Research Article

AN EXTENDED ENTROPY MEASURE FOR INTERVAL-VALUED PICTURE FUZZY NUMBERS: APPLICATION TO DEPRESSION FACTORS AMONG WORKING WOMEN

Prabakaran RAMACHANDIRAN

Department of Mathematics, St. Joseph's Institute of Technology, Chennai, India
prabaperception@gmail.com , ORCID: 0000-0002-2520-8727

Kalaiselvan SAMAYAN

Department of Social Work, SRMX College of Arts and Science, Coimbatore – 641046
kalaiselvan@rmv.ac.in, ORCID: 0000-0002-7214-7752

Dragan PAMUCAR

Department of Operations Research and Statistics, Faculty of Organizational Sciences,
University of Belgrade, Belgrade, Serbia; Faculty of Engineering, Dogus University,
Istanbul, Türkiye; Department of Applied Mathematical Science, College of Science and
Technology, Korea University, Sejong 30019, Republic of Korea
dragan.pamucar@fon.bg.ac.rs, ORCID: 0009-0004-2488-9403

Narayanamoorthy SAMAYAN*

Department of Mathematics, Bharathiar University, Coimbatore – 641046, India
snmphd@buc.edu.in, ORCID: 0000-0002-3782-4666

Abstract: In recent years, the mental well-being of working women has emerged as a critical concern due to increasing psychological stress and societal expectations. This study proposes a novel extended entropy measure tailored for Interval-Valued Picture Fuzzy Numbers (IVPFNs) to effectively model and analyze uncertainty in decision-

---

*Corresponding author

making scenarios involving ambiguous and imprecise information. The proposed entropy measure captures the intricate degrees of membership, non-membership, and neutral values inherent in PFNs, providing a more comprehensive understanding of data complexity. To demonstrate the applicability of the proposed measure, a real-world case study was conducted focusing on depression among working women. A total of 15 key depression-related factors were evaluated under four criteria: psychological, social, environmental, and occupational, using expert opinion expressed in linguistic terms converted to T2PFNs. The decision matrix was analyzed using three widely-used distance-based Multi-Criteria Decision-Making (MCDM) methods: TOPSIS, VIKOR, and WASPAS. A sensitivity analysis was performed to assess the stability and robustness of the rankings under varying decision scenarios. The results reveal the most influential factors contributing to depression in working women, offering valuable insights for policymakers, healthcare professionals, and organizational management. The integration of the extended entropy measure enhances the discrimination power of the decision model and supports more reliable prioritization in fuzzy decision-making environments.

1. INTRODUCTION

In today's fast-paced and competitive world, women have increasingly assumed significant roles in the workforce in all sectors. Although this reflects progress toward gender equality and empowerment [1], it also presents a complex network of challenges. Working women, particularly those juggling professional responsibilities with family or societal expectations, face high levels of stress [2]. This stress is multifaceted, with roots in personal, organizational, and social domains, often leading to serious health and psychological issues. Moreover, assessing the exact level of stress experienced by women remains uncertain due to subjective perceptions, varied environments, and individual coping mechanisms [3].

Working women often experience significant stress due to multiple overlapping responsibilities, including professional duties, family care, and societal expectations. Common risk factors include work-life imbalance, job insecurity, gender discrimination, childcare burdens, and lack of support at the workplace. However, the level of stress experienced by each woman can vary greatly, making it difficult to measure with precision. This is because stress is highly subjective and influenced by individual tolerance, emotional resilience, personal background, and situational context [4]. As a result, there is an inherent uncertainty in identifying and quantifying the exact stress level. Traditional assessment tools may not fully capture this complexity, especially when responses are vague or expressed in terms such as "sometimes stressed" or "very often anxious." Therefore, advanced methods—such as fuzzy logic or uncertainty-based models—are needed to deal with this imprecision and offer a more accurate evaluation of stress levels among working women.

To address this uncertainty in measuring stress levels among working women, fuzzy

set theory becomes a valuable tool, as it can handle imprecise, vague, and linguistic information effectively. In particular, interval-valued fuzzy sets allow for the representation of uncertainty by defining membership degrees as intervals rather than fixed values, capturing the variability in individual perceptions of stress. Furthermore, picture fuzzy sets extend this idea by incorporating three parameters—positive, neutral, and negative membership degrees—offering a more comprehensive and realistic modeling of human judgment under uncertainty [5]. These models are especially useful in psychological assessments where individuals may partially agree, partially disagree, or remain uncertain about their stress levels. By applying such advanced fuzzy frameworks, researchers and decision-makers can gain deeper insights into the mental health conditions of working women and design more effective interventions tailored to their specific stress profiles.

To further enhance the analysis of stress levels under uncertainty, it is also essential to incorporate novel entropy measures tailored to fuzzy environments. Entropy, in this context, serves as a quantitative tool to evaluate the degree of uncertainty, hesitation, or fuzziness present in the data [6]. When dealing with interval-valued and picture fuzzy sets, traditional entropy measures may fall short in capturing the full spectrum of ambiguity involved in human emotions and psychological states. Therefore, extended or newly developed entropy measures—specifically designed for interval-valued and picture fuzzy environments—are crucial [7]. These novel entropy models can effectively quantify the level of disorder or uncertainty in the responses, helping to identify the most critical risk factors contributing to stress. By integrating these entropy measures with fuzzy frameworks, a more nuanced and accurate decision-making model can be developed, ultimately supporting better mental health strategies for working women.

This work utilised TOPSIS [8], VIKOR [9], and WASPAS [10] for better rankings of risk factors of women's depression.

1.1. Literature survey on fuzzy environment

Fuzzy set theory, first introduced by [11], marked a paradigm shift in modeling uncertainty and imprecision in real-world decision-making. Unlike classical binary logic, fuzzy sets allow partial membership ranging between 0 and 1, enabling a more flexible representation of vague concepts such as "tall", "hot", or "likely".

Over time, this foundational theory gave rise to several extensions. One of the earliest was the Intuitionistic fuzzy set (IFS), introduced by [12], which incorporates both membership and non-membership degrees, with an additional parameter to represent hesitation. The condition $\mu + v \leq 1$ allows modeling of incomplete information, offering more expressive power than traditional fuzzy sets.

To further address situations where the sum of membership and non-membership may not capture uncertainty sufficiently, [13] introduced Pythagorean Fuzzy Sets (PFSs), which satisfy the condition $\mu^2 + v^2 \leq 1$. This generalization allows decision-makers to represent more nuanced beliefs with a larger feasible space for modeling.

While IFSs and PFSs accounted for uncertainty and hesitation, they did not fully express neutral or refusal opinions. This led to the introduction of Picture Fuzzy Sets (PFSs) by [14], which added a third component—the neutral membership degree—alongside traditional membership and non-membership. The key condition for PFSs is $\mu + v + \pi \leq 1$,

where μ is the degree of positive membership, ν is the degree of negative membership, and π is the degree of neutrality or refusal.

PFS are especially useful in social science, behavioral analysis, and decision-making domains where individuals may not only agree or disagree but also remain neutral or hesitant. Their ability to explicitly handle neutrality makes them more suitable for applications involving surveys, expert judgments, and group decisions.

Building on this concept, [15] extended PFS to the interval-valued domain and proposed hybrid aggregation operators for linguistic group decision-making. These extensions are important in practical settings where expert opinions are expressed with linguistic uncertainty and hesitation.

In summary, the progression from fuzzy sets to intuitionistic, Pythagorean, and eventually picture fuzzy sets reflects an ongoing effort to more accurately model the complexity of human judgment. PFS, with their tri-component structure, offer a robust framework for handling nuanced and incomplete information in MCDM problems [16].

1.2. Literature survey on recent works

Recent years have witnessed significant advancements in the field of fuzzy set theory and its extensions, particularly in the context of decision-making under uncertainty. Researchers have explored various models and methods to enhance the representation of vagueness, imprecision, and hesitancy in expert judgments. This literature review highlights key contributions and developments that have shaped current methodologies and applications.

Table 1: Literature review on recent works

Articles	Contribution
[17]	It introduced a novel approach to solving MADM problems using interval-valued picture fuzzy graphs (IVPFGs). It effectively models uncertainty and hesitation in decision data by incorporating picture fuzzy information. The work enhances decision-making accuracy by utilizing graph-based representations under interval-valued picture fuzzy environments.
[18]	It introduced interval-valued (p, q, r)-spherical fuzzy sets, extending traditional fuzzy models to better handle uncertainty and hesitancy in decision-making. They developed new aggregation operators and adapted the TOPSIS method within this framework. The proposed approach was applied to both MCGDM and MCDM problems, demonstrating improved accuracy and flexibility.
[19]	It introduced an integrated design concept evaluation model that leverages interval-valued picture fuzzy sets to handle uncertainty and vagueness in expert assessments more effectively. The study enhances the grey relational projection (GRP) method by incorporating improved weighting and aggregation techniques tailored for fuzzy environments. This integrated approach provides a more accurate and robust framework for evaluating complex design concepts in engineering and decision-making contexts.

Table 1 – continued from previous page

Articles	Contribution
[20]	It introduced an interval-valued picture fuzzy uncertain linguistic aggregation operator to better handle ambiguity in decision-making. It is specifically applied to the supplier selection process in logistics service value concretization. The proposed method improves decision accuracy by capturing uncertainty and linguistic hesitancy in expert judgments.
[21]	It presented a dynamic multi-attribute decision-making (DMADM) model using interval-valued picture fuzzy geometric Heronian mean operators. This approach effectively aggregates uncertain, hesitant, and imprecise information in time-varying environments. The model is particularly useful for making informed decisions where attributes and preferences change dynamically.
[22]	It proposed a new ranking method for IVIFNs to enhance decision-making accuracy. This method addresses limitations in existing ranking techniques by providing more consistent and reliable comparisons of IVIFNs. It is effectively applied to MCDM problems, demonstrating improved performance in complex decision environments.
[23]	It presented a decision-making framework using IVPFSs to rank psychological risk factors affecting college students. It employs various aggregation operators and MCDM techniques to process uncertain, imprecise, and hesitant information collected from student surveys. The proposed model effectively identifies and prioritizes key psychological stressors, aiding in targeted interventions for student mental well-being.
[24]	It introduced a novel interval-valued picture q-rung orthopair fuzzy decision-making model to address the complex problem of selecting electric vehicle battery charging technologies. It integrates fuzzy logic with advanced MCDM to handle uncertainty and imprecision in expert evaluations. The proposed model enhances the accuracy and robustness of decision-making in the emerging field of sustainable transportation.
[25]	It proposed an innovative MCDM framework utilizing IFNs to better manage uncertainty in decision environments. It introduces new aggregation strategies and evaluation mechanisms tailored for interval data. The model demonstrates improved flexibility and accuracy in complex decision-making scenarios across various application domains.
[15]	It proposed a generalized interval-valued picture fuzzy linguistic induced hybrid operator to address complex group decision-making problems involving linguistic information. By integrating this operator with the TOPSIS method, the model effectively handles uncertainty, imprecision, and hesitation in expert evaluations. The approach enhances the reliability and flexibility of linguistic group decision-making processes in fuzzy environments.

Table 1 – continued from previous page

Articles	Contribution
[26]	It introduced a decision-making model based on IVHPFSs to manage uncertainty and hesitation in selecting optimal alternatives. It provides a systematic approach for evaluating multiple criteria while incorporating varying degrees of membership, non-membership, and hesitation. The proposed method enhances decision accuracy in complex and vague environments, especially where expert opinions vary.
[27]	It presented a comprehensive review of PFSs in MCDM over the past decade, highlighting key advancements, applications, and methodological developments. It identifies current research gaps, challenges, and limitations in existing models and techniques. The study also outlines promising future directions, offering valuable insights for researchers aiming to enhance decision-making frameworks using PFSs.
[28]	It proposed a novel MADM framework utilizing IVTFNs to support complex policy decisions under uncertainty. It incorporates advanced aggregation and ranking methods to handle imprecise and subjective expert evaluations effectively. The framework is validated through real-world case studies, demonstrating its applicability and robustness for use by policymakers in uncertain environments.
[29]	It proposed a novel T-spherical dual hesitant fuzzy decision-making model to optimize non-invasive remote sensing techniques for geothermal exploration. This approach enhances the accuracy and robustness of site selection under uncertainty by effectively modeling hesitation and dual opinions. The model's effectiveness is demonstrated through its application in evaluating geothermal potential zones.
[30]	It introduced a comprehensive decision-making framework based on Fermatean fuzzy sets, which offer enhanced capability to handle high degrees of uncertainty and vagueness in expert opinions. The model supports more flexible and powerful preference representation compared to traditional fuzzy approaches. Its effectiveness is validated through application in complex decision-making scenarios, demonstrating improved consistency and reliability.
[31]	It looks at different ways to handle uncertainty, like fuzzy sets, intuitionistic fuzzy sets, and neutrosophic sets, and shows how they can improve IT Service Management (ITSM). And presented two new systems: Fuzzy Service Integration and Management (FSIM) and Neutrosophic Service Integration and Management (NSIM). These systems use these uncertainty models in Service Integration and Management (SIAM). FSIM uses fuzzy membership functions to deal with unclear quality, cost, and coordination issues. NSIM goes further by using neutrosophic triples to also measure uncertainty and contradiction.

Table 1 – continued from previous page

Articles	Contribution
[32]	In which, Complex Fermatean fuzzy sets (CFFSs) combine features of complex fuzzy sets and Fermatean fuzzy sets. They use complex numbers to show membership, non-membership, and neutral degrees. This makes them better at showing uncertainty. But, it's hard to measure differences between CFFSs in decision-making. And also presenteda new way to measure these differences. The new measure fixes problems with old methods. It has been tested and proven to be reliable and effective through number comparisons and applied in a post-flood assessment to show its high confidence and consistency.
[33]	This study introduces new ways to work with Cq-RPFNs, which are part of fuzzy set theory. It used Yeager's operations like addition and multiplication. Two tools were created, the Cq-RPFGPPYWA and the Cq-RPFGPPYWG, to help combine fuzzy data in difficult decision-making situations. A method for making decisions with many factors was developed and shown in a case study in India's Power and Energy Sector.

The recent works reflect a growing trend toward integrating advanced fuzzy models with MCDM methods to solve complex real-world problems. These developments not only improve the robustness and flexibility of decision processes but also open new avenues for future research. Continued innovation in this area is crucial for addressing emerging challenges across diverse domains.

1.3. Literature survey of recent works on working women's depression

Working women show consistently higher rates of depressive symptoms compared with men across many settings, with recent systematic reviews and meta-analyses reporting substantial prevalence and clear associations with employment-related factors [34]. Studies synthesising large samples indicate that employment does not uniformly protect against depression; instead, prevalence varies by occupation, life stage (e.g., postpartum or perimenopause) and local socioeconomic context [35].

Workplace psychosocial stressors, including high job demands, low control, workplace harassment or discrimination, poor social support, job insecurity and long working hours, are repeatedly identified as strong, proximal risk factors for depressive symptoms in employed women [36]. Scoping and systematic reviews show consistent associations between such stressors and depressive outcomes, and several recent studies emphasise gendered exposures [37] (e.g., women are more likely to experience precarious work, role overload, and work–family conflict).

The COVID-19 pandemic amplified established risks for working women: lockdowns, increased unpaid care responsibilities, income loss and role strain produced higher rates of depressive and anxiety symptoms in many cohorts of employed women, with frontline and care workers often disproportionately affected [38]. Longitudinal and review articles from the pandemic era document short-term spikes in symptoms and long-term impacts related to altered work arrangements and sustained economic stress [39].

Certain occupational groups, such as healthcare workers, personal support workers, and women in male-dominated and low-control jobs, frequently appear in the literature

as high-risk groups for depression, owing to combined psychosocial stress, exposure to traumatic events, and limited workplace support [40]. Recent reviews focusing on specific sectors recommend sector-tailored prevention strategies, as risk profiles and feasible interventions vary by workplace [41].

1.4. Structure

The remainder of this paper is organised as follows. Section 2 presents the methodological background, and Section 3 includes a detailed description of the TOPSIS, VIKOR, and WASPAS methods used in this study. Section 4 introduces the alternative and criteria selection, and data framework for analysing women's workplace stress. Section 5 provides the results of the proposed model along with discussion and comparative analysis. Section 6 concludes the study with key findings, practical implications, and directions for future research.

2. PRELIMINARIES

Definition 1. *Let X be a universal set. A Picture Fuzzy Set (PFS) $\tilde{A}$ in X is defined as:*

$$\tilde{A} = \{\langle x, \mu_{\tilde{A}}(x), \nu_{\tilde{A}}(x), \pi_{\tilde{A}}(x)\rangle : x \in X\}$$

where $\mu_{\tilde{A}}(x)$, $\nu_{\tilde{A}}(x)$, and $\pi_{\tilde{A}}(x)$ denote the degrees of positive membership, neutral membership, and negative membership of the element $x \in X$ respectively, and satisfy the condition:

$$0 \le \mu_{\tilde{A}}(x) + \nu_{\tilde{A}}(x) + \pi_{\tilde{A}}(x) \le 1.$$

A Picture Fuzzy Number (PFN) is a special case of a PFS defined over a singleton element, represented as:

$$\tilde{A} = (\mu_{\tilde{A}}, \nu_{\tilde{A}}, \pi_{\tilde{A}})$$

where $\mu_{\tilde{A}}, \nu_{\tilde{A}}, \pi_{\tilde{A}} \in [0,1]$ and

$$0 \le \mu_{\tilde{A}} + \nu_{\tilde{A}} + \pi_{\tilde{A}} \le 1.$$

Definition 2. *An Interval-Valued Picture Fuzzy Number (IVPFN) is defined as a triplet*

$$\tilde{A} = ([\mu_L, \mu_U], [\nu_L, \nu_U], [\pi_L, \pi_U])$$

where:

- *$[\mu_L, \mu_U] \subseteq [0,1]$ is the interval-valued degree of positive membership,*

- *$[\nu_L, \nu_U] \subseteq [0,1]$ is the interval-valued degree of neutral membership,*

- *$[\pi_L, \pi_U] \subseteq [0,1]$ is the interval-valued degree of negative membership,*

and the following condition holds:

$$0 \leq \mu_U + \nu_U + \pi_U \leq 1.$$

Here, the sum of the upper bounds ensures that the combined degrees do not exceed unity, preserving the semantics of picture fuzzy logic under interval uncertainty.

Definition 3. *Let $\tilde{A} = ([\mu_L, \mu_U], [\nu_L, \nu_U], [\pi_L, \pi_U])$ be an Interval-Valued Picture Fuzzy Number (IVPFN). The extended Shannon entropy measure $E(\tilde{A})$ is defined as:*

$$E(\tilde{A}) = -\frac{1}{3} \left[\bar{\mu} \ln(\bar{\mu}) + \bar{\nu} \ln(\bar{\nu}) + \bar{\pi} \ln(\bar{\pi}) \right]$$

where:

$$\bar{\mu} = \frac{\mu_L + \mu_U}{2}, \quad \bar{\nu} = \frac{\nu_L + \nu_U}{2}, \quad \bar{\pi} = \frac{\pi_L + \pi_U}{2}$$

and $\ln(\cdot)$ denotes the natural logarithm. If any of $\bar{\mu}, \bar{\nu}, \bar{\pi}$ is zero, its logarithmic term is taken as zero to avoid indeterminacy.

Example. Consider the IVPFN:

$$\tilde{A} = ([0.4, 0.6], [0.2, 0.3], [0.1, 0.2])$$

Compute the midpoints:

$$\bar{\mu} = \frac{0.4 + 0.6}{2} = 0.5, \quad \bar{\nu} = \frac{0.2 + 0.3}{2} = 0.25, \quad \bar{\pi} = \frac{0.1 + 0.2}{2} = 0.15$$

Now compute the entropy:

$$\begin{aligned}
E(\tilde{A}) &= -\frac{1}{3} \left[0.5 \ln(0.5) + 0.25 \ln(0.25) + 0.15 \ln(0.15) \right] \\
&= -\frac{1}{3} \left[0.5 \times (-0.6931) + 0.25 \times (-1.3863) + 0.15 \times (-1.8971) \right] \\
&= -\frac{1}{3} \left[-0.3466 - 0.3466 - 0.2846 \right] \\
&= -\frac{1}{3} (-0.9778) = 0.3259
\end{aligned}$$

Hence, the extended Shannon entropy of $\tilde{A}$ is approximately:

$$E(\tilde{A}) \approx 0.3259$$

3. METHODOLOGY

The methodology put forward introduces an enhanced entropy measure for IVPFNs and a new distance measure to effectively capture the uncertainty, indeterminacy, and hesitation involved in evaluating depression factors among working women. Initially, expert evaluations are represented as IVPFNs, and the extended entropy measure is employed to calculate the objective criteria weights. Following this, an aggregated IVPFN decision matrix is created and transformed into a weighted normalised decision matrix, where the novel distance measure ensures precise determination of the closeness between the alternatives and ideal solutions. Finally, three well-known MCDM methods, such as TOPSIS, VIKOR, and WASPAS, are utilised to rank the depression factors, and the comparative results, supported by sensitivity analysis, underscore the stability, reliability, and effectiveness of the proposed framework as shown in Figure 1
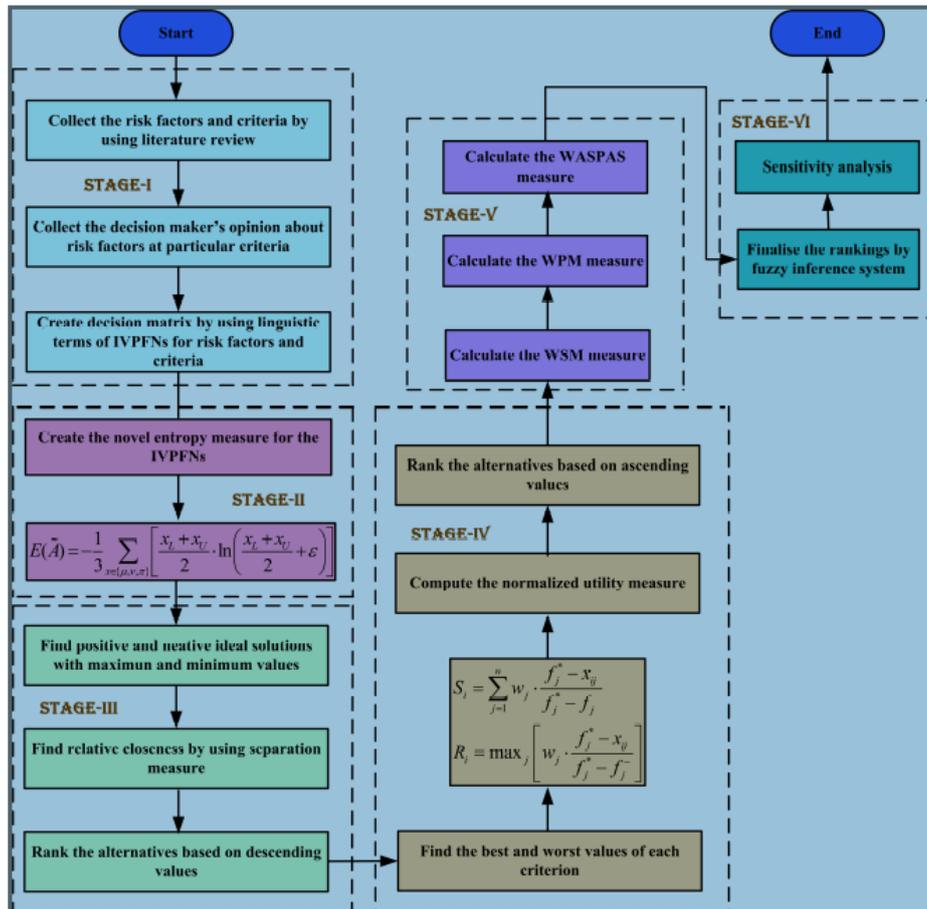

Figure 1: Flowchart of the proposed model

Algorithm 1 TOPSIS Method

1: Input: Decision matrix $D = [x_{ij}]$, weights w_j
2: Normalize the decision matrix: $r_{ij} = \frac{x_{ij}}{\sqrt{\Sigma_{i=1}^m x_{ij}^2}}$
3: Calculate the weighted normalized matrix: $v_{ij} = w_j \cdot r_{ij}$
4: Determine the positive ideal (A^+) and negative ideal (A^-) solutions
5: Compute separation measures:

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - A_j^+)^2}, \quad S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - A_j^-)^2}$$

6: Compute relative closeness: $C_i = \frac{S_i^-}{S_i^+ + S_i^-}$
7: Rank alternatives based on descending C_i values

Algorithm 2 VIKOR Method

1: Input: Decision matrix $D = [x_{ij}]$, weights w_j
2: Determine best f_j^* and worst f_j^- values for each criterion
3: Compute:

$$S_i = \sum_{j=1}^n w_j \cdot \frac{f_j^* - x_{ij}}{f_j^* - f_j^-}, \quad R_i = \max_j \left[w_j \cdot \frac{f_j^* - x_{ij}}{f_j^* - f_j^-} \right]$$

4: Compute $Q_i = v \cdot \frac{S_i - S^*}{S^- - S^*} + (1 - v) \cdot \frac{R_i - R^*}{R^- - R^*}$
5: Rank alternatives based on Q_i, S_i, and R_i
6: Identify compromise solution based on acceptable advantage and stability conditions

---

Algorithm 3 WASPAS Method

1: Input: Decision matrix $D = [x_{ij}]$, weights w_j
2: Normalize the decision matrix
3: Compute the WSM score: $Q_i^{(1)} = \sum_{j=1}^n w_j \cdot x_{ij}$
4: Compute the WPM score: $Q_i^{(2)} = \prod_{j=1}^n x_{ij}^{w_j}$
5: Compute the overall WASPAS score:

$$Q_i = \lambda \cdot Q_i^{(1)} + (1 - \lambda) \cdot Q_i^{(2)}, \quad 0 \le \lambda \le 1$$

6: Rank alternatives in descending order of Q_i

---

4. CASE STUDY

Working women experience significant pressure due to the need to balance professional and personal responsibilities. This pressure stems from societal expectations, workplace demands, and household duties, often all occurring simultaneously. Many working women are expected to perform well in their careers while also managing domestic responsibilities such as childcare, cooking, cleaning, and taking care of elderly family members. This dual role can lead to physical exhaustion and mental stress. In many cases, women receive limited support either at home or at work, making it difficult to find time for self-care or relaxation.

Table 2: Performance indicators and its notions

Notions	Performance indicators
C_1	Severity of impact
C_2	Frequency of occurrence
C_3	Difficulty to manage or control
C_4	Long-term consequences

Table 3: Linguistic terms and its values

Linguistic terms	Values
VL	([0.0, 0.2], [0.3, 0.5], [0.4, 0.6])
L	([0.2, 0.4], [0.3, 0.4], [0.2, 0.3])
M	([0.4, 0.6], [0.2, 0.3], [0.1, 0.2])
H	([0.6, 0.8], [0.1, 0.2], [0.0, 0.1])
VH	([0.8, 1.0], [0.0, 0.1], [0.0, 0.1])

Table 4: Risk factors and its notions

Notions	Risk factors
R_1	Work-Life Imbalance
R_2	Job Insecurity
R_3	Workplace Harassment
R_4	Discrimination and Gender Bias
R_5	Long Working Hours
R_6	Lack of Support at Workplace
R_7	Childcare Responsibilities
R_8	Financial Stress
R_9	Poor Physical Health
R_{10}	Isolation or Lack of Social Support
R_{11}	Unrealistic Expectations or Perfectionism
R_{12}	Limited Career Growth Opportunities
R_{13}	Domestic Violence or Emotional Abuse
R_{14}	Lack of Sleep and Rest
R_{15}	Cultural or Societal Pressure

The situation becomes more stressful when workplaces offer little flexibility, such as rigid work hours or a lack of maternity support, making it harder to attend to family

needs. In cultures where traditional gender roles are still dominant, women are often judged harshly if they fall short in either role as a professional or as a homemaker, further adding to their pressure.

Table 5: First decision maker opinion

RF	C_1	C_2	C_3	C_4
R_1	VL	L	M	M
R_2	L	L	M	VH
R_3	L	M	H	VH
R_4	VL	M	H	H
R_5	VL	H	M	H
R_6	M	M	H	VH
R_7	M	M	VH	VH
R_8	M	M	VH	VH
R_9	VL	H	VH	VH
R_{10}	VL	H	H	VH
R_{11}	L	M	M	H
R_{12}	VL	M	M	H
R_{13}	M	M	M	VH
R_{14}	M	M	M	H
R_{15}	M	M	M	H

Table 6: Second decision maker opinion

RF	C_1	C_2	C_3	C_4
R_1	L	L	H	H
R_2	L	L	H	VH
R_3	L	H	H	VH
R_4	L	H	H	H
R_5	L	M	H	H
R_6	H	M	H	VH
R_7	H	H	VH	VH
R_8	H	H	VH	VH
R_9	L	M	VH	VH
R_{10}	L	H	H	VH
R_{11}	L	H	H	H
R_{12}	L	M	H	H
R_{13}	VL	H	H	VH
R_{14}	H	H	H	H
R_{15}	VL	M	H	H

As a result, many working women suffer from emotional fatigue, guilt, anxiety, and burnout. The ongoing pressure can affect their health, career growth, and personal life satisfaction. Tackling this issue requires not only individual coping strategies but also systemic changes including flexible work policies, shared domestic responsibilities, and greater societal recognition of women's dual contributions at home and in the workplace.

- **Work-life imbalance** is a significant risk factor affecting both mental and physical health. It occurs when an individual struggles to effectively manage professional

Table 7: Third decision maker opinion

RF	C_1	C_2	C_3	C_4
R_1	VL	L	H	H
R_2	L	L	M	VH
R_3	VL	M	H	VH
R_4	L	H	H	H
R_5	L	M	H	H
R_6	M	H	H	H
R_7	H	M	VH	VH
R_8	H	H	VH	H
R_9	M	H	VH	VH
R_{10}	L	H	H	VH
R_{11}	L	H	H	H
R_{12}	M	M	H	H
R_{13}	H	VH	VH	VH
R_{14}	H	H	H	VH
R_{15}	H	H	H	H

duties and personal life. For working women, this imbalance often leads to stress, fatigue, and emotional burnout [42]. The constant pressure to meet workplace demands while fulfilling household responsibilities can cause anxiety and depression. It also reduces time for self-care, leading to lifestyle-related health problems. Over time, this imbalance can impact job performance, relationships, and overall well-being. Women with poor work-life balance may feel guilt or dissatisfaction in either role. It also contributes to long-term health issues like insomnia and heart problems. Addressing this risk factor requires supportive work environments and equitable domestic responsibilities [43].

- **Job insecurity** refers to the fear or uncertainty of losing one's job or not having stable employment in the future [44]. It is a major psychological stressor that can negatively impact both mental and physical health. Individuals experiencing job insecurity often feel anxious, demotivated, and distracted at work. This uncertainty can lead to decreased productivity and lower job satisfaction. It may also result in emotional issues such as depression, low self-esteem, and sleep disturbances. Prolonged job insecurity can strain relationships and disrupt family life. For working women, it adds an extra layer of pressure when combined with household responsibilities. It discourages long-term planning and financial stability. Job insecurity is especially common in sectors with contract-based, temporary, or gig work. Creating supportive policies and stable employment opportunities can help reduce its harmful effects [45].

- **Workplace harassment** refers to unwelcome behavior, actions, or comments that create a hostile or intimidating work environment. It can take many forms, including verbal abuse, sexual harassment, discrimination, bullying, or psychological intimidation. Such behavior often targets an individual based on gender, race, age, religion, or personal characteristics. Victims of workplace harassment may experience stress, anxiety, low self-esteem, and depression. It affects their confidence,

productivity, and overall job satisfaction. For women, especially, workplace harassment can be a major barrier to career growth and safety. It may lead to absenteeism, high turnover, or even withdrawal from the workforce. Harassment also damages workplace morale and team dynamics. Preventing it requires strong policies, awareness, and a safe, supportive reporting system [46]. Addressing complaints promptly and sensitively is essential to ensure a respectful and inclusive work culture.

- **Discrimination and gender bias** refer to unfair treatment or attitudes based on a person's gender, often disadvantaging women in the workplace. This bias can appear in hiring practices, unequal pay, limited promotion opportunities, or exclusion from leadership roles. Women may also face stereotypical assumptions about their abilities or roles, especially in male-dominated fields. Gender bias creates an environment of inequality, reducing motivation and job satisfaction. It limits professional growth and contributes to emotional stress, frustration, and decreased self-worth. Discrimination also affects access to training, mentorship, and decision-making roles [47]. Such bias discourages talented women from staying in or advancing within their careers. For organizations, it results in a loss of diversity, innovation, and overall productivity. Promoting gender equality requires awareness, inclusive policies, and a commitment to fair treatment for all employees.

- **Long working hours** refer to extended time spent on job duties beyond regular working schedules, often exceeding 8–10 hours a day. This can lead to physical exhaustion, mental fatigue, and increased stress levels, especially when there is little time for rest or recovery [48]. For working women, it becomes even more challenging due to additional household and caregiving responsibilities. Prolonged work hours reduce personal and family time, contributing to work-life imbalance. It can negatively impact health, causing issues like insomnia, high blood pressure, and weakened immunity. Over time, long hours may lead to burnout, reduced job performance, and lack of motivation. It also limits opportunities for self-care, hobbies, and social interactions. Constant overwork can strain relationships and emotional well-being. Women in high-demand jobs may feel pressured to prove themselves, worsening the impact. Addressing this issue requires time management, supportive work cultures, and enforcement of healthy work-hour limits.

- **Lack of support at workplace** refers to the absence of emotional, professional, or logistical assistance from colleagues, supervisors, or the organization. It can make employees feel isolated, undervalued, and overwhelmed. For working women, this issue is more pronounced due to added pressures from balancing work and family responsibilities. Without adequate support systems such as mentorship, flexible policies, or understanding leadership, job satisfaction and performance can decline [49]. It may lead to increased stress, burnout, and low self-esteem. Employees may hesitate to voice concerns or ask for help, fearing judgment or backlash. This lack of support also hampers career growth and professional development. In the long term, it contributes to high turnover and low morale. Creating a supportive, inclusive, and empathetic work environment is essential for employee well-being. Strong workplace support encourages motivation, loyalty, and overall success.

- **Childcare responsibilities** involve the day-to-day care, supervision, and nurtur-

ing of children, including tasks like feeding, schooling, health management, and emotional support. For working women, balancing these responsibilities with a full-time job can be overwhelming. The lack of reliable and affordable childcare options often forces women to take career breaks or reduce working hours. This dual role contributes to stress, fatigue, and reduced job performance. It also affects career advancement, as women may miss out on promotions or important assignments. Social expectations often place the burden of childcare primarily on mothers, increasing pressure and guilt [50]. Constant multitasking between work and family can lead to mental exhaustion and burnout. Without support from employers or partners, maintaining a work-life balance becomes difficult. Providing on-site childcare, flexible schedules, and family-friendly policies can ease this burden. Recognizing and sharing childcare duties is essential for gender equality and women's empowerment.

- **Financial stress** refers to the anxiety and pressure caused by inadequate income, debt, or inability to meet daily expenses. Working women often experience financial stress due to wage inequality, career interruptions (e.g., maternity leave), or part-time work. Managing household expenses, childcare costs, and personal needs on a limited budget can lead to constant worry and emotional strain. It can affect concentration, productivity, and decision-making at work. Prolonged financial pressure may also lead to mental health issues like anxiety, depression, and insomnia [51]. Women supporting families as single earners face added financial burdens. Financial stress can limit access to education, healthcare, or opportunities for career growth. It may also cause tension in personal relationships and reduce quality of life. Budgeting, financial literacy, and access to fair pay and benefits are crucial to managing this risk. Supporting women's financial independence is key to reducing stress and enhancing overall well-being.

- **Poor physical health** refers to a state where the body is not functioning optimally due to illness, fatigue, or lack of proper care. For working women, this often results from neglecting personal health while balancing job demands and family responsibilities. Long working hours, lack of sleep, irregular meals, and insufficient exercise contribute to declining health. Common issues include headaches, back pain, obesity, anemia, and fatigue [52]. Chronic stress and overexertion can also lead to serious conditions like hypertension, diabetes, or heart problems. Poor physical health affects energy levels, concentration, and job performance. Many women delay seeking medical care due to time constraints or prioritizing others' needs. This ongoing neglect worsens their condition over time. Creating awareness, promoting regular health checkups, and encouraging a healthy lifestyle are vital. A supportive environment at work and home can help women prioritize and maintain their physical well-being.

- **Isolation or lack of social support** refers to the absence of emotional, psychological, or practical help from family, friends, colleagues, or community. For working women, this can lead to feelings of loneliness, helplessness, and emotional exhaustion. Without someone to share responsibilities or concerns, managing both work and home becomes overwhelming. It can contribute to stress, anxiety, and even

depression, affecting overall well-being [53]. Lack of support may also discourage women from pursuing career growth or taking on new challenges. Social isolation limits the exchange of ideas, encouragement, and motivation needed for personal and professional development. In times of crisis or burnout, support systems are crucial for resilience and recovery. Many women struggle silently due to societal expectations to "manage everything" on their own. Creating networks of support, whether through family, friends, or workplace groups, is essential. Encouraging open communication and shared responsibilities can greatly reduce the burden of isolation.

- **Unrealistic expectations or perfectionism** involve setting excessively high standards for oneself, often striving to meet every demand flawlessly. Many working women feel pressured to excel in both their professional and personal roles without showing signs of struggle [54]. This mindset can lead to constant self-criticism, fear of failure, and overworking. Perfectionism often results in burnout, anxiety, and diminished self-worth when expectations aren't met. It can also delay decision-making and reduce overall productivity due to the fear of making mistakes. Women may push themselves beyond limits to gain validation or avoid judgment, especially in competitive or unsupportive environments. This pressure leaves little room for rest or self-care, affecting mental and physical health. Unrealistic standards are often influenced by societal norms or workplace cultures that value output over well-being. Overcoming perfectionism requires setting realistic goals, accepting imperfections, and fostering self-compassion. Supportive environments can help women feel valued for their efforts, not just outcomes.

- **Limited career growth opportunities** refer to the restricted chances for advancement, promotions, or skill development in the workplace. Many working women face this challenge due to gender bias, lack of mentorship, or organizational structures that favor male employees. Responsibilities like maternity breaks or childcare can interrupt career progression, often leading to slower growth compared to male peers. Women may be overlooked for leadership roles or challenging projects due to assumptions about their availability or commitment [55]. This lack of opportunity can result in frustration, low motivation, and decreased job satisfaction. It also contributes to the gender pay gap and underrepresentation in top management. Without access to training, networking, or visibility, women's professional potential remains untapped. Societal expectations and workplace discrimination further reinforce this barrier. Creating inclusive policies, leadership training, and mentorship programs can help bridge this gap. Promoting equal growth opportunities is essential for empowering women and building diverse, successful organizations.

- **Domestic violence or emotional abuse** refers to patterns of behavior in a relationship used to gain control over a partner, often through fear, manipulation, or intimidation. For working women, experiencing such abuse at home can severely impact their mental health, self-esteem, and ability to focus at work. Emotional abuse includes constant criticism, isolation, threats, or controlling behavior, which can be just as damaging as physical violence. Victims often feel trapped, anxious, and fearful, leading to depression, stress, and social withdrawal. The trauma may

reduce job performance, increase absenteeism, and hinder career growth. Many women hide their abuse due to stigma, fear of judgment, or lack of support [56]. The burden of enduring abuse while maintaining a professional front creates immense emotional strain. Workplaces can play a vital role by offering support systems, confidential counseling, and flexible work options. Raising awareness and encouraging safe reporting can help victims seek help. Addressing domestic abuse is essential for the safety, dignity, and well-being of working women.

- **Lack of sleep and rest** is a serious issue that affects both physical and mental health, especially among working women juggling multiple responsibilities. When women balance work, household duties, and caregiving without adequate rest, it leads to chronic fatigue. Insufficient sleep can impair concentration, decision-making, and productivity at work [57]. It also weakens the immune system, increasing the risk of illness. Over time, sleep deprivation may contribute to anxiety, depression, and burnout. Working late hours or managing household chores after work reduces the time available for proper rest. Many women sacrifice sleep to meet societal or family expectations, unaware of the long-term harm. This imbalance affects mood, relationships, and overall well-being. Prioritizing sleep is essential for maintaining health, performance, and emotional stability. Employers and families must recognize the importance of rest and support better time management and self-care practices.

- **Cultural or societal pressure** refers to the expectations and norms imposed by society regarding how individuals, especially women, should behave, work, and manage family life. Working women often face the burden of conforming to traditional roles as caregivers, even while pursuing careers [47]. Society may judge them harshly for prioritizing work over home, leading to guilt, stress, and emotional conflict. These pressures can discourage women from seeking leadership roles or working long hours. In some cultures, women are expected to sacrifice their ambitions for family responsibilities, limiting their professional growth. Such expectations often result in a lack of support at home and in the workplace. The fear of social judgment can lead to anxiety, self-doubt, and decreased confidence. Cultural bias also affects women's access to education, promotions, and equal pay. Challenging these norms requires awareness, education, and inclusive policies. Empowering women starts with breaking societal stereotypes and recognising their right to choose their own path.

4.1. Determinants of Stress in Working Women

Stress among working women has become a growing concern in modern society. It arises from the combined pressures of professional, personal, and social responsibilities. Identifying the key determinants is essential for understanding their impact and designing effective coping strategies.

- **Severity of Impact** For women who work, the impact of stressors can be particularly intense due to their dual roles at work and at home. They must juggle professional demands like meeting deadlines, handling multiple tasks, and undergoing

performance reviews, alongside domestic responsibilities such as caring for children, cooking meals, and managing household chores. This combination of duties amplifies stress levels, sometimes resulting in burnout or health issues, especially for nurses. The pressure is even greater when societal norms expect them to excel in both areas.

- **Frequency of Occurrence** Working women often face stressors that are both frequent and repetitive. The daily routine of juggling office duties, commuting, and managing family obligations creates an ongoing cycle of stress. For instance, a woman might deal with stress from her job during the day and then shift to household stress in the evening. This repeated exposure to stressors leaves minimal opportunity for recovery, leading to an accumulation of psychological strain.

- **Difficulty to Manage** Balancing stress is particularly difficult for working women because they must juggle both personal and professional responsibilities. While stress at work can sometimes be alleviated with organisational help or effective time management, the expectations at home and from society are more challenging to manage. Social norms frequently presume that women will take care of household duties regardless of their job status, complicating their ability to establish boundaries or delegate responsibilities. This lack of control contributes to an increased stress load.

- **Long-term Consequences** If not addressed, the long-term effects of stress on working women can be severely harmful. Continuous exposure to high stress levels may result in chronic health issues like high blood pressure, anxiety, and depression. Additionally, stress can impact family dynamics and career advancement, as it often leads to decreased productivity and job satisfaction. Over time, the accumulation of these stressors can negatively affect the overall well-being and quality of life for working women.

Table 8: Final values of each method

ine RF	VIKOR	WASPAS	TOPSIS
R_1	0.0000	0.9511	0.9696
R_2	0.5831	0.8595	0.6755
R_3	0.7586	0.7549	0.3719
R_4	0.4970	0.8323	0.6851
R_5	0.4634	0.8603	0.7905
R_6	0.6670	0.7359	0.3217
R_7	0.9998	0.6152	0.0480
R_8	1.0000	0.6269	0.0382
R_9	0.9600	0.6171	0.0559
R_{10}	0.8421	0.7094	0.2741
R_{11}	0.4384	0.8699	0.8015
R_{12}	0.2614	0.8772	0.8595
R_{13}	0.9827	0.6577	0.1794
R_{14}	0.8254	0.7723	0.5412
R_{15}	0.7838	0.8026	0.6573

5. DISCUSSION

In this study, 15 risk factors related to working women's stress were evaluated using three well-known MCDM methods: VIKOR, TOPSIS, and WASPAS. Each method follows a distinct decision logic: VIKOR ranks alternatives based on minimising group utility and regret, while TOPSIS and WASPAS prioritise alternatives with higher scores, indicating closeness to the ideal solution. Table 8 and Figure 5 show the values of each method.

From the VIKOR method, R_1 stands out as the most preferred risk factor with a score of 0.0000, signifying the best compromise solution. In contrast, R_8, R_7, and R_9 have the highest VIKOR scores, indicating they are the least favorable in this context. This implies that these three risk factors contribute significantly to stress and require immediate attention. Similarly, R_{12}, R_{11}, and R_5 have relatively better performance with lower VIKOR scores, suggesting a more moderate influence.

In the TOPSIS evaluation, R_1 again ranks first with a score of 0.9696, demonstrating consistent performance across both VIKOR and TOPSIS. R_{12} and R_{11} follow closely, suggesting that these factors are highly influential when considering closeness to the ideal solution. On the lower end, R_8, R_7, and R_9 show the weakest performance, with scores below 0.06, confirming their critical status and consistency with VIKOR results.

For WASPAS, which blends weighted sum and weighted product models, the results also highlight R_1, R_{12}, and R_{11} as the top risk factors with scores above 0.86, reinforcing the conclusion that these are dominant stress-related contributors. Once again, R_7, R_8, and R_9 show the lowest scores in this method, validating their adverse impact on working women's stress.

When we synthesise the rankings from all three methods, R_1 emerges as the most critical and stable risk factor, consistently ranked first across VIKOR, TOPSIS, and WASPAS. R_{11} and R_{12} also appear within the top five across all models, underlining their consistent influence. On the other hand, R_7, R_8, and R_9 persistently fall into the lowest ranks, indicating these factors require focused interventions. Some risk factors, such as R_2, R_5, and R_4 perform moderately across methods, with fluctuations between mid and high ranks, reflecting their context-dependent impact. Interestingly, R_{13}, despite having a high VIKOR score (indicating low desirability), shows moderate scores in WASPAS and very low in TOPSIS, revealing model sensitivity and possible evaluation bias.

This ranking discrepancy highlights the importance of using multiple MCDM methods to ensure robustness in decision-making. The convergence of results among methods for certain RFs provides validation, while divergence invites further exploration into data characteristics or model behaviour.

By identifying consistently top-ranked factors (like R_1, R_{11}, and R_{12}) and consistently low-ranked factors (like R_7, R_8, and R_9), decision-makers can prioritize interventions more effectively. Additionally, risk factors with high variability across methods, such as R_{14} or R_{10}, may require sensitivity analysis or fuzzy modelling to account for the inherent uncertainty in perception-based data.

In conclusion, the combination of VIKOR, TOPSIS, and WASPAS offers a comprehensive perspective on the relative importance of stress-related risk factors among working women. We utilised fuzzy inference rankings (FIR) [58], [59]. Table 9 shows the
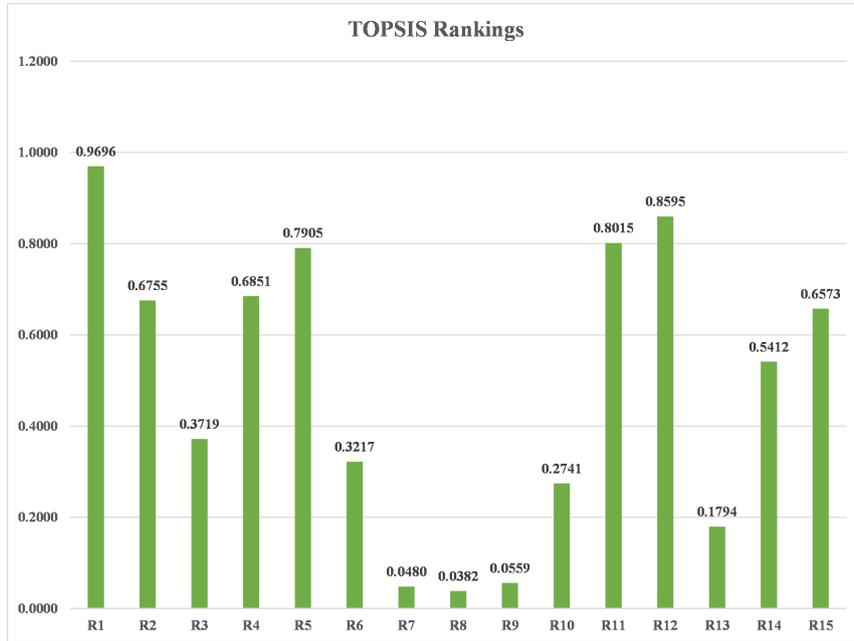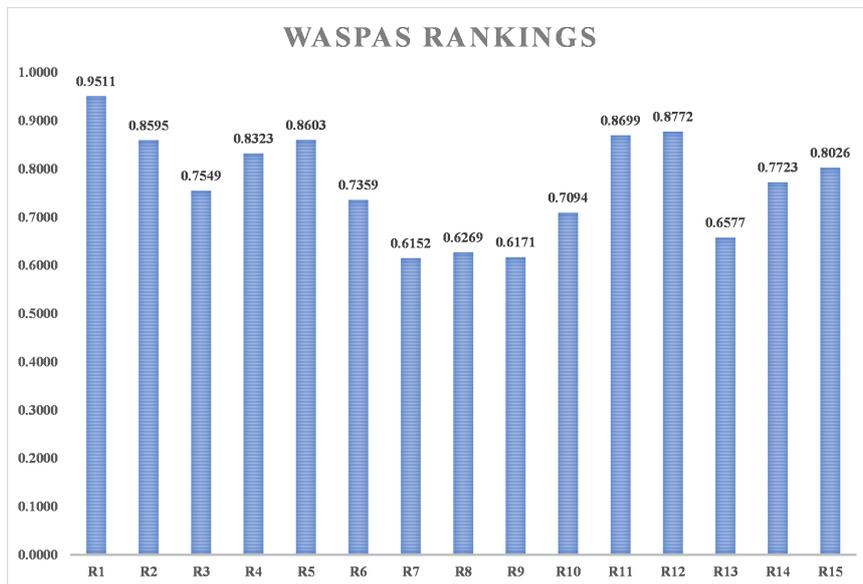
Figure 2: TOPSIS Rankings

Figure 3: WASPAS Rankings

Figure 4: VIKOR Rankings

FIR value of risk factors. The alignment between methods for certain risk factors [60] ensures confidence in decision-making, while discrepancies highlight areas for deeper investigation and methodological refinement.

The analysis reveals that Work-Life Imbalance (R_1) is consistently ranked as the most critical stressor across the methods, such as VIKOR, WASPAS, TOPSIS, and FIR, highlighting its dominant impact on women's mental well-being. This suggests that managing responsibilities at both the workplace and home remains a significant challenge and requires urgent attention through policy and organisational support.

The results of this study carry several practical implications for organisations, policymakers, and society at large. First, by identifying and ranking the key stress factors affecting working women, our model provides employers with evidence-based insights to design targeted workplace interventions. For instance, high-ranked stressors such as workload, time pressure, or lack of flexibility can be addressed by introducing flexible work arrangements, promoting workload redistribution, and offering employee assistance programs. Second, the findings emphasise the importance of acknowledging the dual burden of professional and domestic responsibilities that many working women face. Organisations can incorporate family-friendly policies, childcare support, and awareness programs to reduce the invisible cognitive and emotional load that often goes unrecognised. Third, policymakers and labour authorities can use these insights to frame regulations and guidelines that safeguard women's mental health at work. This includes strengthening maternity benefits, promoting equal sharing of caregiving duties, and mandating stress management resources in organisations. Finally, from a societal perspective, the study underscores the need to shift cultural expectations that place disproportionate

household responsibilities on women. Encouraging equitable domestic participation and raising awareness about the hidden cognitive load can contribute to reducing long-term stress. Together, these implications ensure that the results are not only theoretically significant but also actionable in shaping healthier, more supportive environments for working women.
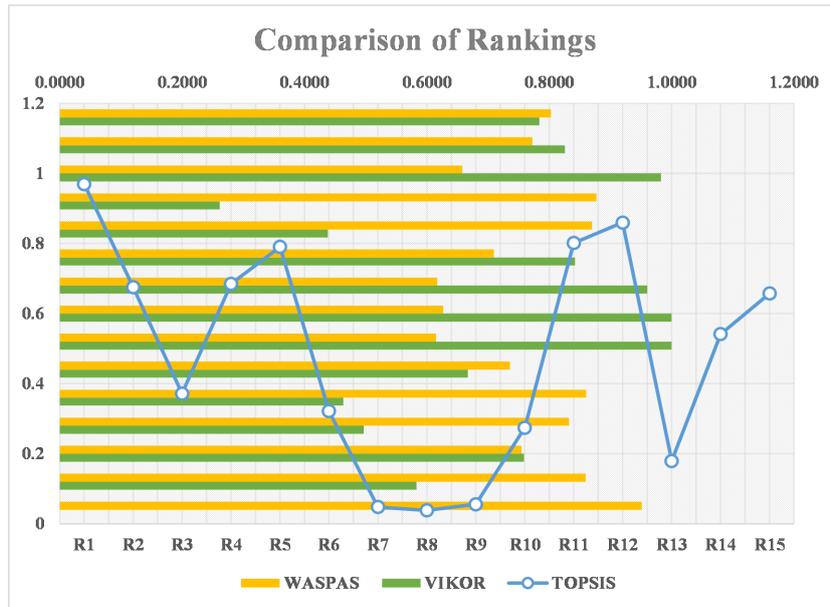

Figure 5: Comparison of rankings

Limited Career Growth Opportunities (R_{12}) and Unrealistic Expectations or Perfectionism (R_{11}) occupy the next highest priority rankings (2nd and 3rd, respectively, in all methods), indicating that professional stagnation and pressure to meet high standards are major contributors to long-term stress among working women. These issues can lead to dissatisfaction, burnout, and reduced motivation.

Long working hours (R_5) and Discrimination and Gender Bias (R_4) are ranked 4th and 5th, showing that extended work schedules and unequal treatment are persistent structural issues that exacerbate mental and physical strain. Gender bias can particularly hinder career advancement and affect workplace morale.

Stressors like job insecurity (R_2) and lack of support at workplace (R_6) rank in the mid-range, reflecting their importance as secondary stressors. Although not as immediate as the top-ranked factors, they still significantly contribute to emotional distress and affect performance and retention.

At the lower end of the rankings are childcare responsibilities (R_7), financial stress (R_8), and poor physical health (R_9), which, although still important, appear to be perceived as less pressing compared to organisational and psychological stressors. This could be due to increasing access to childcare support or economic coping mechanisms, but they remain key challenges in specific demographics.

Table 9: Final rankings of each method

RF	VIKOR	WASPAS	TOPSIS	FIR
R_1	1	1	1	1
R_2	6	5	6	6
R_3	8	9	9	9
R_4	5	6	5	5
R_5	4	4	4	4
R_6	7	10	10	10
R_7	14	15	14	14
R_8	15	13	15	15
R_9	12	14	13	13
R_{10}	11	11	11	11
R_{11}	3	3	3	3
R_{12}	2	2	2	2
R_{13}	13	12	12	12
R_{14}	10	8	8	8
R_{15}	9	7	7	7

Domestic violence or emotional abuse (R_{13}), lack of sleep (R_{14}), and cultural or societal pressure (R_{15}) also rank in the lower half, but their cumulative effect on mental health cannot be overlooked. Particularly, cultural expectations and domestic environment play a subtle yet enduring role in psychological burden.

Overall, the final rankings from all three MCDM methods converge to offer a clear prioritisation of stressors. Interventions should focus first on improving work-life balance, providing growth opportunities, and addressing perfectionist cultures, followed by addressing institutional factors like gender bias, workload, and support systems. The results serve as a strategic guide for employers, policymakers, and mental health professionals to create a healthier and more equitable working environment for women.

5.1. Sensitivity analysis

The Figure 6 presents a sensitivity analysis of 15 Risk Factors, labeled as R_1 to R_{15}, evaluated under varying values of the parameter k, ranging from 2 to 100. This parameter k may represent a model-specific parameter such as the number of nearest neighbors, fuzzification level, or resolution level in the decision-making process. Each cell in the table indicates the importance score of a particular risk factor under a specific value of k. From the analysis, it is observed that certain risk factors such as R_1, R_{11}, and R_{12} maintain consistently high values across all values of k, showing minimal variation. This implies that these factors are highly stable and critical in determining stress levels among working women, regardless of parameter changes.

Conversely, risk factors such as R_3, R_6, R_7, R_8, and R_9 show noticeable sensitivity to changes in k. For instance, R_3 starts at a low score of 0.45 when $k = 5$, but gradually increases to approximately 0.76 as k increases to 100. This indicates that these factors are more sensitive to model configuration and may only show significant influence under broader or fuzzier environments. Such behavior highlights the importance of using flexible frameworks like interval-valued or picture fuzzy sets, which can accommodate

uncertainty in expert opinions and assessments.

Overall, this sensitivity analysis helps in identifying which risk factors remain dominant and which are dependent on specific parameter settings, providing valuable insights for the prioritization and management of stress-related issues among working women.
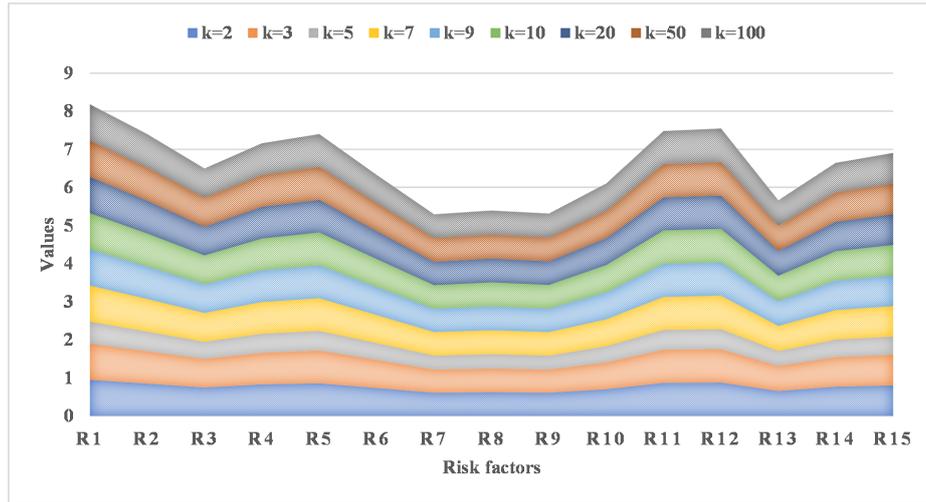

Figure 6: Sensitivity analysis

6. CONCLUSION

In this study, we employed IVPFNs to handle uncertainty in evaluating stress-related Risk Factors among working women. The IVPFN framework captured the imprecision and hesitation in expert assessments. To rank the risk factors effectively, we applied three robust MCDM methods: TOPSIS, VIKOR, and WASPAS. The results showed that R_1 (Work-Life Imbalance) was consistently the most significant factor. It scored 0.9696 in TOPSIS, 0.9511 in WASPAS, and 0.0000 in VIKOR, ranking first across all methods. This confirms R_1 as the most critical and stable contributor to stress among working women. Similarly, R_{11} (Lack of Support at Workplace) and R_{12} (Job Insecurity) also showed high influence, with TOPSIS scores of 0.8015 and 0.8595, WASPAS scores of 0.8699 and 0.8772, and low VIKOR scores of 0.4384 and 0.2614, respectively. On the other hand, R_7, R_8, and R_9 consistently ranked lowest. R8 scored 1.0000 in VIKOR, 0.0382 in TOPSIS, and 0.6269 in WASPAS, highlighting its strong negative impact. The consistency of R_1, R_{11}, and R_{12} across all methods demonstrates the strength of using IVPFNs in modeling uncertainty. The divergence in rankings for R_{13} and R_{14} suggests that certain RFs are more sensitive to methodological perspectives, which could be further explored using sensitivity analysis. The use of IVPFNs allowed experts to express opinions through degrees of positive, neutral, and negative membership along with hesitation. This approach provides a more accurate and comprehensive analysis, particularly in psychological and social studies where uncertainty is inherent. Moreover, combining IVPFNs with TOPSIS, VIKOR, and WASPAS ensured a balanced evaluation of both

closeness to the ideal and compromise solutions. By identifying top-ranked RFs (R_1, R_{11}, R_{12}) and bottom-ranked RFs (R_7, R_8, R_9), this model helps prioritize policy interventions. It also enables mental health professionals to tailor support strategies based on consistently high-impact stress factors. This IVPFN-MCDM framework is valuable for stress analysis in uncertain environments like workplaces and social systems. Future research can extend this approach with entropy-based weighting, clustering, and fuzzy inference for deeper insight. Ultimately, this study reinforces the applicability of interval-valued fuzzy modeling in real-world decision problems with psychological complexity.

REFERENCES

[1] N. Ezghiyr and V. Varahrami, "The effect of changing gender composition in the labor market on the economic growth of syria before and after war using autoregressive distributed lag (ardl) model," *Spectrum of Decision Making and Applications*, vol. 2, no. 1, pp. 286–297, 2025.

[2] K. H. Gazi, N. Raisa, A. Biswas, F. Azizzadeh, and S. P. Mondal, "Finding the most important criteria in women's empowerment for sports sector by pentagonal fuzzy dematel methodology," *Spectrum of Decision Making and Applications*, vol. 2, no. 1, pp. 28–52, 2025.

[3] S. Ayers, A. Horsch, S. Garthus-Niegel, M. Nieuwenhuijze, A. Bogaerts, K. Hartmann, S. I. Karlsdottir, M. Oosterman, G. Tecirli, J. D. Turner *et al.*, "Traumatic birth and childbirth-related post-traumatic stress disorder: International expert consensus recommendations for practice, policy, and research," *Women and birth*, vol. 37, no. 2, pp. 362–367, 2024.

[4] B. Oftung and R. Tyssen, "Occupational stress among norwegian physicians: A literature review of long-term prospective studies 2007–2019," *Scandinavian Journal of Public Health*, vol. 53, no. 3, pp. 302–310, 2025.

[5] M. J. Kuck and E. Hogervorst, "Stress, depression, and anxiety: psychological complaints across menopausal stages," *Frontiers in Psychiatry*, vol. 15, p. 1323743, 2024.

[6] S. Sharma and S. Singh, "Single-valued neutrosophic yager power aggregation operators and its application to mcdm," *Yugoslav Journal of Operations Research*, no. 00, pp. 4–4, 2025.

[7] Z. Bürger, C. Kordowich, J. Kübbeler, C. Müllerschön, A.-C. S. Kimmig, M. Su, M. Lämmerhofer, J. Sacher, M. Henes, E. Comasco *et al.*, "Subjective, behavioural and physiological correlates of stress in women using hormonal contraceptives," *The British Journal of Psychiatry*, pp. 1–9, 2025.

[8] C.-L. Hwang and K. Yoon, "Multiple attribute decision making methods and applications: A state-of-the-art survey," *Springer-Verlag, Berlin*, 1981, tOPSIS was introduced in this book.

[9] S. Opricovic and G. Tzeng, "Multicriteria optimization and compromise solution—the method of vikor," *European Journal of Operational Research*, vol. 112, no. 3, pp. 445–455, 1999.

[10] E. K. Zavadskas and Z. Turskis, "A hybrid multiple criteria decision-making model based on the waspas method," *Informatica*, vol. 23, no. 1, pp. 55–64, 2012.

[11] L. A. Zadeh, "Fuzzy sets," *Information and Control*, vol. 8, no. 3, pp. 338–353, 1965.

[12] K. T. Atanassov, "Intuitionistic fuzzy sets," *Fuzzy Sets and Systems*, vol. 20, no. 1, pp. 87–96, 1986.

[13] R. R. Yager, "Pythagorean fuzzy subsets," *Proceedings of the Joint IFSA World Congress and NAFIPS Annual Meeting*, pp. 57–61, 2013.

[14] B. Cuong and V. Kreinovich, "Picture fuzzy sets," in *2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE)*. IEEE, 2014, pp. 214–219.

[15] M. Qiyas, S. Abdullah, Y. D. Al-Otaibi, and M. Aslam, "Generalized interval-valued picture fuzzy linguistic induced hybrid operator and topsis method for linguistic group decision-making," *Soft Computing*, vol. 25, pp. 5037–5054, 2021.

[16] J. Kannan, V. Jayakumar, M. A. B. Kather, and M. Tamilvizhi, "Entropy-based analysis using linear diophantine multi fuzzy soft sets: A dea approach for improved decision systems," *Yugoslav Journal of Operations Research*, no. 00, pp. 55–55, 2024.

[17] S. Amanathulla and J. Khatun, "Multiple attribute decision making problem using interval-valued picture fuzzy graphs," *Journal of Fuzzy Extension and Applications*, vol. 6, no. 2, pp. 284–299, 2025.

[18] F. Karaaslan and F. Karamaz, "Interval-valued (p, q, r)-spherical fuzzy sets and their applications in mcgdm and mcdm based on topsis method and aggregation operators," *Expert Systems with Applications*, vol. 255, p. 124575, 2024.

[19] Q. Ma, Z. Chen, Y. Tan, and J. Wei, "An integrated design concept evaluation model based on interval valued picture fuzzy set and improved grp method," *Scientific Reports*, vol. 14, no. 1, p. 8433, 2024.

[20] M. Naeem, M. Qiyas, and S. Abdullah, "An approach of interval-valued picture fuzzy uncertain linguistic aggregation operator and their application on supplier selection decision-making in logistics service value concretion," *Mathematical Problems in Engineering*, vol. 2021, no. 1, p. 8873230, 2021.

[21] J.-P. Fan, H. Zhang, and M.-Q. Wu, "Dynamic multi-attribute decision-making based on interval-valued picture fuzzy geometric heronian mean operators," *IEEE Access*, vol. 10, pp. 12 070–12 083, 2022.

[22] J. Selvaraj and A. Majumdar, "A new ranking method for interval-valued intuitionistic fuzzy numbers and its application in multi-criteria decision-making," *Mathematics*, vol. 9, no. 21, p. 2647, 2021.

[23] M. Taghizadeh, A. Hadi-Vencheh, M. J. Varnamkhasti, and A. Jamshidi, "Harnessing interval fuzzy numbers: A novel approach to multi-criteria decision-making models," *International Journal of Mathematical Modelling & Computations*, vol. 15, no. 3, pp. 161–179, 2025.

[24] T. N. Parthasarathy, S. Narayanamoorthy, N. S. K. Devi, D. Pamucar, V. Simic, and D. Kang, "An idiosyncratic interval valued picture q-rung orthopair fuzzy decision-making model for electric vehicle battery charging technology selection," *International Journal of Fuzzy Systems*, vol. 26, no. 6, pp. 2023–2038, 2024.

[25] R. Prabakaran, "Ranking psychological risk factors among college students using interval-valued picture fuzzy set with various operators and mcdm techniques," in *2024 First International Conference on Innovations in Communications, Electrical and Computer Engineering (ICICEC)*. IEEE, 2024, pp. 1–9.

[26] T. Rashid and M. Sarwar Sindhu, "Selection of an alternative based on interval-valued hesitant picture fuzzy sets," *Journal of Intelligent & Fuzzy Systems*, vol. 42, no. 1, pp. 551–561, 2021.

[27] C. O. Nwokoro and P. A. Ejegwa, "A decade of picture fuzzy sets in multi-criteria decision-making: A comprehensive review of trends, gaps, and future directions," *Knowledge and Decision Systems with Applications*, vol. 1, pp. 145–164, 2025.

[28] A. Mohammadian, J. Heidary Dahooie, A. R. Qorbani, E. K. Zavadskas, and Z. Turskis, "A new multi-attribute decision-making framework for policy-makers by using interval-valued triangular fuzzy numbers," *Informatica*, vol. 32, no. 3, pp. 583–618, 2021.

[29] M. Sandra, S. Narayanamoorthy, K. Suvitha, D. Pamucar, and D. Kang, "Optimizing non-invasive remote sensing for geothermal exploration with t-spherical dual hesitant fuzzy decision model," *Facta Universitatis, Series: Mechanical Engineering*, 2025.

[30] K. Suvitha, R. Saraswathy, C. S. Thilagasree, S. Kalaiselvan, and S. Narayanamoorthy, "Designing and analyzing fermatean fuzzy decision models: a comprehensive decision making

approach," *Journal of Intelligent Decision Making and Information Science*, vol. 2, pp. 272–288, 2025.

[31] T. Fujita, "A proposed framework for fuzzy and neutrosophic extensions of service integration and management (siam) and itil-based models," *Journal of Intelligent Decision Making and Granular Computing*, vol. 1, no. 1, pp. 161–198, 2025.

[32] Y. Li, S. Zhu, J. Liao, S. Letchmunan, J. Shi, and Z. Liu, "Application of new divergence measure in complex fermatean fuzzy sets for post-flood assessment," *Journal of Intelligent Decision Making and Granular Computing*, vol. 1, no. 1, pp. 127–142, 2025.

[33] S. Petchimuthu, C. Mahendiran, T. Premala *et al.*, "Power and energy transformation: multi-criteria decision-making utilizing complex q-rung picture fuzzy generalized power prioritized yager operators," *Spectrum of Operational Research*, vol. 2, no. 1, pp. 219–258, 2025.

[34] S. H. Adam, F. Junne, S. Schlachter, M. Mehler, H. Gündel, N. Rüsch, J. von Wietersheim, K. E. Giel, S. Zipfel, and R. Erschens, "Interventions to foster mental health and reintegration in individuals who are unemployed: Systematic review," *JMIR public health and surveillance*, vol. 11, p. e65698, 2025.

[35] G. Perera, K. Jayapala, M. Khondoker, K. Glaser, G. Di Gessa, and R. Stewart, "Associations of non-employment with common mental disorder subcomponents among working age population: Analysis of national data from 1993, 2000, 2007 and 2014," *International Journal of Social Psychiatry*, vol. 71, no. 2, pp. 404–413, 2025.

[36] T. Liang, "Sexual harassment at work: Scoping review of reviews," *Psychology Research and Behavior Management*, pp. 1635–1660, 2024.

[37] P. S. Vatharkar and M. Aggarwal-Gupta, "Relationship between role overload and the work–family interface," *South Asian Journal of Business Studies*, vol. 9, no. 3, pp. 305–321, 2020.

[38] K. Power, "The covid-19 pandemic has increased the care burden of women and families," *Sustainability: Science, practice and policy*, vol. 16, no. 1, pp. 67–73, 2020.

[39] O. Borah Hazarika and S. Das, "Paid and unpaid work during the covid-19 pandemic: A study of the gendered division of domestic responsibilities during lockdown," *Journal of Gender Studies*, vol. 30, no. 4, pp. 429–439, 2021.

[40] A. Wilcock and C. Hocking, *An occupational perspective of health*. Routledge, 2024.

[41] T. J. Haney and K. Barber, "The extreme gendering of covid- 19: Household tasks and division of labour satisfaction during the pandemic," *Canadian Review of Sociology/Revue canadienne de sociologie*, vol. 59, no. S1, pp. 26–47, 2022.

[42] M. Uddin, "Addressing work-life balance challenges of working women during covid-19 in bangladesh," *International Social Science Journal*, vol. 71, no. 239-240, pp. 7–20, 2021.

[43] P. Kotini-Shah, B. Man, R. Pobee, L. E. Hirshfield, B. J. Risman, I. A. Buhimschi, and H. M. Weinreich, "Work–life balance and productivity among academic faculty during the covid-19 pandemic: A latent class analysis," *Journal of Women's Health*, vol. 31, no. 3, pp. 321–330, 2022.

[44] Y.-K. Kim, A. Kramer, and S. Pak, "Job insecurity and subjective sleep quality: The role of spillover and gender," *Stress and Health*, vol. 37, no. 1, pp. 72–92, 2021.

[45] S. Blomqvist, M. Virtanen, A. D. LaMontagne, and L. L. M. Hanson, "Perceived job insecurity and risk of suicide and suicide attempts: a study of men and women in the swedish working population," *Scandinavian journal of work, environment & health*, vol. 48, no. 4, p. 293, 2022.

[46] S. B. Rabichuk, L. Williamson, and S. Frankel, "Stress experiences of women in policing: A scoping review," *International Journal of Police Science & Management*, vol. 27, no. 1, pp. 63–77, 2025.

[47] M. E. Heilman, S. Caleo, and F. Manzi, "Women at work: pathways from gender stereotypes to gender bias and discrimination," *Annual Review of Organizational Psychology and Organizational Behavior*, vol. 11, no. 1, pp. 165–192, 2024.

[48] M. Naseer, A. U. Haq, and S. M. A. Shah, "Understanding turnover intentions in pakistan's healthcare sector: A qualitative exploration of supervisory behavior, stress, and cultural norms," *Annual Methodological Archive Research Review*, vol. 2, no. 5, pp. 1–18, 2024.

[49] A. Ueno, C. Yu, L. Curtis, and C. Dennis, "Job demands-resources theory extended: stress, loneliness, and care responsibilities impacting uk doctoral students' and academics' mental health," *Studies in Higher Education*, vol. 50, no. 4, pp. 808–823, 2025.

[50] C. E. Nichols and J. Davis, "The women farmer stress inventory: examining women farmer stress in the united states corn belt," *The Journal of Rural Health*, vol. 40, no. 3, pp. 457–466, 2024.

[51] S. S. Swarup, B. K. Padhi, P. Satapathy, M. Shabil, G. Bushi, A. P. Gandhi, M. N. Khatib, S. Gaidhane, Q. S. Zahiruddin, S. Rustagi *et al.*, "Cardiovascular consequences of financial stress: a systematic review and meta-analysis," *Current Problems in Cardiology*, vol. 49, no. 2, p. 102153, 2024.

[52] S. Mengelkoch and G. M. Slavich, "Sex differences in stress susceptibility as a key mechanism underlying depression risk," *Current Psychiatry Reports*, vol. 26, no. 4, pp. 157–165, 2024.

[53] P. Chen, "Finding life and balance in our busy lives as women leaders in healthcare and tech," in *Journeys of Women Leaders Pushing Boundaries in Asia and Healthcare*. Springer, 2024, pp. 57–63.

[54] A. Alacreu-Crespo, E. Sebti, R. M. Moret, and P. Courtet, "From social stress and isolation to autonomic nervous system dysregulation in suicidal behavior," *Current psychiatry reports*, vol. 26, no. 6, pp. 312–322, 2024.

[55] S. Chasserio and E. Bacha, "Women-only training programmes as tools for professional development: analysis and outcomes of a transformative learning process," *European Journal of Training and Development*, vol. 48, no. 3/4, pp. 455–477, 2024.

[56] E. G. Emirza and S. Uzun, "The effect of psychotherapeutic interventions on posttraumatic stress disorder symptoms, depression and self-esteem in women exposed to violence: a systematic review and meta-analysis," *Current Psychology*, vol. 43, no. 32, pp. 26 301–26 316, 2024.

[57] F. Zolfaghary, H. Adib-Rad, F. Nasiri-Amiri, M. Faramarzi, H. Pasha, and H. Gholinia-Ahangar, "Effectiveness of computer-based stress inoculation training (sit) counseling approach on anxiety, depression, and stress of students with premenstrual syndrome," *BMC Public Health*, vol. 24, no. 1, p. 555, 2024.

[58] R. M. Sheela and S. Dhanasekar, "Analyzing risk factors of tuberculosis using type-2 interval-valued trapezoidal fuzzy numbers with einstein aggregation operators extended to mcdm," *Heliyon*, vol. 10, no. 16, 2024.

[59] M. Sheela Rani and S. Dhanasekar, "Application of type-2 heptagonal fuzzy sets with multiple operators in multi-criteria decision-making for identifying risk factors of zika virus," *BMC Infectious Diseases*, vol. 25, no. 1, p. 450, 2025.

[60] S. Rani and S. Dhanasekar, "Type-2 trapezoidal pythagorean fuzzy number with novel entropy measure and aggregation operators extended to mcdm," *Complex & Intelligent Systems*, vol. 11, no. 10, pp. 1–45, 2025.