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PATIENT PRIORITIZATION IN WAITING LISTS USING MULTI-CRITERIA METHODS: A SYSTEMATIC LITERATURE REVIEW

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1. INTRODUCTION

Support tools for patient prioritization (PP) in waiting lists assist healthcare facilities in attending to the most severe cases first when demand exceeds capacity. The primary objective is to reduce waiting times for higher-priority patients and to ensure that patients with similar characteristics are treated within equal timeframes (Breton et al., 2020).

The use of PP tools, such as scoring measures, provides a transparent and standardized method for assigning priorities to patients on waiting lists (Déry et al., 2020). Patient ordering can be determined based on scores, urgency classification, or a combination of these approaches (Breton et al., 2020), and is often supported by Multi-Criteria Decision-Making (MCDM) methods.

Several factors are considered in PP models for waiting lists, including: a) The assessment of the relative importance of decision-makers based on experience, education, and knowledge of the problem (Cai et al., 2023; Perez-Aguilar et al., 2024); b) Severity criteria, waiting time, and clinical conditions (Doshmangir et al., 2021; Li et al., 2019; Pécora et al., 2021; Zhang, C. et al., 2018); c) Weighting of criteria according to their relevance (Albahri et al., 2024; Pécora et al., 2021); d) Data analysis to classify patients by severity (Lin; Harris, 2013; Mohammed et al., 2020). Such approaches aim to improve patient care and the use of available resources.

Previous reviews by MacCormick, Collecutt, and Parry (2003), Rahimi et al. (2014), and Déry et al. (2020) have indicated that patient prioritization requires clear ethical criteria, validated and flexible methods, and the integration of multiple perspectives to ensure greater equity and efficiency and to increase acceptance in clinical practice. Despite the significant contributions of these studies, certain aspects of the PP process still require further investigation, such as the characteristics of group decision-making, modeling of uncertainty, and hesitation. In this regard, the present research, through a Systematic Literature Review (SLR), aims to map the characteristics of patient prioritization models for waiting lists, focusing on the use of MCDM methods, group decision-making, and approaches to handling uncertainty, thereby complementing previous reviews.

The article is structured as follows: Chapter 1 presents the context and objectives of the research; Chapter 2 provides a brief theoretical background; Chapter 3 details the methodological procedures for conducting the SLR; Chapter 4 presents and discusses the results obtained; and finally, Chapter 5 offers the conclusion and identifies research gaps and opportunities for future studies.

2. PATIENT PRIORITIZATION AND MULTI-CRITERIA METHODS

Patient prioritization in waiting lists is a critical issue in healthcare organizations, occurring when the number of available appointments is lower than the number of patients requiring procedures. This process is inherently associated with uncertainty and imprecision (Sun *et al.*, 2018).

The PP models are developed through processes that include: a) criteria development, involving a literature review of previously used criteria, consultation with specialists to select the most appropriate criteria for the context, and assigning importance weights through consensus methods (Breton *et al.*, 2020; MacCormick; Collecutt; Parry, 2003; Pécora *et al.*, 2021); b) collecting patient data from waiting lists based on symptoms and diagnoses (Breton *et al.*, 2020; Pécora *et al.*, 2021); and c) prioritizing patients using tools that process patient data and calculate scores or rankings based on defined criteria (Breton *et al.*, 2020; MacCormick; Collecutt; Parry, 2003). Additionally, some models consider the maximum recommended waiting times (MacCormick; Collecutt; Parry, 2003).

During criteria development, a literature review identifies relevant criteria, followed using CRPs such as Brainstorming, Delphi, TRIAGE, and their extensions to discuss criteria for prioritizing waiting lists (Doshmangir *et al.*, 2021; Taherkhani *et al.*, 2022). Group evaluations by expert panels enhance confidence in the results (Déry *et al.*, 2020; Rahimi *et al.*, 2014). Criteria set for patient prioritization include personal, social, clinical, and context-specific factors (Déry *et al.*, 2020; Rahimi *et al.*, 2014). Some evaluations, such as disease severity, patient satisfaction, or healthcare needs, are subjective and abstract (Déry *et al.*, 2020).

For weighting criteria and calculating prioritization scores, MCDM methods have been applied due to their versatility and robustness. Chakraborty *et al.* (2023) explored their application in healthcare, demonstrating how MCDM methods evaluate treatment options, prioritize patient care, and improve resource allocation, adapting to domain-specific needs and generating positive impacts in critical areas. Sahoo and Goswami (2023) highlighted hybrid approaches integrating traditional methods like AHP and TOPSIS to address complex problems, incorporating contemporary concerns such as sustainability and environmental criteria. Boix-Cots *et al.* (2023) present Fuzzy logic-based methods to handle uncertainties and conflicting multi-objective optimization, ensuring MCDM methods remain dynamic and prepared for future challenges.

The application of MCDM methods in waiting list prioritization enables more transparent and efficient decisions, integrating multiple factors and significantly reducing waiting times. Contributions of MCDM methods to patient prioritization include: a) Quantifiable operational improvements: reduced average and maximum waiting times (Silva-Aravena *et al.*, 2022; Rana *et al.*, 2023), increased patient evaluation rates (Silva-Aravena *et al.*, 2022), and reduced critical events and staff hours (Silva-Aravena *et al.*, 2022); b) Qualitative enhancements: greater transparency and equity in decision-making (Rana *et al.*, 2023), integration of clinical and social variables (Romero *et al.*, 2006), consideration of specialists' and patients' opinions (Rahimi *et al.*, 2016b) and improved real-time understanding of patient conditions (Rana *et al.*, 2023); and c) Methodological contributions: development of structured decision-making frameworks (Rahimi *et al.*, 2016b), creation of scoring systems based on social preferences (Romero *et al.*, 2006), implementation of objective scoring methods (Rana *et al.*, 2023), and integration of multiple criteria using techniques like AHP, ANP, and Fuzzy logic (Rahimi *et al.*, 2016a).

3. METHODOLOGICAL PROCEDURES

The SLR aims to map proposed models for PP in waiting lists using a multi-criteria approach through bibliographic analysis (Cauchick-Miguel, 2007) and can be classified as analytical with a thematic scope. The research protocol, based on the PRISMA method (Page *et al.*, 2021), is detailed in Table 1. The phases consist of planning, conducting, and reporting, as proposed by Kitchenham *et al.* (2007).

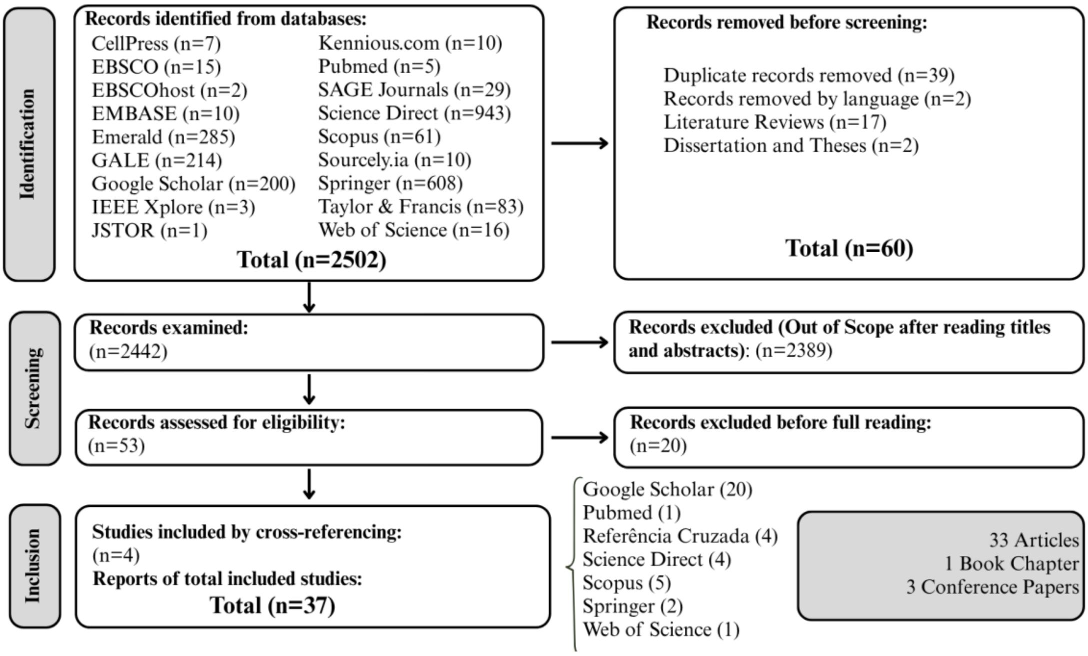
TABLE 1 – SLR PROTOCOL

Phases	Research Elements	Description
Planning	Population	Studies proposing PP models in waiting lists using multi-criteria decision-making methods.
	Intervention	Approaches used to support group decision-making and evaluations under uncertainty and hesitation.
	Comparison	Characteristics of PP models.
	Outcome	Mapping PP model's characteristics in healthcare waiting lists, extracting applied consensus methods, uncertainty handling methods, weighting of decision-makers and criteria, and application areas. Identification of research gaps.
	Context	Patient prioritization in waiting lists.
	Research Questions	Q1. Which MCDM methods are used in the PP process for waiting lists? Q2. What are the application areas of the proposed models? Q3. Which models use weights for decision-makers and criteria, and how are these weights obtained? Q4. Which models use CRPs, and how are they applied in healthcare waiting list prioritization? Q5. How do the analyzed models handle uncertainty and hesitation? Q6. What research gaps can be identified from the study analysis?
Conducting	Keywords	Patient prioritization; Waiting lists; Multi-criteria Decision-Making Methods.
	Databases	CellPress; EBSCO; EBSCOhost; EMBASE; Emerald; GALE; Google Scholar; IEEE Xplore; JSTOR; Kennious.com; PubMed; SAGE Journals; Science Direct Scopus; Sourcely.ia; Springer; Taylor & Francis; Web of Science.
	Search Dates	December 26 and 27, 2024
	Period	Up to 2024
	Language	English, Portuguese, and Spanish
	Inclusion Criteria	Studies proposing PP models using MCDM methods; cross-referenced studies cited in analyzed articles but not retrieved from database searches.
Conducting	Exclusion Criteria	Duplicate articles, out-of-scope articles not meeting inclusion criteria, literature reviews, theses and dissertations, and articles in languages outside the analysis scope.
	Search String	*Taylor & Francis*: [[*All*: "*multicriteria decision making*"] *OR* [*All: "multi-criteria decision making"*] *OR* [*All*: MCDM]] *AND* [[*All*: "*patients ranking*"] *OR* [*All*: "*patients prioritization*"] *OR* [*All*: "*waiting times*"] *OR* [*All*: "*waiting lists*"]]; Other databases: (*ALL* = ("*multi-criteria decision making*" OR "*multicriteria decision making*" *OR* MCDM) *AND ALL=* ("*Patients Prioritization*" OR "*Waiting List*" OR "*Waiting Time*"))
	Filters	No filters
	Selection	Conducted by reading titles, keywords, and abstracts.
	Data Extraction	Extracted characteristics: a) Study objective; b) Method(s) used; c) Uncertainty handling; d) Preference modelling; e) Group decision-making support; f) Decision-maker weighting; g) Decision-maker weight calculation; h) Criteria weighting; i) Criteria weight calculation; j) Use of consensus process; k) Consensus method; l) Application area; m) Application type (real, fictitious, secondary data, or not applied)
Reporting	Information Synthesis	Summary of results and answers to research questions. Identification of research gaps and recommendations for future studies. Conclusions, contributions, and limitations

SOURCE: Based on (Kitchenham, 2007; Page et al., 2021).

Figure 1 illustrates the phases of the systematic literature selection process, including the number of identified and excluded documents. Search results were exported to spreadsheets for data compilation and initial analyses.

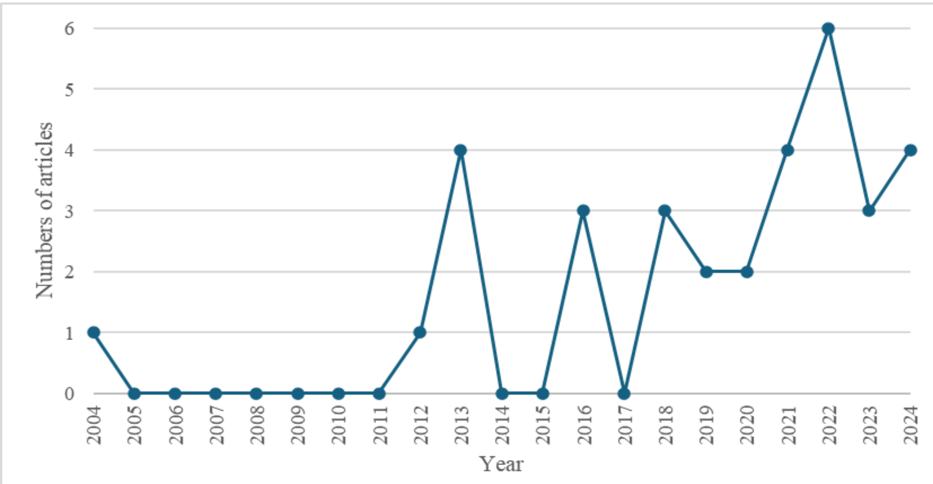
FIGURE 1 - PRISMA PROTOCOL FOR DOCUMENT SELECTION



SOURCE: The Authors (2025)

To map the characteristics of PP models in waiting lists, thirty-seven peer-reviewed documents published between 2004 and 2024 were selected. The sample comprises thirty-three journal articles with distribution shown in Figure 2, 3 conference papers, which were presented at the Industrial & Systems Engineering Research Conference (ISERC), the Congress International DE Genie Industrial, and the IESM Conference, and a book chapter published at Springer Nature Link.

FIGURE 2 – DISTRIBUTION OF ARTICLES PUBLISHED BY YEAR



SOURCE: The Authors (2025)

The articles were published across thirty different journals, as shown in Table 2. Only three journals: Applied Intelligence, Journal of Simulation, and Mathematics published more than one article on the topic, suggesting that this is a distributed research area across Operations Research, Healthcare, and Management.

TABLE 2 – FREQUENCY OF ANALYZED ARTICLES BY JOURNAL (continue)

Journals	Number of Publications
Applied Intelligence	2
Journal of Simulation	2
Mathematics	2
Applied Soft Computing	1
BMC Nephrology	1
BMC Public Health	1
Brazilian Journal of Operations & Production Management	1
Clinical Governance	1
Complex & Intelligent Systems	1
Computer methods and programs in biomedicine	1
Decision Making: Applications in Management and Engineering	1
Decision Support Systems	1
European Journal of Operational Research	1
Expert Systems with Applications	1
Health Policy	1
Heliyon	1
IEEE Access	1
IISE Transactions on Healthcare Systems Engineering	1
International Journal of Environmental Research and Public Health	1
International Journal of Fuzzy Systems	1
Journal of Ambient Intelligence and Humanized Computing	1
Journal of Biomedical Informatics	1
Journal of Intelligent & Fuzzy Systems	1
Journal of Medical Systems	1
Journal of Multi-Criteria Decision Analysis	1
Journal of the Operational Research Society	1
Knowledge-Based Systems	1
Scientific Reports	1
Sensors	1
The Journal of Modern Project Management	1
Total Articles	**33**

SOURCE: The Authors (2025)

4. DISCUSSION

From the analysis of the thirty-seven documents, the MCDM methods used in PP, their application areas, group decision-making characteristics, and uncertainty handling approaches were mapped. The results are presented and discussed in the following sections.

4.1 Multi-criteria Methods Used for Patient Prioritization in Waiting Lists and Application Areas

MCDM methods were applied in distinct phases of the prioritization process, including criteria identification, criteria weighting, and patient ranking. Table 3 details the

MCDM methods used in each phase, along with the respective studies, addressing research question Q1 (Table 1).

TABLE 3 – MCDM METHODS IN WAITING LIST PRIORITIZATION PHASES

Phase	Methods (Authors)
Criteria Identification	• Brainstorming with ANP (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016) • F-DEMATEL (Perez-Aguilar *et al.*, 2024) • TPM (Salman; Aal-Nouman; Taha, 2020)
Criteria Weighting	• 2-tuple DEMATEL (Zhu *et al.*, 2019) • AHP (Alsalem *et al.*, 2022; Doshmangir *et al.*, 2021; Frichi; Aboueljinane; Jawab, 2023; Lin; Harris, 2013; Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016) • ANP (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Rahimi; Jamshidi, 2014) • Fuzzy-AHP (Pécora *et al.*, 2021; Rahimi; Jamshidi; Ait-Kadi; Bartolome, 2015; Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016) • Fuzzy-ANP (Davodabadi *et al.*, 2021; Rahimi; Jamshidi; Ait-Kadi; Bartolome, 2015) • IF-AHP (Perez-Aguilar *et al.*, 2024; Taherkhani *et al.*, 2022) • MLAHP (Hamid *et al.*, 2022; Kalid *et al.*, 2018) • PAPRIKA (Perris; Labib, 2004)
Decision-Makers Weighting	• Not obtained using MCDM methods
Patient Prioritization (Classification/Ranking)	• CoCoSo (Perez-Aguilar *et al.*, 2024) • FOFWZIC-TROOIL (Alamoodi *et al.*, 2023) • Fuzzy VIKOR (Zhu *et al.*, 2019) • Fuzzy-TOPSIS (Davodabadi *et al.*, 2021; Rana *et al.*, 2023) • HFL-MABAC (Sun *et al.*, 2018) • HFL-ORESTE (Li *et al.*, 2019) • HFL-VIKOR (Zhang, Fengyi *et al.*, 2016) • IM ORESTE (Zhang, C. *et al.*, 2018) • MABAC (Albahri *et al.*, 2024) • OWA (Doshmangir *et al.*, 2021; Rana S. *et al.*, 2022) • PL-WASPAS (Darko; Liang, 2022) • q-RF2L-WASPAS (Abbas *et al.*, 2024) • TOPSIS (Hamid *et al.*, 2022; Kalid *et al.*, 2018) • TROOIL (Mohammed *et al.*, 2020) • VIKOR (Alsalem *et al.*, 2022)

SOURCE: The Authors (2025)

ABBREVIATIONS: Analytic Network Process (ANP), Intuitionistic Fuzzy (IF), Triage and Prioritization Model (TPM), Decision-Making Trial and Evaluation Laboratory (DEMATEL), Analytic Hierarchy Process (AHP), Multi-Layer Analytic Hierarchy Process (MLAHP), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), Combined Compromise Solution (CoCoSo), Fractional Orthotriple Fuzzy Weighted Zero Inconsistency (FOFWZIC), Multi-criteria Optimization and Compromise Solution (VIKOR), Hesitant Fuzzy Linguistic Terms (HFL), Multi-Attribute Border Approximation Area Comparison (MABAC), Organization, Ranking, and Synthesis of Relational Data (ORESTE), Ordered Weighted Averaging (OWA), Weighted Aggregated Sum Product Assessment (WASPAS), Probabilistic Linguistic (PL), q-Rung Orthopair Fuzzy 2-Tuple Linguistic (q-RF2L), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Technique for Reorganization of Opinion Order to Interval Levels (TROOIL).

Addressing research question Q2 (Table 1), the PP methods analyzed were applied in various areas: elective surgery, emergency care, inpatient care, liver transplantation, elective examinations, kidney transplantation, appointment scheduling, ICU bed allocation, stem cell receipt, and lung transplantation, as shown in Table 4. These methods were used in different contexts, including real scenarios (59%), fictitious patient data (24%), secondary data (5%), and some models were only developed without application (11%).

TABLE 4 – APPLICATION AREAS AND TYPES OF ANALYZED MODELS

Application Area	Authors (Chronological Order)	Application Type
Elective Surgery (11)	Hansen *et al.* (2012) Solans-Domènech *et al.* (2013) Rahimi, Jamshidi, Ait-Kadi e Bartolome (2015) Rahimi, Jamshidi, Ait-Kadi e Ruiz (2015) Rahimi *et al.* (2016a, b) Silva-Aravena *et al.* (2021) Rana *et al.* (2022) Frichi, Aboueljinane e Jawab (2023) Rana *et al.*, (2023) Rana *et al.* (2024)	Real Not applied Fictitious Fictitious Fictitious/Real Real Fictitious Fictitious Secondary data Not applied
Emergency Care (8)	Fields, Okudan e Ashour (2013) Kalid *et al.* (2018) Mohammed *et al.* (2020) Salman, Aal-Nouman e Taha (2020) Hamid *et al.* (2022) Alamoodi *et al.* (2023) Albahri *et al.* (2024) Perez-Aguilar *et al.* (2024)	Fictitious Real Real Fictitious Real Secondary data Real Real
Inpatient care (7)	Zhang *et al.* (2016) Zhang *et al.* (2018) Sun *et al.* (2018) Li e Jialing *et al.* (2019) Zhu *et al.* (2019) Darko e Liang (2022) Abbas *et al.* (2024)	Real Real Real Real Real Real Real
Liver Transplantation (3)	Lin e Harris (2013) Feng, Kong e Wan (2013) Rahimi e Jamshidi (2014)	Real Fictitious Real
Elective Examinations (2)	Doshmangir *et al.* (2021) Pécora *et al.* (2021)	Not applied Not applied
Kidney Transplantation (2)	Perris e Labib (2004) Taherkhani *et al.* (2022)	Real Real
Appointment Scheduling (1)	Silva-Aravena *et al.* (2022)	Real
ICU Beds (1)	Davodabadi *et al.* (2021)	Fictitious
Stem Cell Receipt (1)	Alsalem *et al.* (2022)	Real
Lung Transplantation (1)	Al-Ebbini, Oztekin e Chen (2016)	Real

SOURCE: The Authors (2025)

This section identified various MCDM methods used for patient prioritization, including AHP, ANP, Fuzzy-AHP, Fuzzy-ANP, TOPSIS, VIKOR, among others. All analyzed studies integrated multiple methods, demonstrating the complexity of the PP problem, requiring specific techniques for consensus reaching, criteria identification, decision-maker and criteria weighting, and patient prioritization. The methods were predominantly applied to elective surgery, corroborating Déry *et al.* (2020). Studies were conducted in real and fictitious contexts, using secondary data or theoretical model propositions. PP in waiting lists is a critical issue that can be addressed with MCDM methods.

4.2 Decision-Makers' Importance Weights

Regarding research question Q3 (Table 1), 31 models (84%) supported group decision-making, while six focused on individual decisions (16%). In individual decision-making models, two studies adapted existing prioritization models to represent inputs as triangular or trapezoidal Fuzzy numbers (Perris; Labib, 2004; Rana *et al.*, 2023) for greater flexibility in patient evaluations. Two studies used linguistic expressions represented by Hesitant Fuzzy Linguistic Term Sets (HFLTS) (Sun *et al.*, 2018; Zhang, Fengyi *et al.*, 2016). Two others used binary inputs combined with emergency department database data for triage (Feng; Kong; Wan, 2013; Salman; Aal-Nouman; Taha, 2020).

Among group decision-making models, only six used decision-maker importance weights. In three studies, weights were assigned without specifying their derivation (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Zhu *et al.*, 2019). In the other three, weights were calculated. Darko and Liang (2022) calculated weights from individual decision matrices expressed in linguistic terms and represented by Probabilistic Linguistic Term Sets, used to aggregate matrices into a normalized collective decision matrix. Abbas *et al.* (2024) used a similar process with evaluations represented by q-RF2L, proposing prioritized average and Maclaurin symmetric mean operators for q-RF2L. Perez-Aguilar *et al.* (2024) collected evaluations as linguistic terms transformed into triangular Intuitionistic Fuzzy numbers, calculating decision-maker weights by dividing individual evaluations by the sum of all decision-makers' evaluations using a specific equation for triangular Intuitionistic Fuzzy numbers. Decision-makers' characteristics were not used in weight calculations.

This section confirmed that most proposed models support group decision-making, but few consider decision-makers' importance weights, which are crucial for fair and effective decisions. Among those using weights, only two calculated them from decision matrices, and one based the weights on participant evaluations. Evaluations were conducted in linguistic terms, represented by Fuzzy sets for natural language proximity. These findings highlight the need for more research on models calculating decision-maker weights based on evaluations and exploring characteristics like experience, education, and decision-making proximity.

4.3 Criteria's Importance Weights

Of the analyzed studies, only one did not assign weight criteria, focusing on aggregating nurse prioritizations to assess aggregation methods (Fields; Okudan; Ashour, 2013). In three studies, weight values were reported without explaining their derivation (Abbas *et al.*, 2024; Sun *et al.*, 2018; Zhang, Fengyi *et al.*, 2016). To obtain criteria weights, addressing research question Q3 (Table 1), decision-makers provided evaluations based on their opinions, expressed as numerical values, linguistic terms, or expressions. Table 5 presents the representations used for these evaluations.

TABLE 5 – REPRESENTATIONS FOR CRITERIA EVALUATION

Evaluation Type	**Fuzzified As**
Numerical Values	• Generalized sinusoidal Fuzzy numbers (Al-Ebbini; Oztekin; Chen, 2016) • Trapezoidal Fuzzy numbers (Taherkhani *et al.*, 2022)
Linguistic Terms	• Generalized sinusoidal Fuzzy numbers (Al-Ebbini; Oztekin; Chen, 2016) • Triangular Fuzzy numbers (Davodabadi *et al.*, 2021; Perris; Labib, 2004; Rahimi; Jamshidi; Ait-Kadi; Ruiz, 2015; Rana *et al.*, 2023, 2024; Zhu *et al.*, 2019) • Fuzzy Soft Sets (Rahimi; Jamshidi; Ait-Kadi; Bartolome, 2015) • Linguistic intervals (Mohammed *et al.*, 2020) • Probabilistic Linguistic Sets (Darko; Liang, 2022) • Fractional Orthotriple Fuzzy Sets (FOFN) (Alamoodi *et al.*, 2023) • Single-Valued Neutrosophic 2-tuple Linguistic Sets (SVN2TL) (Albahri *et al.*, 2024) • q-Rung Orthopair Fuzzy 2-Tuple Linguistic Sets (q-RF2L) (Abbas *et al.*, 2024)
Linguistic Expressions	• *Hesitant Fuzzy Linguistic Term Sets* (Li *et al.*, 2019; Sun *et al.*, 2018)

SOURCE: The Authors (2025)

In 31 studies, criteria weights were calculated using various procedures, as shown in Table 6, classified by input type.

TABLE 6 – CRITERIA WEIGHT CALCULATION PROCEDURES

Evaluation Type	**Weight Calculation Procedure**

Numerical Values	• Arithmetic average (Rana *et al.*, 2023; Rana *et al.*, 2022)
	• Percentage of each criterion relative to all assigned scores (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Solans-Domènech *et al.*, 2013)
	• Normalization by dividing the sum of each criterion's scores by the total scores of all criteria across all experts (Silva-Aravena *et al.*, 2022, 2021)
	• MCDM methods:
	  o AHP (Alsalem *et al.*, 2022; Doshmangir *et al.*, 2021; Feng; Kong; Wan, 2013; Frichi; Aboueljinane; Jawab, 2023; Lin; Harris, 2013; Rahimi; Jamshidi, 2014).
	  o ANP (Rahimi; Jamshidi, 2014); PAPRIKA (Hansen *et al.*, 2012).
	  o Multi-layer (ML)-AHP (Hamid *et al.*, 2022; Kalid *et al.*, 2018).

Linguistic Terms	• Triangular or trapezoidal Fuzzy numbers (Davodabadi *et al.*, 2021; Pécora *et al.*, 2021; Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Rana *et al.*, 2024) • Intuitionistic Fuzzy Set (Perez-Aguilar *et al.*, 2024; Taherkhani *et al.*, 2022) • Numerical intervals using entropy values (Mohammed *et al.*, 2020) • Fractional Orthotriple Fuzzy Set (FOFS) aggregated with FOFS operator and defuzzied to crisp weights (Alamoodi *et al.*, 2023) • 2-tuple, weights obtained by arithmetic average aggregation (Zhu *et al.*, 2019) • Single-Valued Neutrosophic 2-tuple Linguistic (SV2TL), weights obtained by dividing the sum of each criterion's weights by the total weights of all criteria for SV2TL (Albahri *et al.*, 2024) • Intuitionistic Multiplicative Numbers (IMN) with paired evaluations, weights obtained from distances using the IMN score function (Zhang, C. *et al.*, 2018).
Linguistic Expressions	• HFLTS, weights calculated by distances of each criterion relative to the highest-rated criterion among decision-makers (Li *et al.*, 2019).

SOURCE: The Authors (2025)

This section presents the representations and procedures for calculating the importance weights of criteria. Studies used various representations transformed into Fuzzy numbers to enhance model flexibility and address uncertainty and imprecision. Criteria weight calculations involved averages, percentages, normalization, and MCDM methods like AHP, ANP, and PAPRIKA based on paired evaluations.

4.4 Use of Consensus Reaching Processes

This section addresses research question Q4 (Table 1), identifying CRPs used in the analyzed studies. Seven studies did not use CRPs (Feng; Kong; Wan, 2013; Perris; Labib, 2004; Rahimi; Jamshidi; Ait-Kadi; Bartolome, 2015; Rahimi; Jamshidi, 2014; Salman; Aal-Nouman; Taha, 2020; Sun *et al.*, 2018; Zhang, Fengyi *et al.*, 2016). In 30 studies, CRPs were used for criteria identification, aggregating individual decision matrices, achieving agreement on weighted decision matrices, reaching consensus on criteria weights, and defining criterion interrelationships. Table 7 details the CRPs used by the objective.

Among studies using CRPs, 11 applied them for criteria identification, 18 for aggregating individual decision matrices, 7 for consensus on criteria weights, 1 for defining criterion interrelationships, and 3 in other phases. Various procedures were used, but few detailed the processes for Delphi, SEJ, and TRIAGE methods. Most CRPs used Fuzzy approaches to handle uncertainty. Evaluations were expressed using numerical values, linguistic terms, and expressions represented by Fuzzy sets. CRPs are essential for inclusive decision-making, ensuring legitimacy and acceptability.

TABLE 7 – USE OF CRPs (continue)

Objective	Procedure
Criteria Identification	• Delphi (Doshmangir *et al.*, 2021) • Fuzzy-Delphi (Davodabadi *et al.*, 2021; Taherkhani *et al.*, 2022) • Structured Expert Judgment (SEJ) (Alamoodi *et al.*, 2023; Albahri *et al.*, 2024) • Modified-Delphi with iteration (Hansen *et al.*, 2012; Li *et al.*, 2019) • Discussion meetings (Pécora *et al.*, 2021; Silva-Aravena *et al.*, 2022) • Nominal Technique and Delphi by panel (Solans-Domènech *et al.*, 2013) • TRIAGE with Fleiss' Kappa for inter-rater agreement (Rana S. *et al.*, 2022)
Aggregation of Individual Decision Matrices for Criteria Weighting or Alternative Evaluation	• Aggregation operators with decision-maker weights (Abbas *et al.*, 2024; Perez-Aguilar *et al.*, 2024) • Aggregation operators without decision-maker weights (Alsalem *et al.*, 2022; Kalid *et al.*, 2018) • Arithmetic average (Hamid *et al.*, 2022; Rahimi; Jamshidi; Ait-Kadi; Ruiz, 2015; Silva-Aravena *et al.*, 2021; Zhu *et al.*, 2019) • 2-Tuple arithmetic average (Zhu *et al.*, 2019) • Arithmetic average for DEMATEL influence matrix aggregation (Perez-Aguilar *et al.*, 2024) • Prioritized average (PA) and Maclaurin symmetric mean (MSM) (Darko; Liang, 2022) • Geometric averaging (Frichi; Aboueljinane; Jawab, 2023) • Normalized averaging (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016) • Ordered Weighted Averaging (OWA), including Borda-Kendall method (Fields; Okudan; Ashour, 2013) • Maclaurin symmetric average for q-Rung Orthopair Fuzzy 2-Tuple Linguistic Set (q-RF2L) (Abbas *et al.*, 2024) • Min-Max Regret Approach (MRA) (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016) • Global scoring operator based on preference aggregation with Pearson coefficient for IMN distances (Zhang, C. *et al.*, 2018) • Utility interval estimation operators using linear and non-linear programming (Fields; Okudan; Ashour, 2013)
Agreement on Decision Matrices	• Agreement and consensus index (Perez-Aguilar *et al.*, 2024) • Fuzzy-Weighted Zero Inconsistency method (Alamoodi *et al.*, 2023)
Consensus on Criteria Weights	Delphi (Lin; Harris, 2013), Fuzzy-Delphi (Taherkhani *et al.*, 2022), Modified-Delphi (Hansen *et al.*, 2012), Nominal Technique and Delphi (Solans-Domènech *et al.*, 2013), TRIAGE (Rana S. *et al.*, 2022), Structured Expert Judgment (SEJ) (Albahri *et al.*, 2024), Agreement and consensus index (Rana *et al.*, 2024).
Definition of Criterion Interrelationships	• Brainstorming method (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016)
Other Phases	• Defining triangular Fuzzy interval values for each criterion (Al-Ebbini; Oztekin; Chen, 2016) • Validating Fuzzy Inference System rules (Mohammed *et al.*, 2020) • Aggregation operators with decision-maker weights in the result simulation phase (Rana *et al.*, 2023)

SOURCE: The Authors (2025)

4.5 Approaches to Handling Decision-Making Under Uncertainty

This section addresses research question Q5 (Table 1), identifying approaches to handle uncertainty in waiting list prioritization. PP is a complex problem (Albahri *et al.*, 2024) reliant on human evaluations (Al-Ebbini; Oztekin; Chen, 2016) in dynamic (Perez-Aguilar *et al.*, 2024) and uncertain environments (Davodabadi *et al.*, 2021; Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016). In 16 studies (43%), uncertainty was not considered in the model design. Fuzzy and Rough Sets approaches were used to address uncertainty, as shown in Table 8, based on evaluation expression types.

TABLE 8 – REPRESENTATIONS FOR HANDLING UNCERTAINTY

Evaluation Type	Uncertainty Representation
Numerical Values	• Triangular or Trapezoidal Fuzzy numbers (Perris; Labib, 2004) • Membership degrees in Fuzzy Inference Systems (Al-Ebbini; Oztekin; Chen, 2016) • Intuitionistic Multiplicative Set (Zhang, C. *et al.*, 2018) • Fuzzy Soft Sets (Rahimi; Jamshidi; Ait-Kadi; Bartolome, 2015) • Interval Rough Number (Mohammed *et al.*, 2020; Rana *et al.*, 2023)
Linguistic Terms	• Probabilistic Linguistic Term Sets (Darko; Liang, 2022) • Single-Valued Neutrosophic 2-tuple Linguistic Sets (Albahri *et al.*, 2024) • Triangular Fuzzy numbers with probability rates via Dempster-Shafer Theory (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016) • Triangular Fuzzy numbers (Pécora *et al.*, 2021; Rana *et al.*, 2024; Zhu *et al.*, 2019) • Triangular and Trapezoidal Fuzzy numbers (Davodabadi *et al.*, 2021; Rahimi; Jamshidi; Ait-Kadi; Ruiz, 2015; Taherkhani *et al.*, 2022) • Intuitionistic Fuzzy Set (Perez-Aguilar *et al.*, 2024) • q-Rung Orthopair Fuzzy 2-Tuple Linguistic (Abbas *et al.*, 2024) • Fractional Orthotriple Fuzzy Numbers (Alamoodi *et al.*, 2023) • 2-Tuple (Zhu *et al.*, 2019)
Linguistic Expressions	• HFLTS (Li *et al.*, 2019; Sun *et al.*, 2018; Zhang, Fengyi *et al.*, 2016)

SOURCE: The Authors (2025)

5 CONCLUSION AND RESEARCH GAPS

This article mapped PP models in waiting lists using MCDM methods. The results showed that MCDM methods are widely used, considering criteria related to health conditions, disease severity, and waiting times. Table 9 summarizes the answers to the research questions from the protocol.

TABLE 9 – SUMMARY OF RESEARCH QUESTION RESPONSES (continue)

Question	Summary
Q1. Which MCDM methods are used in the PP process for waiting lists?	MCDM methods are used in criteria identification, criteria weighting, decision-maker weighting, and PP. Nominal descriptions are provided in Section 4.1 – Table 3.
Q2. What are the application areas of the proposed models?	Application areas include elective surgery, emergency care, hospitalization, liver transplantation, elective examinations, kidney transplantation, appointment scheduling, ICU beds, stem cell receipt, and lung transplantation. Authors and application types are detailed in Section 4.1 – Table 4.
Q3. Which models use weights for decision-makers and criteria, and how are these weights obtained?	**Decision-makers' weights**: Reported in three studies (Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Rahimi; Jamshidi; Ruiz; Ait-Kadi, 2016; Zhu *et al.*, 2019), calculated in three (Abbas *et al.*, 2024; 2022; Perez-Aguilar *et al.*, 2024), details in Section 4.2. **Criteria's weights**: One study did not use criteria's weights (Fields; Okudan; Ashour, 2013), three reported values without derivation (Abbas *et al.*, 2024; Sun *et al.*, 2018; Zhang, Fengyi *et al.*, 2016), 31 calculated weights, detailed in Section 4.3 – Table 6.
Q4. Which models use CRPs, and how are they applied in healthcare waiting list prioritization?	Nine studies did not use CRPs; 29 used CRPs for criteria identification (7), aggregating individual decision matrices (12), consensus on criteria's weights (6), and defining criterion interrelationships (1), detailed in Section 4.4 – Table 7.
Q5. How do the analyzed models handle uncertainty and hesitation?	Models handle uncertainty and hesitation using numerical values, linguistic terms, and expressions represented as shown in Table 8, Section 4.5.

TABLE 9 – SUMMARY OF RESEARCH QUESTION RESPONSES (end)

Question	Summary
Q6. What research gaps can be identified from the study analysis?	Need for practical, flexible, and structured tools to improve PP. Development of models tailored to specific institutional needs. Consideration of decision-making characteristics for weight generation. Use of HFLTS to capture hesitation in other application areas. Use of AI tools for dynamic decision-maker weight calculation in CRPs to enhance consensus and eliminate iterative rounds. Need for comparative studies of PP models using MCDM methods with identified characteristics as comparison factors. Detailed in Section 5.

SOURCE: The Authors (2025)

This review identified several research gaps in patient prioritization using MCDM methods, particularly the need for practical evaluation, flexible and structured tools, and adaptation to specific institutional contexts, in line with Déry et al. (2020). Key characteristics of PP models include the use of decision-makers' and criteria's weights, consensus methods, and approaches for managing uncertainty. While most models support group decision-making, few account for the relative importance of decision-makers. A summary of the research gaps identified in response to Q6 (Table 1) is presented in Table 9.

The findings underscore the value of assigning importance weights to decision-makers and combining consensus methods with judgment aggregation at distinct stages to ensure robust and accepted outcomes. HFLTS-based linguistic expressions, though mainly applied to hospitalization prioritization, show potential for capturing hesitation in broader contexts.

Consensus Reaching Processes—such as Delphi, TRIAGE, and focus groups—are commonly used but are often resource-intensive due to the need for moderators and multiple evaluation rounds. Future studies should explore artificial intelligence to streamline CRP, dynamically weight decision-makers, and enhance consensus. Further research is also needed in areas like organ transplantation, appointment scheduling, and elective examinations.

Future studies should focus on developing models that account for uncertainty and hesitation, as well as exploring innovative approaches to managing uncertainty. Moreover, considering the characteristics of decision-makers and using HFLTS-represented linguistic expressions to capture hesitation is crucial.

Despite these efforts, it is essential to acknowledge that this research is not exhaustive and can be complemented by consulting other knowledge bases, including articles written in other languages. Additionally, the limitations of this research include the subjectivity of researchers in article selection and result analysis.

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