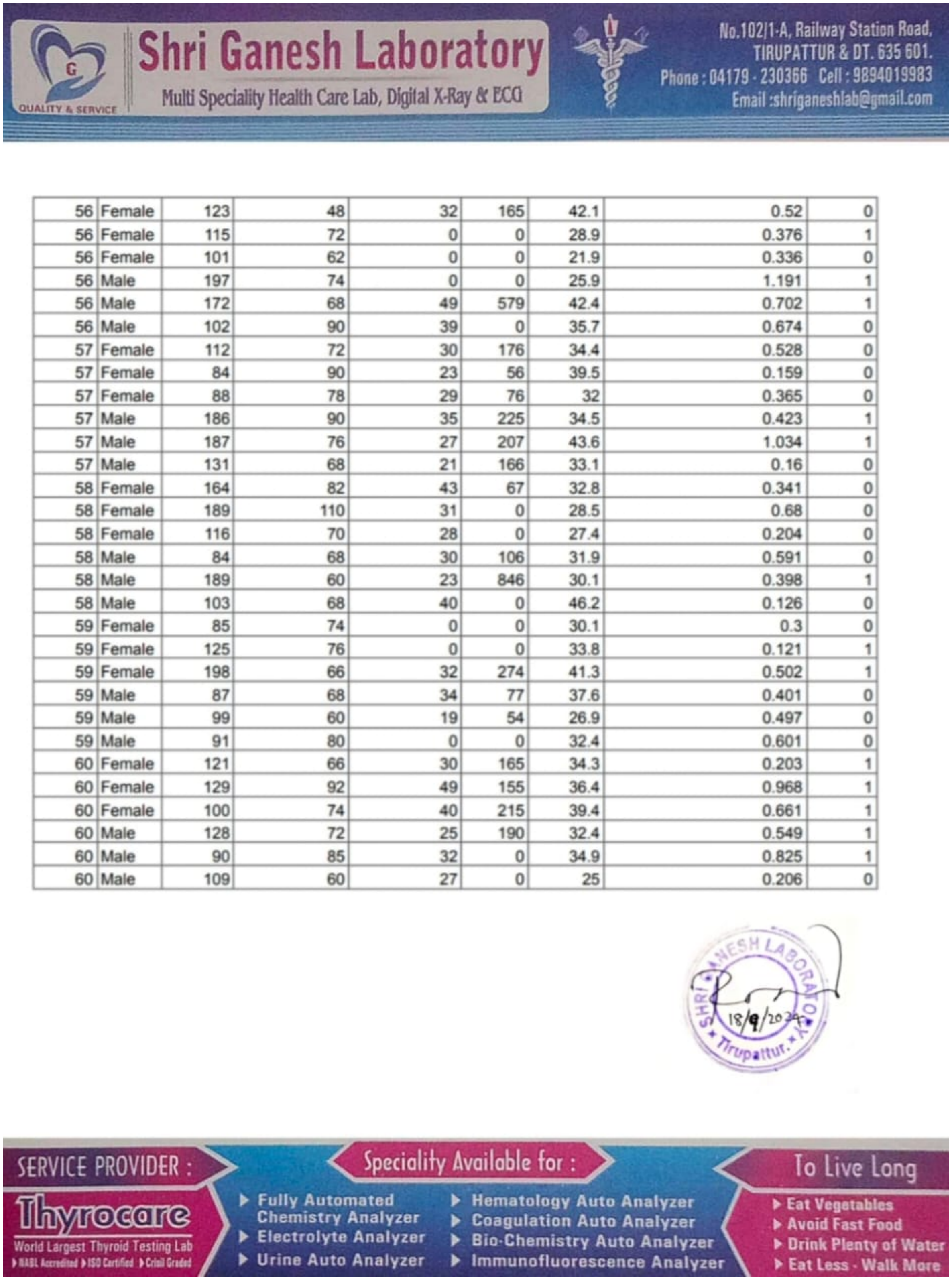
51	Female	143	94	33	146	36.6	0.254	1
51	Female	108	70	0	0	30.5	0.955	1
51	Female	117	62	12	0	29.7	0.38	1
51	Male	166	72	19	175	25.8	0.587	1
51	Male	180	78	63	14	59.4	2.42	1
51	Male	100	72	12	70	25.3	0.658	0
52	Female	95	80	45	92	36.5	0.33	0
52	Female	104	64	37	64	33.6	0.51	1
52	Female	120	74	18	63	30.5	0.285	0
52	Male	82	64	13	95	21.2	0.415	0
52	Male	134	70	0	0	28.9	0.542	1
52	Male	189	104	25	0	34.3	0.435	1
53	Female	197	70	45	543	30.5	0.158	1
53	Female	173	78	32	265	46.5	1.159	0
53	Female	99	72	17	0	25.6	0.294	0
53	Male	145	0	0	0	44.2	0.63	1
53	Male	135	68	42	250	42.3	0.365	1
53	Male	89	90	30	0	33.5	0.292	0
54	Female	125	96	0	0	0	0.232	1
54	Female	158	78	0	0	32.9	0.803	1
54	Female	127	58	24	275	27.7	1.6	0
54	Male	96	56	34	115	24.7	0.944	0
54	Male	131	66	40	0	34.3	0.196	1
54	Male	82	70	0	0	21.1	0.389	0
55	Female	193	70	31	0	34.9	0.241	1
55	Female	95	64	0	0	32	0.161	1
55	Female	137	61	0	0	24.2	0.151	0
55	Male	136	84	41	88	35	0.286	1
55	Male	72	78	25	0	31.6	0.28	0
55	Male	168	64	0	0	32.9	0.135	1

SHRI GANESH LABORATORY Tirupattur
18/9/20

Figure 8



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Shri Ganesh Laboratory

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56	Female	123	48	32	165	42.1	0.52	0
56	Female	115	72	0	0	28.9	0.376	1
56	Female	101	62	0	0	21.9	0.336	0
56	Male	197	74	0	0	25.9	1.191	1
56	Male	172	68	49	579	42.4	0.702	1
56	Male	102	90	39	0	35.7	0.674	0
57	Female	112	72	30	176	34.4	0.528	0
57	Female	84	90	23	56	39.5	0.159	0
57	Female	88	78	29	76	32	0.365	0
57	Male	186	90	35	225	34.5	0.423	1
57	Male	187	76	27	207	43.6	1.034	1
57	Male	131	68	21	166	33.1	0.16	0
58	Female	164	82	43	67	32.8	0.341	0
58	Female	189	110	31	0	28.5	0.68	0
58	Female	116	70	28	0	27.4	0.204	0
58	Male	84	68	30	106	31.9	0.591	0
58	Male	189	60	23	846	30.1	0.398	1
58	Male	103	68	40	0	46.2	0.126	0
59	Female	85	74	0	0	30.1	0.3	0
59	Female	125	76	0	0	33.8	0.121	1
59	Female	198	66	32	274	41.3	0.502	1
59	Male	87	68	34	77	37.6	0.401	0
59	Male	99	60	19	54	26.9	0.497	0
59	Male	91	80	0	0	32.4	0.601	0
60	Female	121	66	30	165	34.3	0.203	1
60	Female	129	92	49	155	36.4	0.968	1
60	Female	100	74	40	215	39.4	0.661	1
60	Male	128	72	25	190	32.4	0.549	1
60	Male	90	85	32	0	34.9	0.825	1
60	Male	109	60	27	0	25	0.206	0

SHRI GANESH LABORATORY
Tirupattur

Figure 9

61	Female	121	78	17	0	26.5	0.259	0
61	Female	100	76	0	0	38.7	0.19	0
61	Female	124	76	24	600	28.7	0.687	1
61	Male	93	56	11	0	22.5	0.417	0
61	Male	143	66	0	0	34.9	0.129	1
61	Male	103	66	0	0	24.3	0.249	0
62	Female	176	86	27	156	33.3	1.154	1
62	Female	73	0	0	0	21.1	0.342	0
62	Female	111	84	40	0	46.8	0.925	1
62	Male	112	78	50	140	39.4	0.175	0
62	Male	132	80	0	0	34.4	0.402	1
62	Male	150	78	29	126	35.2	0.692	1
63	Female	183	0	0	0	28.4	0.212	1
63	Female	188	82	14	185	32	0.682	1
63	Female	67	76	0	0	45.3	0.194	0
63	Male	89	24	19	25	27.8	0.559	0
63	Male	173	74	0	0	36.8	0.088	1
63	Male	174	58	22	194	32.9	0.593	1
64	Female	168	88	42	321	38.2	0.787	1
64	Female	105	80	28	0	32.5	0.878	0
64	Female	138	74	26	144	36.1	0.557	1
64	Male	106	72	0	0	25.8	0.207	0
64	Male	117	96	0	0	28.7	0.157	0
64	Male	68	62	13	15	20.1	0.257	0
65	Female	112	82	24	0	28.2	1.282	1
65	Female	119	0	0	0	32.4	0.141	1
65	Female	112	80	45	132	34.8	0.217	0
65	Male	145	82	18	0	32.5	0.235	1
65	Male	111	70	27	0	27.5	0.141	1
65	Male	199	76	43	0	42.9	1.394	1

SHRI GANESH LABORATORY
Tirupattur
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Figure 10

66	Female	167	106	46	231	37.6	0.165	1
66	Female	145	80	46	130	37.9	0.637	1
66	Female	121	78	39	74	39	0.261	0
66	Male	108	62	24	0	26	0.223	0
66	Male	156	86	0	0	24.8	0.23	1
66	Male	93	60	0	0	35.3	0.263	0
67	Female	121	52	0	0	36	0.127	1
67	Female	142	90	24	480	30.4	0.128	1
67	Female	89	62	0	0	22.5	0.142	0
67	Male	101	76	48	180	32.9	0.171	0
67	Male	122	70	27	0	36.8	0.34	0
67	Male	115	0	0	0	0	0.261	1
68	Female	127	46	21	335	34.4	0.176	0
68	Female	164	78	0	0	32.8	0.148	1
68	Female	93	64	32	160	38	0.674	1
68	Male	80	82	31	70	34.2	1.292	1
68	Male	162	84	0	0	27.7	0.182	0
68	Male	129	62	36	0	41.2	0.441	1
69	Female	81	74	41	57	46.3	1.096	0
69	Female	173	78	39	185	33.8	0.97	1
69	Female	92	52	0	0	30.1	0.141	0
69	Male	130	78	23	79	28.4	0.323	1
69	Male	95	60	32	0	35.4	0.284	0
69	Male	126	86	27	120	27.4	0.515	0
70	Female	65	72	23	0	32	0.6	0
70	Female	102	74	0	0	39.5	0.293	1
70	Female	120	80	37	150	42.3	0.785	1
70	Male	102	44	20	94	30.8	0.4	0
70	Male	109	58	18	116	28.5	0.219	0
70	Male	140	94	0	0	32.7	0.734	1

SHRI GANESH LABORATORY Tirupattur.
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Figure 11

4.2 IMPLEMENTATION OF SAW

Step 1: Categorize Dataset

- **Case 1:** The Dataset mentioned above[4.3] was obtained from the "ShriGanesh Laboratory, Tirupattur District."
- **Case 2:** The dataset from case 1, which contains the records of 300 people (150 males and 150 females), was gathered to determine which age group of people will be most susceptible to the emerging viral threats.

Step 2: The dataset was categorized by determining the average for each age group, as shown in table 1.

Age	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function
21-25	108.7667	61.7	21.66667	69.66666667	27.72	0.454167
26-30	110	60.4666667	21.6	67.6	30.45333	0.407167
31-35	114.0667	63.2	21.56666667	68.66666667	33.63	0.5344
36-40	125.9	67.16666667	20.8	72.46666667	30.63333	0.473233333
41-45	122.93333	70.73333333	21.46666667	94.43333333	33.36667	0.538066667
46-50	127	71.9	23.36666667	121.8666667	32.18667	0.492433333
51-55	129.8667	70.9	21.26666667	75.16666667	31.54	0.536233333
56-60	126.8333	73.96666667	25.6	126.6333333	33.84667	0.488066667
61-65	127.06667	66.66666667	17.3	67.93333333	32.29	0.4734
65-70	119	69.6	21.13333333	82.03333333	32.49	0.407366667

Table 1: Health Data by Age Group

Step 3: Fixing the weightage as 0.166 and multiplying it with the table 1, we the following table 2.

Age	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function
21-25	18.0552722	10.2422	3.59666722	11.56466667	4.60152	0.075391722
26-30	18.26	10.03746672	3.5856	11.2216	5.055253333	0.067589722
31-35	18.9350722	10.4912	3.580066667	11.39866667	5.58258	0.0887104
36-40	20.8994	11.14966667	3.4528	12.02946667	5.0853278	0.078556733
41-45	20.4069328	11.74173333	3.563466667	15.67593333	5.53866722	0.089319067
46-50	21.082	11.9354	3.878866667	20.22986667	5.3429872	0.081749333
51-55	21.5578672	11.7694	3.530266667	12.47766667	5.23564	0.089043133
56-60	21.0543328	12.27846667	4.2496	21.02113333	5.6184752	0.081019067
61-65	21.0930672	11.06666667	2.8718	11.27693333	5.36014	0.0785844
66-70	19.754	11.5536	3.508133333	13.61753333	5.39343	0.067622867

Table 2: Average Weightage by Age Group

Step 4: Ranking is given accruing to the result of total value, from minimum to maximum as shown in the table 3.

Age	Total	Ranking
21-25	48.13571781	10
26-30	48.22750978	9
31-35	50.07629593	8
36-40	52.69502285	6
41-45	57.0162524	3
46-50	62.55086449	2
51-55	54.65985529	4
56-60	64.30309906	1
61-65	51.74719162	7
66-70	53.89422953	5

Table 3: Total Score and Ranking by Age Group

From the above ranking we get to know that the diabetic people between the age 56-60 are the most susceptible for the emerging viral threats.

4.3 IMPLEMENTATION OF FUZZY TOPSIS

Step 1: Categorize Dataset

- **Case 1:** The Dataset mentioned above [4.2] was obtained from the "ShriGanesh Laboratory, Tirupattur District."
- **Case 2:** The dataset from case 1, which contains the records of 300 people (150 males and 150 females), was gathered to determine which age group of people will be most susceptible to the emerging viral threats.

Step 2: The dataset was categorized by determining the average for each age group, as shown in table 4.

Age	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function
21-25	108.7667	61.7	21.66667	69.66666667	27.72	0.454167
26-30	110	60.4666667	21.6	67.6	30.45333	0.407167
31-35	114.0667	63.2	21.56666667	68.66666667	33.63	0.5344
36-40	125.9	67.16666667	20.8	72.46666667	30.63333	0.473233333
41-45	122.93333	70.73333333	21.46666667	94.43333333	33.36667	0.538066667
46-50	127	71.9	23.36666667	121.8666667	32.18667	0.492433333
51-55	129.8667	70.9	21.26666667	75.16666667	31.54	0.536233333
56-60	126.8333	73.96666667	25.6	126.6333333	33.84667	0.488066667
61-65	127.06667	66.66666667	17.3	67.93333333	32.29	0.4734
65-70	119	69.6	21.13333333	82.03333333	32.49	0.407366667

Table 4: Health Data by Age Group

Step 3: Choosing Scale Point

- **Case 1:** By consider the column of affected diabetes (Outcome), the possibility of diabetes where fixed with the linguistic of the range [0,1]

RANGE	**REMARK**
$0 \leq$ POD	**Very Low**
$0.35 \leq$ POD ≤ 0.44	**Low**
$0.45 \leq$ POD ≤ 0.49	**Normal**
$0.50 \leq$ POD ≤ 0.59	**High**
$0.6 \leq$ POD	**Very High**

Table 5: Linguistic Value for the Possibility of Diabetes

- **Case 2:** Table 6 displays the linguistic values for the Affected Diabetes Patient as determined in step 1

AGE	**AFFECTED BY DIABETES**	**LINGUISTIC VALUE OF POD**
21-25	0.687875	Very High
26-30	0.43175	Low
31-35	0.667615	Very High
36-40	0.581538	High
41-45	0.619214	Very High
46-50	0.424923	Low
51-55	0.5585	High
56-60	0.615	Very High
61-65	0.57475	High
66-70	0.480533	Normal

Table 6: Linguistic Values

- **Case 3:** Scale point values are designed based on the linguistic values

Linguistic Value	**Scale Point**
Very Low	1
Low	2
Normal	3
High	4
Very High	5

Table 7: Scale Point

- **Case 4:** Based on the linguistic values the scaling point for the simplified dataset in Table 6 is indicated in Table 8

SCALE POINT	AFFECTED BY DIABETICS	LINGUISTIC VALUE OF POD
5	0.687875	Very High
2	0.43175	Low
5	0.667615	Very High
4	0.581538	High
5	0.619214	Very High
2	0.424923	Low
4	0.5585	High
5	0.615	Very High
4	0.57475	High
3	0.480533	Normal

Table 8: Simplified Dataset with Scale Points

Step 4: Fixing the weightage, beneficial and non-beneficial of the simplified dataset. The following step discusses the weighting, beneficial and non-beneficial value of the simplified dataset used to determine the ranking using the TOPSIS approach.

- **Case 1:**Determine the weighting for the factors such as blood sugar, blood pressure, skin thickness, insulin, scale point, body mass index and diabetes pedigree function as stated in Table 8.

FACTORS	WEIGHTAGE
Glucose	0.142
Blood Pressure	0.142
Skin Thickness	0.142
Insulin	0.142
Scale Point	0.142
BMI	0.142
Diabetes Pedigree Function	0.142

Table 9: Weightage

- **Case 2:** The terms “Beneficial” and “Non-Beneficial” refer to features that give more significance to certain factors and loss weight to others. In the case of diabetes, the insulin level determines whether the person has the diabetes rather than the other components. As indicated in Table 10, insulin is defined as beneficial in this paper whereas the other components are defined as not beneficial

- **Case 3:** In order to make all factors comparable, the normalization process can be calculated. There are two types of formula to calculate the normalization for the beneficial and non-beneficial for the TOPSIS method for the MCDM method such that,

FACTORS	BENEFICIAL / NON-BENEFICIAL
Glucose	Non-Beneficial
Blood Pressure	Non-Beneficial
Skin Thickness	Non-Beneficial
Insulin	Beneficial
Scale Point	Non-Beneficial
BMI	Non-Beneficial
Diabetes Pedigree Function	Non-Beneficial

Table 10: Beneficial / Non-Beneficial

$$\text{Beneficial} = \frac{x_{ij}}{\max\{x_{ij}\}} \quad \text{and} \quad \text{Non-Beneficial} = \frac{\min\{x_{ij}\}}{x_{ij}}$$

Age	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function	Scale Point
21-25	1	0.980010	0.798461	0.550144	1	0.896513	0.2
26-30	0.988788	1	0.800925	0.533824	0.910425	1	0.5
31-35	0.953535	0.956751	0.802163	0.542247	0.824264	0.761914	0.2
36-40	0.863913	0.900248	0.831730	0.572255	0.904896	0.860393	0.25
41-45	0.884761	0.854853	0.805900	0.745722	0.830769	0.756722	0.2
46-50	0.856430	0.840982	0.740370	0.962358	0.861226	0.826846	0.5
51-55	0.837525	0.852844	0.813479	0.593577	0.878883	0.753909	0.2
56-60	0.857556	0.817485	0.675781	1	0.819897	0.834424	0.2
61-65	0.855981	0.907000	1	0.536456	0.858470	0.860090	0.25
66-70	0.914005	0.868773	0.818611	0.647802	0.853185	0.999509	0.3333

Table 11: Normalization

Step 5: Ranking

The primary objective of this study is to identify the age group of females affected by diabetes using the ranking method of TOPSIS method in the manner described in the stages below,

- **Case 1:** As indicated in table 12, the weightage value is multiplied by normalized dataset.

Age	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function	Scale Point
21-25	0.142	0.139161	0.113381	0.078120	0.142	0.127305	0.0284
26-30	0.140408	0.142	0.113731	0.075803	0.129255	0.145	0.071
31-35	0.135402	0.135859	0.113907	0.076999	0.117045	0.108192	0.0284
36-40	0.122676	0.127835	0.118106	0.081260	0.128495	0.122175	0.0355
41-45	0.125636	0.121389	0.114438	0.105892	0.117996	0.107454	0.0284
46-50	0.121613	0.119419	0.105132	0.136654	0.122294	0.117412	0.071
51-55	0.118928	0.121104	0.115514	0.084288	0.124801	0.107822	0.0355
56-60	0.121772	0.116082	0.095960	0.142	0.116296	0.118463	0.0284
61-65	0.121549	0.128764	0.142	0.076177	0.121903	0.122133	0.0355
66-70	0.129789	0.123366	0.116243	0.091988	0.121152	0.141930	0.0473

Table 12: Normalization * Weightage

- **Case 2:** As seen in the Table 13, in the total value is determined for each row in accordance with the age group that is specified.

Age	Glucose	Blood Pressure	Skin Thickness	Insulin	BMI	Diabetes Pedigree Function	Scale Point	Total
21-25	0.142	0.139161	0.113381	0.078120	0.142	0.127305	0.0284	0.77037
26-30	0.140408	0.142	0.113731	0.075803	0.129255	0.145	0.071	0.81719
31-35	0.135402	0.135859	0.113907	0.076999	0.117045	0.108192	0.0284	0.71580
36-40	0.122676	0.127835	0.118106	0.081260	0.128495	0.122175	0.0355	0.73605
41-45	0.125636	0.121389	0.114438	0.105892	0.117969	0.107454	0.0284	0.72118
46-50	0.121613	0.119419	0.105132	0.136654	0.122294	0.117412	0.071	0.79352
51-55	0.118928	0.121104	0.115514	0.084288	0.124801	0.107822	0.0355	0.70796
56-60	0.121772	0.116082	0.095960	0.142	0.116296	0.118463	0.0284	0.73897
61-65	0.121549	0.128764	0.142	0.076177	0.121903	0.122133	0.0355	0.74803
66-70	0.129789	0.123366	0.116243	0.091988	0.121152	0.141930	0.0473	0.77177

Table 13: Total Value

- **Case 3:** Ranking is given accruing to the result of total value, from minimum to maximum as shown in the table 14.

AGE	TOTAL	RANKING
21-25	0.77037	4
26-30	0.81719	1
31-35	0.71580	9
36-40	0.73605	7
41-45	0.72118	8
46-50	0.79352	2
51-55	0.70796	10
56-60	0.73897	6
61-65	0.74803	5
66-70	0.77177	3

Table 14: Ranking

From the above ranking we get to know that the diabetic people between the age 26-30 are the most susceptible for the emerging viral threats.

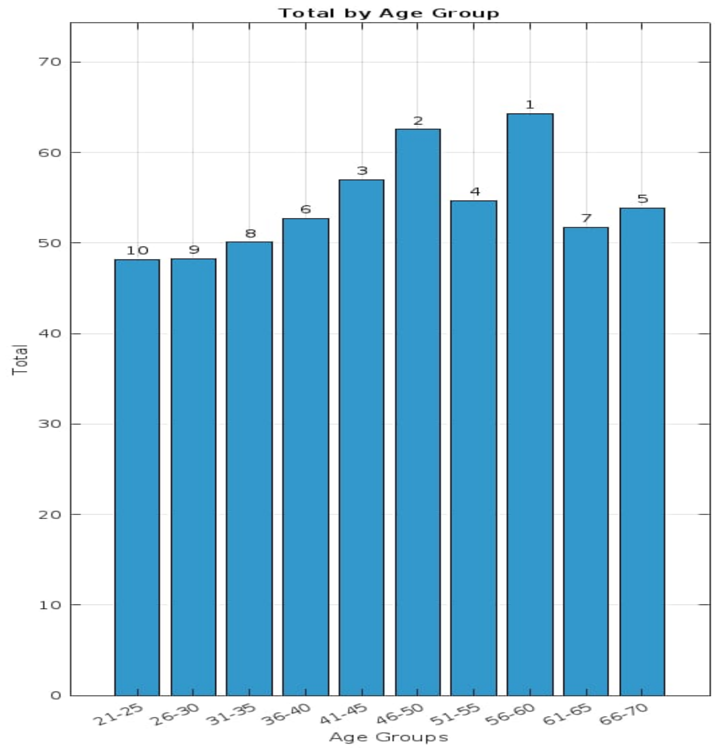
4.4 MATLAB VISUALIZATION

Utilizing the MATLAB language, a 2-Dimension graph is created to visualize the people age group in connection to the ranking of SAW. The MATLAB code given below is used to plot the graph to show the age distribution of diabetic people who are susceptible to emerging viral threats. For the average of people age and rank is taken as input.

4.4.1 SAW MATLAB CODING:

```
% Data
ageGroups = {'21-25', '26-30', '31-35', '36-40', '41-45', '46-50',
'51-55', '56-60', '61-65', '66-70'};
totalValues = [48.13571781, 48.22750978, 50.07629593, 52.69502285, 57.0162524,
        62.55086449, 54.65985529, 64.30309906, 51.74719162, 53.89422953];
rankings = [10, 9, 8, 6, 3, 2, 4, 1, 7, 5];
% Create a bar graph
figure;
bar(totalValues, 'FaceColor', [0.2 0.6 0.8]); % Customize color if needed
set(gca, 'XTickLabel', ageGroups); % Set x-axis labels
xlabel('Age Groups');
ylabel('Total');
title('Total by Age Group');
grid on;
% Annotate with rankings
for i = 1:length(rankings)
    text(i, totalValues(i) + 1, num2str(rankings(i)), ...
        'HorizontalAlignment', 'center', 'Color', 'black');
end
% Adjust Y-axis limits for better visualization
ylim([0 max(totalValues) + 10]);
```

OUTPUT

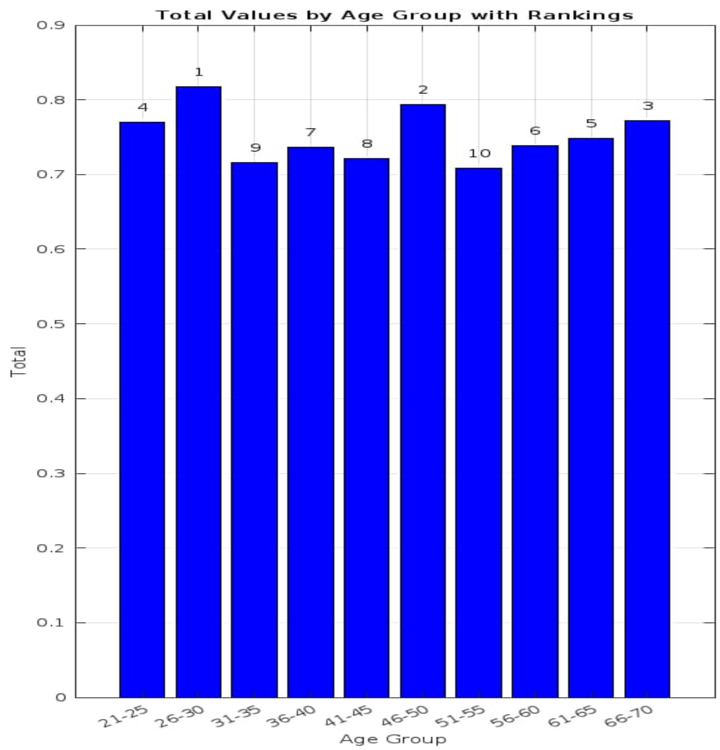


4.4.2 TOPSIS MATLAB CODING:

Utilizing the MATLAB language, a 2-Dimension graph is created to visualize the people age group in connection to the ranking using TOPSIS method's MCDM process. The MATLAB code given below is used to plot the graph to show the age distribution of diabetic people who are susceptible to emerging viral threats. For the average of people age and rank is taken as input.

```
% Data
age_groups = {'21-25', '26-30', '31-35', '36-40', '41-45',
              '46-50', '51-55', '56-60', '61-65', '66-70'};
total_values = [0.77037, 0.81719, 0.71580, 0.73605, 0.72118,
                0.79352, 0.70796, 0.73897, 0.74803, 0.77177];
rankings = [4, 1, 9, 7, 8, 2, 10, 6, 5, 3];
% Create the bar graph
figure;
bar(total_values, 'b');
% Set the x-tick labels
set(gca, 'XTickLabel', age_groups);
% Title and labels
title('Total Values by Age Group with Rankings');
xlabel('Age Group');
```

OUTPUT




```
ylabel('Total');
% Display rankings on the bars
for i = 1:length(total_values)
    text(i, total_values(i) + 0.02, num2str(rankings(i)), '
  HorizontalAlignment', 'center');
end
% Display grid
grid on;
% Show the figure
hold off;
```

4.5 COMPARISION OF SAW AND FUZZY TOPSIS

1. **Methodology:**

    - **SAW :** This method aggregates scores of alternatives across multiple criteria by summing the weighted normalized scores. It is straightforward and easy to implement.
    - **Fuzzy TOPSIS :** This method evaluates alternatives based on their distance from an ideal solution. It incorporates fuzzy logic to handle uncertainty and imprecision in data.

2. **Handling Uncertainty:**

   - **SAW:** While it can use fuzzy numbers, it generally requires precise values for the decision matrix, making it less effective in environments with high uncertainty.
   - **Fuzzy TOPSIS:** Specifically designed to manage fuzzy data, it effectively incorporates uncertainty, making it more suitable for applications where data may be imprecise, such as predicting diabetic vulnerability.

3. **Decision Criteria:**

   - **SAW:** Requires clearly defined criteria and works well when these criteria are independent. It may struggle with interrelated criteria..
   - **Fuzzy TOPSIS:** Can handle correlated criteria more efficiently by comparing the distance to both the ideal and negative-ideal solutions, allowing for more nuanced decision-making.

4. **Application Suitability:**

   - **SAW:** Best suited for simpler problems with well-defined metrics. It may provide quick results but can overlook subtleties in complex scenarios.
   - **Fuzzy TOPSIS:** More appropriate for complex decision-making situations like assessing diabetic vulnerability where multiple overlapping factors and uncertainties exist.

Suggested Method for Predicting Diabetic Vulnerability

Given the complexities involved in assessing diabetic vulnerability in the context of emerging viral threats, **Fuzzy TOPSIS** is recommended. Its ability to manage uncertainty, evaluate interrelated criteria, and provide a robust ranking of alternatives makes it more effective for this application. By incorporating fuzzy logic, the method can accommodate the varying degrees of risk associated with different factors, leading to more accurate and informed decision-making.

4.6 DEVELOPED PYTHON CODING FOR TOPSIS METHOD

Simple software creation using python:

```
age=input("Enter the age :")
gulcose=float(input("\nEnter the value of Glucose :"))
blood_pressure=float(input("\nEnter the value of blood pressure :"))
skin_thickness=float(input("\nEnter the value of skin thickness :"))
insulin=float(input("\nEnter the value of insulin :"))
bmi=float(input("\nEnter the value of BMI :"))
```

```python
diabetes_pedigree_function=float(input("\nEnter the value of Diabetes Pedigree Function :"))


affected_by_diabetes=float(input("\nEnter the value of Affected by diabetes :"))

#lingustic value
if (0<=affected_by_diabetes<=0.34):
    print(age)
    print("\n",affected_by_diabetes)
    print("\nVery Low")
    l=("Very low")
elif (0<=affected_by_diabetes<=0.44):
    print(age)
    print("\n",affected_by_diabetes)
    print("\nLow")
    l=("Low")
elif (0.45<=affected_by_diabetes<=0.49):
    print(age)
    print("\n",affected_by_diabetes)
    print("\nNormal")
    l=("Normal")
elif (0.50<=affected_by_diabetes<=0.59):
    print(age)
    print("\n",affected_by_diabetes)
    print("\nHigh")
    l=("High")
else :
    print(age)
    print("\n",affected_by_diabetes)
    print("\nVery High")
    l=("Very high")

#scale point
if(l=="Very low"):
    scale_point=1
elif(l=="Low"):
    scale_point=2
elif(l=="Normal"):
    scale_point=3
elif(l=="High"):
    scale_point=4
elif(l=="Very high"):
    scale_point=5
else:
    print("\nInvalid function")

print("\nScale point :",scale_point)
```

```
print("\nAffected by diabetics :",affected_by_diabetes)
print("\nlinguistic value of POD :",l)

weightage=0.142
weightage=float(weightage)

print("\nGlucose = Non-Benificial")
print("\nBlood Pressure = Non-Benificial")
print("\nSkin thicness = Non-Benificial")
print("\nInsulin = Benificial")
print("\nScale Point = Non-Benificial")
print("\nBMI = Non-Benificial")
print("\nDiabetes Pedigree Function = Non-Benificial")

max_insulin=float(input("\nEnter the maximum value of insuline :"))
min_glucose=float(input("\nEnter the minimam value of glucose :"))
min_blood_pressure=float(input("\nEnter the minimum value of Blood
    Pressure :"))
min_skin_thickness=float(input("\nEnter the minimum value of Skin
    thickness :"))
min_scale_point=float(input("\nEnter the minimum value of Scale point
    :"))
min_bmi=float(input("\nEnter the minimum value of BMI :"))
min_diabetes=float(input("\nEnter the minimum value of Diabetes
    pedigree function :"))

a=(min_glucose/gulcose)
a=float(a)
b=(min_blood_pressure/blood_pressure)
b=float(b)
c=(min_skin_thickness/skin_thickness)
c=float(c)
d=(insulin/max_insulin)
d=float(d)
e=(min_scale_point/scale_point)
e=float(e)
f=(min_bmi/bmi)
f=float(f)
g=(min_diabetes/diabetes_pedigree_function)
g=float(g)

print("\nAge :",age)
print("\nGlucose :",a)
print("\nBlood pressure :",b)
print("\nSkin thickness :",c)
print("\nInsulin :",d)
print("\nBMI :",f)
print("\nDiabetes prdigree function :",g)
print("\nScale point :",e)
```

```
h=(a*weightage)
h=float(h)
i=(b*weightage)
i=float(i)
j=(c*weightage)
j=float(j)
k=(d*weightage)
k=float(k)
m=(e*weightage)
m=float(m)
n=(f*weightage)
n=float(n)
o=(g*weightage)
o=float(o)

print("\nAge :",age)
print("\nGlucose :",h)
print("\nBlood pressure :",i)
print("\nSkin thickness :",j)
print("\nInsulin :",k)
print("\nBMI :",n)
print("\nDiabetes prdigree function :",o)
print("\nScal_point:",m)

total=(h+i+j+k+m+n+o)
total=float(total)

print("\n",age)
print("Total:",total)
```

Output:

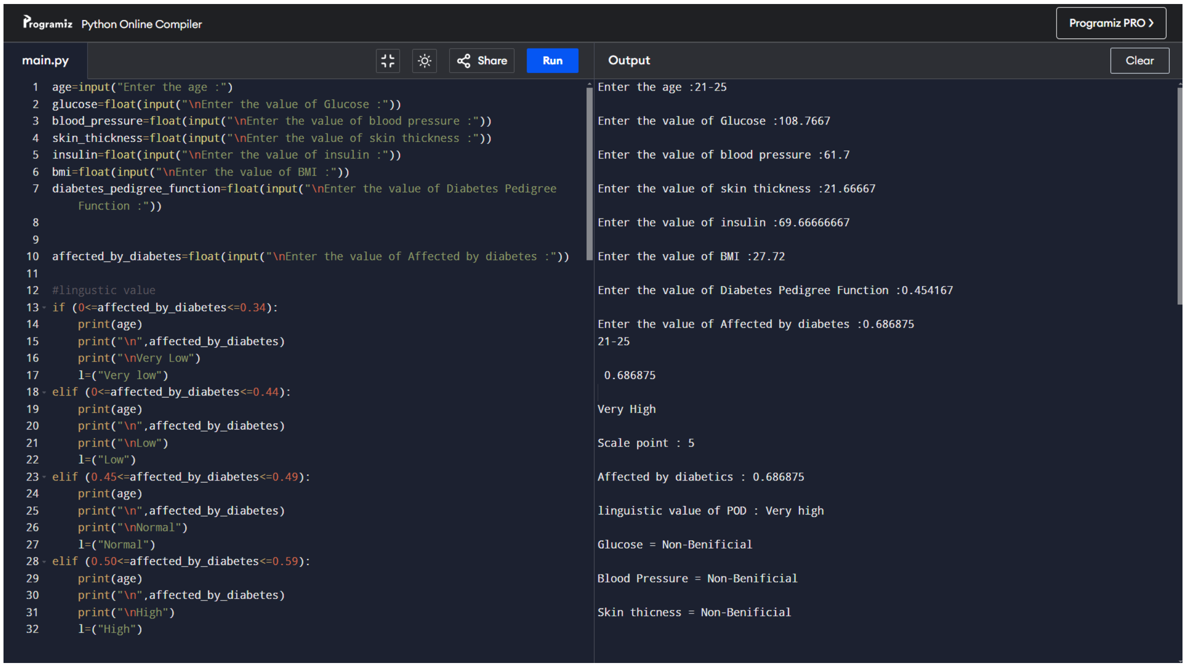


Figure 12

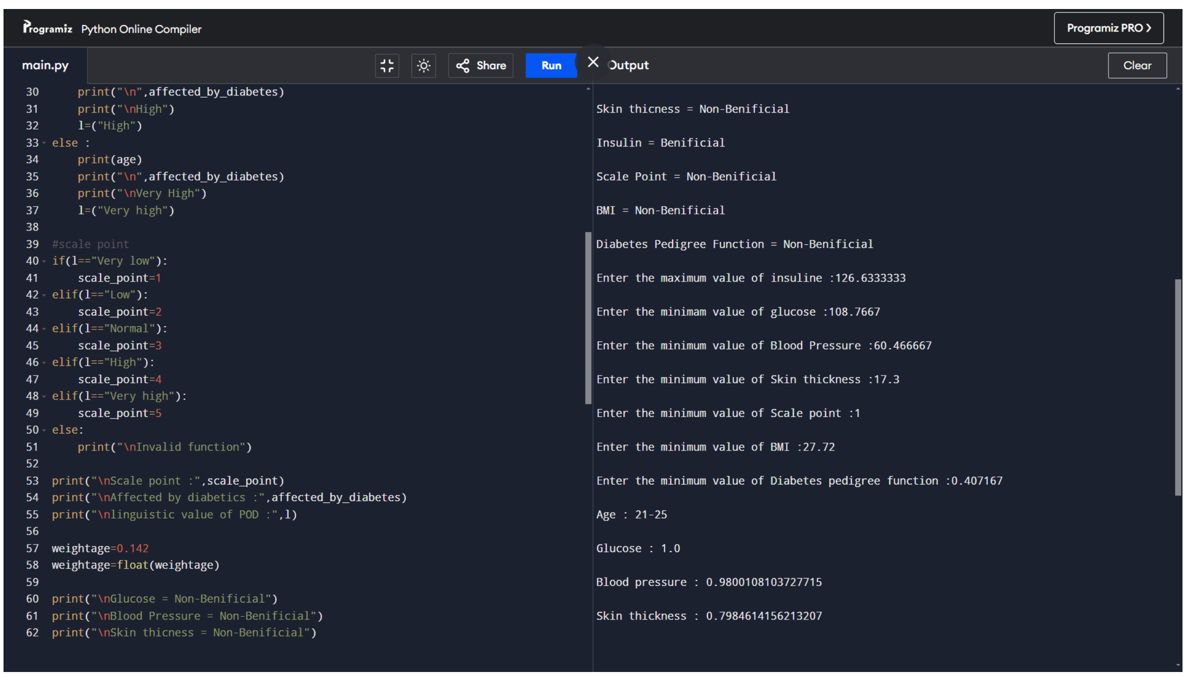


Figure 13

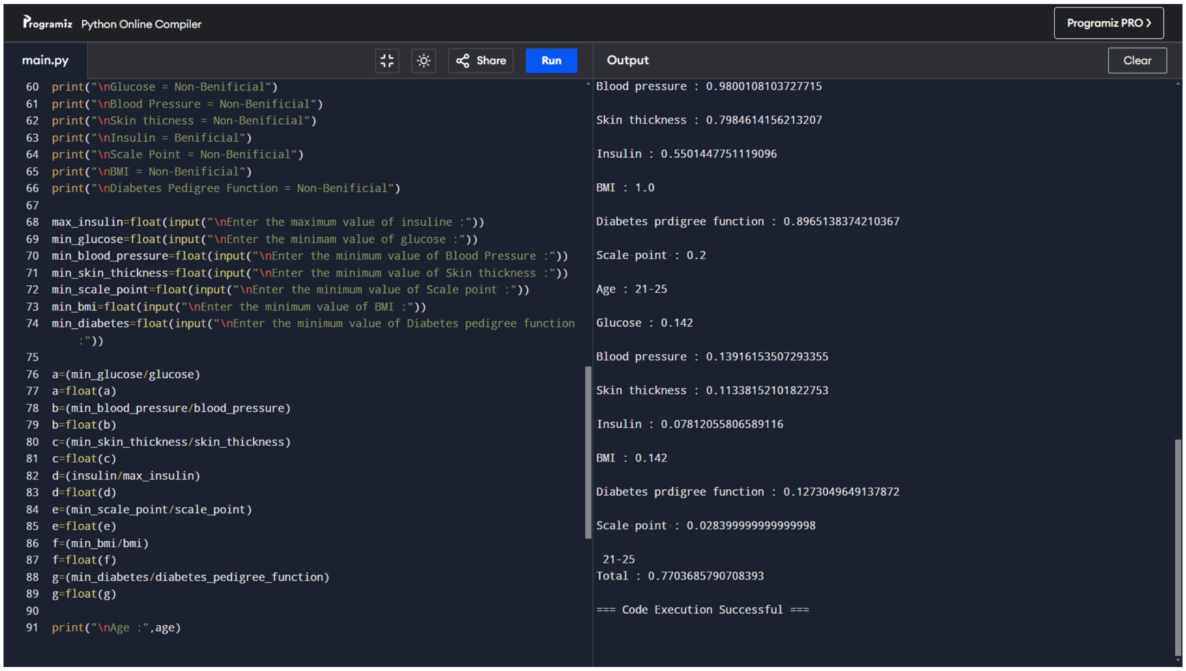


Figure 14

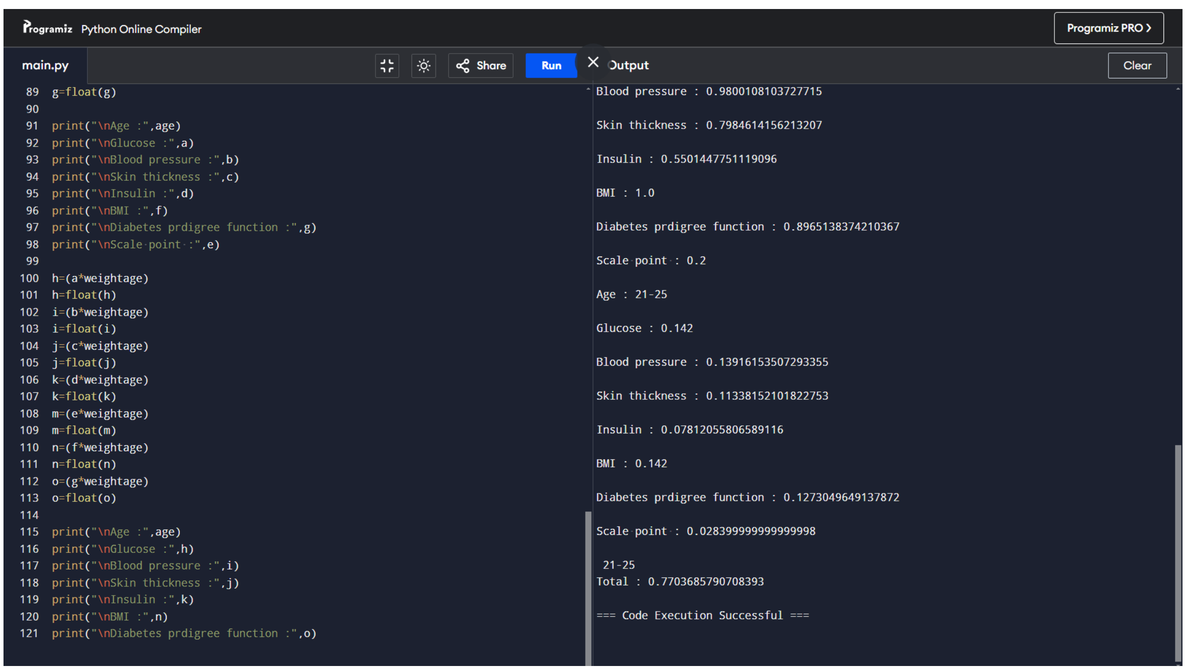


Figure 15

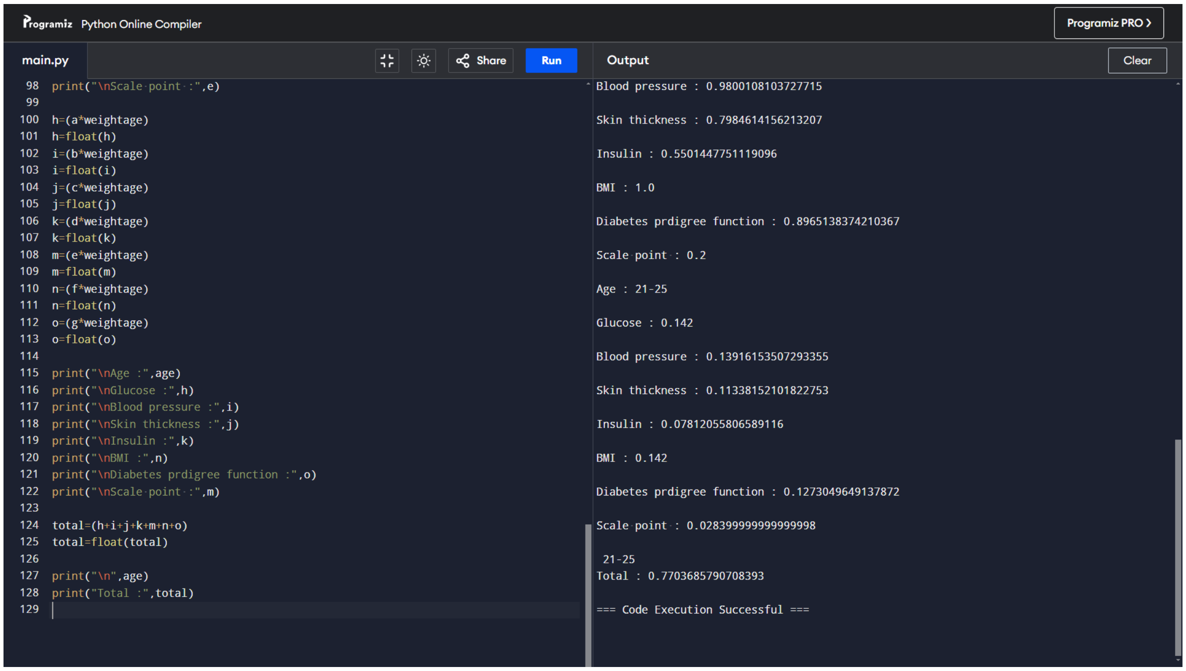


Figure 16

4.7 SUGGESTIONS FOR CONTROL AND PREVENTION

Preventing viral threats in diabetic patients requires a holistic approach that incorporates dietary choices, lifestyle modifications, and mental well-being practices[3]. Here are some detailed suggestions:

1. **Nutritional Strategies**

   (a) **Balanced Diet**

   - **Focus on Whole Foods:** Emphasize vegetables, whole grains, lean proteins, and healthy fats. This helps maintain stable blood sugar levels and overall health.
   - **Low Glycemic Index Foods:** Choose foods with a low glycemic index (e.g., legumes, nuts, and most vegetables) to prevent spikes in blood sugar.
   - **Adequate Hydration:** Drink plenty of water. Staying hydrated helps the immune system function properly.

   (b) **Nutritional Supplements**

   - **Vitamins and Minerals:** Consider supplements like vitamin C, vitamin D, and zinc, which can boost immune function. Consult a healthcare provider before starting any new supplements.
   - **Probiotics:** Foods rich in probiotics (like yogurt and fermented vegetables) may enhance gut health, which plays a role in immune response.

2. **Regular Physical Activity**

    - **Exercise Routine:** Engage in regular physical activity such as walking, cycling, or swimming for at least 150 minutes a week. Exercise helps control blood sugar and enhances immune function.
    - **Strength Training:** Incorporate resistance training 2-3 times a week to improve muscle mass and insulin sensitivity.

3. **Stress Management and Mental Well-being**

    (a) **Meditation and Mindfulness**

    - **Daily Meditation:** Practicing mindfulness meditation for 10-20 minutes daily can reduce stress and improve mental clarity, which is beneficial for diabetes management.
    - **Deep Breathing Exercises:** Engage in deep breathing exercises to promote relaxation and reduce anxiety, which can impact blood sugar levels..

    (b) **Yoga and Tai Chi**

    - **Gentle Movement Practices:** Incorporate yoga or tai chi into your routine. These practices help reduce stress, improve flexibility, and can aid in blood sugar control.

4. **Sleep Hygiene**

    - **Prioritize Sleep:** Aim for 7-9 hours of quality sleep per night. Poor sleep can negatively affect blood sugar levels and immune function.
    - **Sleep Routine:** Maintain a consistent sleep schedule and create a restful environment by minimizing light and noise.

5. **Preventive Healthcare Measures**

    - **Regular Check-ups:** Schedule routine appointments with healthcare providers to monitor blood sugar levels and overall health.
    - **Vaccinations:** Stay updated on vaccinations, including flu and pneumonia vaccines, which are crucial for diabetic patients.

6. **Hygiene Practices**

    - **Hand washing:** Practice good hand hygiene by washing hands frequently, especially before meals and after being in public places.

- **Avoiding Crowded Places:** During outbreaks, limit exposure to crowded areas to reduce the risk of infection.

7. **Educating and Empowering Patients**

    - **Awareness Programs:** Participate in educational workshops or webinars that focus on diabetes management and viral prevention strategies.
    - **Support Groups:** Engage in community support groups to share experiences and strategies with other diabetic patients.

8. **Healthy Snacking**

    - **Smart Snack Choices:** Opt for healthy snacks like nuts, seeds, or cut vegetables. Avoid high-sugar snacks that can cause blood sugar spikes and weaken the immune system.

CONCLUSION

This project demonstrates the effectiveness of integrating SAW and Fuzzy TOPSIS methodologies to assess the vulnerability of specific age groups to diabetes in the context of emerging viral threats. By analyzing real-time health data, critical metrics influencing susceptibility were identified, enhancing decision-making accuracy in public health contexts. The comparative analysis revealed the respective strengths of these techniques, with Fuzzy TOPSIS emerging as the superior method for this type of analysis.

Further the development of software using Python code has significantly expedited the generation of results, enabling swift predictions. This project not only contributes to the field of public health but also offers a robust framework for decision-making across diverse sectors, emphasizing the far-reaching impact of interdisciplinary approaches in addressing contemporary challenges.

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