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Multi-Criteria Decision Making (MCDM) Applications in Military Healthcare Field

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ABSTRACT

Military decision-making is a critical process in which all environmental factors need to be assessed in detail in a risky environment. Due to the risky situation in this field, the decision-making process becomes more serious. Important developments and changes have also been experienced in the healthcare field worldwide. Over the past few years, the limited and even insufficient resources in the face of these developments and changes increase the importance of the studies in the healthcare field. Therefore, when all existing situations, constraints and risks are considered in the field of military and healthcare systems, a decision process is required in the field of military healthcare system in which many criteria are considered and evaluated from various aspects. At this point, Multi-Criteria Decision Making (MCDM) methods are systematic, consistent and powerful approaches to supply this demand. Although a large amount of research has been done so far on healthcare and military field using different methodological approaches, it is

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observed that there is a shortage in the application of MCDM methods in the field of military healthcare. Therefore, an encouraging study is necessary to increase the number of studies in this field. The main purpose of this study is to emphasize the importance and development of MCDM methods in military healthcare by considering how MCDM methods are applied separately in the military and healthcare fields in the literature.

In this context, the basic concept of MCDM methodologies is introduced and the studies that applied MCDM methods in healthcare and military are analyzed. This study is expected to bring insights to further studies in the military healthcare field.

Keywords: Decision-making, Healthcare, Military Healthcare, Military Decision Making, Multi-Criteria Decision Making (MCDM)

INTRODUCTION

Health is defined as the physical, mental, and social well-being of the person as a whole. Health services are the medical intervention that aims to eliminate various factors damaging the health status of a person and protect the society from the effects of these factors and treat patients.

The military force can be defined as the armed forces of a state under the Land, Naval, and Air forces. All systems that involve human beings are responsible to examine the health status of the people by providing the necessary health services. Therefore, investigation of the health system and health conditions of the military personnel and their relatives are priority issues that need to be discussed and analyzed in the military field. For this purpose, healthcare services in the military get involved. The physical, emotional, cognitive and psychological demands of the military environment create great stress even on the well-supported military personnel and also their relatives. Moreover, in such an environment with a high degree of uncertainty and risks that could result in injury or even death, healthcare service in the military is undoubtedly the most important service to be addressed (Rizzo et al., 2011).

The military health system has two essential tasks. The first one is to provide care to people who are injured during military interventions. The second one is to offer the provision of all healthcare assistance to maintain the current health status of both active and retired military personnel and their relatives during peacetime. These two separate objectives have a common purpose: to make all the necessary arrangements for the provision of healthcare services in a good and sustainable system. The operation of the military healthcare system can differ from country to country to maintain these missions of military healthcare systems. Healthcare service benefits and fees can vary among countries. For instance, in the UK, Germany, and China, health services are provided to soldiers free of charge. In France, soldiers do not pay for military healthcare. However, when these personnel are transferred to a civilian medical center, the soldiers cover 15% of the service costs in France (Magnezi et al., 2005). Moreover, the United States has one of the largest and complex healthcare institutions and the world's prominent military healthcare delivery operation as The Military Health System (MHS). The MHS can be defined as a federal system which consists of uniformed, civilian and contracted personnel and additional civilian partners at all levels of the Ministry of Defense. MHS provides health services through a program called TRICARE at military treatment facilities ("Elements of the MHS", n.d.). However, since the dynamic structure of health systems cannot remain unresponsive to changes, development is observed in this system. In this dynamic environment, which technologies cause innovation in the military health system in the future has become an important issue to measure the response of the system to changes (Green et al., 2018). Virtual health, augmented reality, 3D printing, robotic surgery, next-generation patient-centered care, wearables, augmented intelligence, blockchain, precision medicine and regenerative medicine are 10 technologies that are expected to spur MHS innovation. These developments are expected to affect not only the system within this country but also the ones worldwide. Moreover, there have been remarkable transformations in the field of health in recent years. Under the health transformation programs, the concept of value-based comes to the forefront among all systems in which health is involved. Value-based expression requires restructuring in various aspects of the healthcare system such as pricing of medical equipment and devices, reimbursement and treatment of patients. Existing health systems are continuously involved in the renewal process to respond to these changes and developments. The military health system, which is a major component of the healthcare system, is also affected by these changes.

The objective of this study is to review and analyze conducted MCDM studies in the military and healthcare field separately and also to provide a motivation study via creating new ideas about how it can be used in the field of military health.

This chapter is organized as follows. Section-2 provides a brief introduction to decision making and military decision making. Section-3 gives an introduction to MCDM with History and Brief Explanation of Multi-Criteria Decision Making, Basic Principles and Terms and Its Application Areas. Section-4 presents selected studies conducted with MCDM in military, healthcare and military healthcare. Finally, the conclusion is presented in the last section.

INTRODUCTION TO DECISION-MAKING

Decision-making can be defined as the physical and mental efforts, in which the decision-maker or makers encounter more than one alternative, to choose the most appropriate one under the determined objective. A good decision can be defined as a decision based on logic, taking into account all available data and possible alternatives, and applying a quantitative approach.

Furthermore, to make the most accurate decision, the environment data should be as accessible, identifiable and precise as possible. A decision-making process mainly consists of five steps: defining the problem and objective, determination of criteria, identifying the alternatives, application of the appropriate methodology and evaluation and validation of results. Every step requires logical action for rationality and efficiency in the decision-making process. The relationship between logic and decision has been investigated for a long time. Decision support systems are established as an outcome of these efforts (Çakir et al.,2009; Temuçin et al.,2014).

Decision-making problems are encountered in every part of life. The solution to the decision-making problems faced might be easy if there are single-featured options. However, it might still require a procedure to be followed. In such cases where the decision-making process becomes more complex, a method or a tool is needed to make this type of decision-making process easier and more explicit (Tozan,2011).

Military Decision-Making

The military decision-making process (MDMP) is a unique, well-established and accepted systematic process. The MDMP helps the commander who is in charge of the military decision-making process and military personnel to examine, analyze and predict the situation before a war or on time to make reasonable decisions. MDMP is generally used to manage decision processes effectively in a time-constrained environment. ("Staff Organization and Operations", 1997)

A military decision support system should support operations, planning and strategic decisions at any military organization level. Besides, it should be applicable to other fields such as healthcare within the military system. Commanders should investigate the applicability of decision support systems and training development methods to achieve better decisions. The decision support system to be implemented should be appropriate to this situation when there are varying situations in this decision-making process and there are many criteria to be evaluated. However, the classical military decision-making process is not an effective method in these circumstances and may not be appropriate to apply. In this manner, when there are many criteria and alternatives to be considered in the decision-making process, a new approach is proposed for MCDM methods. Classic MDMP has seven steps which are mission determination, mission analysis, course of action development, course of action analysis, course of action comparison, course of action approval and orders production. However, the new approach consists of five steps. These are; mission determination, mission analysis, course of action development and analysis applying MCDM, analysis of course of action alternatives and approving the selected course of action respectively (Goztepe and Kahraman, 2015).

INTRODUCTION TO MULTI-CRITERIA DECISION MAKING

This section aims to give brief information about MCDM and its definition in literature. Under this purpose, history and a brief explanation of MCDM are the first focus and basic principles and terms associated with MCDM methodologies are the second part of this section.

History and Brief Explanation of Multi-Criteria Decision Making

MCDM, also referred to as Multi-criteria Decision Analysis (MCDA), is a decision-making tool that conducts mathematical analysis through data provided by potential solution alternatives under certain conflicting criteria to select optimal choice among multiple alternatives. MCDM methods address problems in which alternatives are predefined and decision-makers evaluate these alternatives according to multiple criteria. MCDM methods can improve the quality of decisions by making the decision process more explicit, rational and efficient (Montazer et al., 2009).

The earliest reference about the MCDM approach can be traced to Benjamin Franklin in the 1700s. He compared the arguments in favor of and against him to make a decision and also mentioned weighting in decision making (Köksalan et al., 2013).

In the literature, there are many different definitions and expressions for MCDM. For example, MCDM is a set of methodologies used to compare and sort alternatives or make a selection among them under multiple and conflicting criteria that include both tangible and intangible factors (Sadeghzadeh and Salehi 2011). Belton and Stewart stated that MCDM can be defined as a decision-making process for a situation that requires to be balanced by more than one evaluation factor that may be significantly conflicting (Belton and Stewart, 2002). From another point of view, MCDM methods are analytical methods that can involve many decision-makers in the decision-making process, to enable the simultaneous evaluation of measurable and unmeasurable strategic and operational factors (Çelikten et al., 2019).

The MCDM problems can be classified into two different categories: Multiple Attribute Decision Making (MADM), and Multiple Objective Decision Making (MODM). In MODM type of problems, alternatives are not predetermined; they consist of decision variable values determined in a continuous or integer field by considering large or even an infinite number of alternatives. The selection of the best alternative from a set of alternatives should meet the constraints and preference priorities of the decision-maker. Unlike MODM type of problems, MADM problems are generally discrete by including a specific number of predetermined alternatives (Toker et al.,2013).

Basic Principles and Terms associated with MCDM Methodologies

For getting a solid grasp of MCDM, its methodologies and roles in various studies, it is focused on the basic terms and principles associated with MCDM methodologies in this section. Initially, the basic terms associated with MCDM are listed and explained briefly. Then, the general principles of MCDM methodologies are clarified.

Alternative: A series of activities that are planned to make a selection through a decision-making process.

Criterion: A factor used to evaluate the properties and performance of the alternative.

Performance matrix: Table indicating the performance of each alternative according to the criteria using appropriate scales

Scale: A standard determined to be used to measure the performance of an alternative

Weight: Numerical expressions indicating the relative importance of the criteria used to compare alternatives.

Initially, the objective of the decision-making problem should be determined properly. Alternatives to be addressed in the problem and the criteria for comparison of these alternatives should be identified. At this point, the criteria should be able to define the characteristics of the alternatives. Then, the MCDM model is created and an appropriate MCDM methodology is selected. Next, weights of the criteria are determined and the scores of alternatives for each criterion are computed. Weights and scores are used to construct the performance matrix. Finally, the performance matrix is evaluated by the determined MCDM methodology.

MAJOR MCDM METHODS AND THEIR APPLICATION AREAS

Introduction to MCDM Methodologies

MCDM offers a variety of different methods that can be utilized according to changing conditions. Thus, the appropriate methodology can be selected and applied in accordance with the varying objective of each decision problem on hand.

MCDM methodologies are applied by a variety of different sectors and their usages become more and more common day by day due to its flexibility and easy adaptability (Howard et al., 2018). Table 1 presents the most common used MCDM methodologies in the literature.

Table 1: List of widely used MCDM methods

Methodology	Explanation	Advantages	Disadvantages
Analytic Hierarchy Process (AHP)	AHP is based on “a theory of measurement through pairwise comparisons and judgments of experts to derive priority scales” (Saaty, 2008).	An easy-to-apply method that allows the decision-maker to accurately determine his/her preferences related to the objective.	It does not take into account the uncertainties regarding the criteria and alternatives in the evaluations, which significantly affects the decision to be made.

Analytic Network Process (ANP)	ANP was developed based on the general concept of AHP. It relies on the relationships between decision levels and attributes. (Büyükselçuk, 2017)	Easy implementation and applicability in different fields Deals with complex relationships between decision levels and qualifications	Time-consuming Complex survey process for non-specialist participants (Büyükselçuk, 2017)
Fuzzy Set Theory	The classical set theory does not explain all cases encountered in life. Fuzzy set theory is an extension of classical set theory that "enables to solve a lot of problems related to dealing the imprecise and uncertain data" (Balmat, 2011).	To be able to explain the system with linguistic qualifiers Provides better results in complex problems (Rao,2007).	Rules used in Fuzzy set theory applications should be set based on expert experience. Hard to develop

ELECTRE	The basis of the ELECTRE method relies on establishing a superiority relationship between preferred and non-preferred alternatives. To establish the superiority relationship, indices of conformity and non-compliance are created. These indices allow decision-makers to select which alternative is more dominant.	It can include qualitative and quantitative data together in the problem solution. By comparing the alternatives with each other, the superiority relationship of the binary preferability between the alternatives is examined.	It does not calculate the performance values of the alternatives. The identification of the process and outcome is not easy.

Goal Programming	Goal programming which is evaluated as an extension of linear programming focuses on minimizing an objective function which can be defined as a combination of multidimensional absolute deviations from the target value. (Lee et al., 2010; Karacan, 2015).	The simplex algorithm used in solving linear programming problems is also used in goal programming so that calculations are fast and results are effective. The solution of decision problems with two or more purposes is provided.	Subjective nature, since its goal values are determined by decision-makers The goal function is created by combining multiple-goal functions. Therefore, it has a complex structure.
PROMETHEE	The PROMETHEE belongs to the family of outranking methods, including the PROMETHEE I for partial ranking of the alternatives and the PROMETHEE II for the complete ranking of the alternatives (Behzadian et al., 2010)	Enables changes in parameters It is an easy-to-use method in terms of calculation time and difficulty according to the ELECTRE and Analytical Hierarchy Process methods.	Not accepted as a proper methodology to calculate the weights.

Technique for Order Preferences by Similarity to Ideal Solutions (TOPSIS)	The principle of TOPSIS is based on the selection of the alternative which has the shortest distance from the positive ideal and the longest distance from the negative ideal solution.	Powerful computing skills Methodology content is plain and easy to understand It provides a comparison between the maximum and minimum values that the criteria can take according to the ideal situation.	Uncertainty in obtaining weights by objective or subjective methods Does not consider the correlations between the criteria
VIKOR	VIKOR (Vise KriterijumskaOptimizacijaI Kompromisno Resenje) is a compromise ranking method. By creating a multi-criteria ranking index for alternatives, it allows making the closest decision to the ideal solution under certain conditions. (Uğur,2017)	Trade-off the maximum group utility of the ‘‘majority” and the minimum individual regret of the ‘‘opponent”. Besides, calculations of this methodology are straightforward. (Tavana et al., 2016)	Maintaining the consistency of judgments is not easy.

In the following section, conducted MCDM studies in the healthcare and military field will be investigated.

MCDM Applications in Healthcare Field

A decision to be taken in the field of health is critically important due to its process and consequences. For example, in the treatment process of a disease, the timely determination of the right treatment method can bring under control the state of the disease while the wrong decisions can cost the patient's life. Moreover, decisions to be made in the field of healthcare are complex in nature and involve the balance of encounters between multiple and conflicting objectives. Explicit and structured approaches with multiple criteria can be used to improve the quality of the decision-making process. Therefore, the decision-making process in the healthcare field requires the evaluation of each alternative with multiple criteria mindfully. At this point, MCDM is an effective tool to solve and analyze complex problems in real-time due to its ability to evaluate different alternatives based on various criteria for the possible selection of the best alternative (Turgut et al.,2011).

Suggestions for MCDA as an approach for healthcare decisions by researchers and also studies in this field have increased over the last decades (Broekhuizen et al., 2015). The MCDM provides a systematic framework by transforming a complex healthcare decision into a transparent and rational process involving all priorities and values of all stakeholders (Drake et al., 2017).

To examine the applications of MCDM methods in healthcare more comprehensively, the studies conducted in this field are grouped and summarized under sub-titles as Medical Device and Equipment Selection, Hospital Site Selection, Healthcare Performance Assessment and Service Quality respectively.

Medical Device and Equipment Selection

Hospitals are institutions where continuous product movement and pharmaceutical, medical equipment, devices and other administrative expenditures are involved. While the medical devices used in hospital services are becoming complex, the costs paid to these devices are gradually increasing. Along with the developing technology, the existing equipment and medical device alternatives in the market are increasing. At this point, the process of identifying the devices and equipment to be purchased or used from this diversity is becoming more complex. Therefore, the decision-making process needs to be better managed to eliminate complexity.

The purchase of any equipment requires a detailed assessment when the equipment used in the healthcare field is not affordable. Öztürk and Tozan (2015) carried out an MCDM study to provide a decision support model for the selection of the best dialyzer flux between high-flux and low-flux dialyzer alternatives. The model created for flux selection was performed with hybrid fuzzy-based decision support software that allows the use of AHP, Fuzzy Analytic Hierarchy Process (FAHP), Analytic Network Process (ANP), and Fuzzy Analytic Network Process (FANP). As a result of the study, it was determined that the high-flux dialyzer is the best option for hemodialysis treatment. Ivlev et al. (2015) proposed a model that can be used in the selection of medical devices in an uncertain environment. MRI system as a case study was discussed and 9 different alternatives available on the market were compared using AHP and Delphi methodology under determined criteria.

Barrios et al. (2016) presented a hybrid model that consists of the integration of AHP and TOPSIS methods to define the most appropriate tomography equipment. The main purpose of the study was to provide a scientific and rigorous decision support system that can be useful in decision making. Peregrin and Jablonsky (2016) aimed to construct a framework to manage and select ECG (Electrocardiograph) devices in a situation where there is more than one criterion to be evaluated. Improta et al. (2018) stated that the evaluation process of a health technology is a multidisciplinary process and requires many decision-making procedures. Therefore, they applied MCDM methods for the selection process of biomedical equipment technology. In this context, they compared two hernia prostheses using AHP methodology and dynamic simulation.

Hospital Site Selection

The location of healthcare facilities is very important especially in terms of providing timely services to the people in need. Moreover, the increase in the number of private hospitals, which have a substantial share among the health institutions, creates an environment for the competition to determine the best profitable location among hospitals. Therefore, when a new healthcare facility is planned to establish, the first step is to determine the appropriate location. Since the relocation of the hospital is difficult and costly after they are established, the decision made here is vital for the future of the institution (Tozan and Donmez, 2015). At this point, MCDM methods, which take into consideration more than one criterion and allow selection from more than one alternative, have been frequently used (Organ and Tekin, 2017; Kalanlar 2018).

Dehe and Bamford (2015) proposed a model based on 7 criteria and 28 sub-criteria to determine the location of the healthcare infrastructure in the UK. The proposed model was evaluated through AHP and National Health Service (NHS) methodology. Senvar et al. (2016) suggested a different MCDM methodology based on the integration of hesitant fuzzy set (HFS), which is one of the extensions of fuzzy theory, and TOPSIS to choose the optimum site of a new hospital in Istanbul. The proposed methodology was implemented for evaluation of four alternative locations under 7 criteria and 24 sub-criteria determined through literature review and expert opinions. Adalı and Tuş (2019) established a decision support system that can be used in the selection of the hospital location. Accordingly, the performance of different distance-based MCDM methods that are CRITIC (Criteria Importance Through Intercriteria Correlation), TOPSIS, EDAS (Evaluation based on Distance from Average Solution), and CODAS (Combinative Distance-based Assessments) were measured and compared. Miç and Antmen (2019) determined the criteria which are the demographic structure, investment costs, travel time and travel costs, environmental factors, infrastructure, location for a hospital planned to be established in Adana in Turkey and evaluated these criteria with fuzzy TOPSIS approach. The results are expected to be useful for decision-makers for future decisions in this area.

Healthcare Performance Assessment and Service Quality

The health sector is one of the sectors with the largest share in public expenditures. Therefore, performance evaluation can be considered as an important indicator for decision-makers about the allocation of resources allocated to health services and the quality of services provided. Many methods are used in the measurement of institutional performance in hospitals (Düzcü et al., 2019).

Tsai et al. (2010) applied to fuzzy hierarchy sensitive with the Delphi method to evaluate the organization's performance of Taiwanese hospitals. The proposed model for the evaluation includes performance scores as well as weights of criteria. This study can be considered as a reference study in Taiwan's hospital accreditation policy and is applicable for academic and governmental purposes. Kuo et al. (2012) applied the fuzzy TOPSIS methodology to rank the failure risks in the Healthcare Failure Mode and Effects Analysis (HFMEA) developed for improvement outpatient services for elderly patients in Taiwan. Karadayı and Karsak (2014) proposed a fuzzy decision framework that can be used in the assessment of healthcare performance. In this study, the healthcare performance of six different regions in İstanbul was compared with VIKOR methodology in the fuzzy environment to eliminate imperfection approaches that may arise during the performance measurement process. Singh and Prasher (2019) integrated Fuzzy AHP (FAHP) and SERVQUAL methodology to evaluate the healthcare service quality of specified hospitals in India from the patient's point of view. FAHP was applied to determine the priority of each of the dimensions and sub-dimensions of healthcare service quality attributes. Hospitals were ranked according to these priorities and lastly the hospital with the best service quality was determined.

MCDM in Military Field

Different methodologies and approaches have emerged primarily due to the need and problems arising in the military field and various methods that are expected to be the solution to the problem in the military field have been modified to be used in other fields. This situation clearly emphasizes the importance of the military field and every process in this field. Many aspects such as training and operations performed, instructions, command and control systems, organizational structure are the main parameters of the decision-making process in the military. At the same time, any decision in the military field, which has a vital role to play in the defense of the country, has the power to change all the balance between countries at the international level. One of the most essential processes in this area is the decision-making process that needs to be carefully evaluated because of the potential risks and difficulties it involves in its nature.

The military decision-making process can be considered as a complex process that is encountered in many different stages and usually deals with the selection of the best alternative with a rapid reaction. However, changing circumstances and complex structure of military problems generally complicates the determination of the best alternative. At this point, MCDM provides a systematic methodology which adapts to the chaotic, complex and uncertain nature of military problems.

MCDM methods can be used in many different areas for different purposes in the military field. For example, the study of Sennaroglu and Celebi (2018) analyzed a location selection problem for a military airport using MCDM methods. In this manner, AHP integrated PROMETHEE and VIKOR methods were performed for the determination of the most appropriate location for a military airport. The decision problem presented in this study can be evaluated as original since there is no other example of the military airport location selection problem in the literature. Besides, various studies on different subjects such as equipment selection and process planning are available in the literature.

Conducted MCDM-based studies in the military are analyzed by dividing into two sub-titles as Equipment Selection and Strategic Operations and Organizations Planning.

Equipment Evaluation and Selection

The equipment selection problem is a crucial issue in the military field. Inadequate equipment selection affects the entire military system as well as the power of a state. Governments and military equipment buyers often need a scientific decision-making approach that is as independent of intuition as possible. Moreover, only one criterion is not enough for the characterization of the capabilities of the equipment when there is more than one alternative to evaluate in the military field due to the changing economic, military, diplomatic constraints and strategic targets. Taking into account all of these situations, MCDM methods can be applied, since it provides a suitable mathematical method for such an environment where multiple criteria and multiple alternatives are available to be evaluated (Ersöz and Kabak, 2010; Aplak, 2018).

Lin and Hung (2011) applied an efficient fuzzy weighted average algorithm for selection of unmanned aerial vehicle (UAV) under military requirements to eliminate or reduce the complexity of the process of alternative evaluation and uncertainties, vague in managed information. At the end of the study, a computer-based interface that enables making decisions more efficiently by assisting decision-makers has been developed. Gyarmati and Zentay (2013) emphasized that evaluation and comparison processes of military devices over only one feature is not sufficient so that these processes require examination of various criteria. Regarding this issue, they performed AHP methodology for comparison of artillery pieces. József (2015) compared different types of Anti-Tank Missiles (ATM) by a combination of two different MCDM methods TOPSIS and PROMOTHEE. Göleç et al. (2016) stated that determining the best alternative aircraft which can carry the desired number of materials and personnel in the armed units by keeping flight safety at the highest level is a basic issue for the military of a state. Therefore, a study was conducted to determine the decision-making units of the countries that demand to add military cargo aircraft to their armies by applying AHP, TOPSIS, ELECTRE and SAW methods. Wibowo et al. (2016) presented a decision support system that can be used in the selection process of combat aircraft. Hybrid MCDM methodology based on a combination of AHP and TOPSIS methods was performed for evaluation of the presented model. Karadayi et al. (2019) proposed a fuzzy MCDM framework based on the hierarchical fuzzy technique for order preference, similar to the ideal solution for the solution of the weapon selection problem (HFTOPSIS). The proposed framework allows the use of both crisp and fuzzy data at the same time. The performance of the proposed methodology was evaluated in the case of a missile system selection problem, which was identified as a case study and included fuzzy environmental elements. Moreover, the traditional landmine detection process is a very dangerous and slow process to be managed. A metal detector is swept to the surface per square meter, and whenever a response signal is detected, deminer probes into the soil until the object is found. While this detection process is accepted the most reliable one, it is still needed to be developed due to causing a lot of time loss, especially in limited times. At this point, finding the best sensor combination to be used during the mine detection phase is crucial for both reliability and time management. Given this need, De Leeneer and Pastijn (2002) have examined two different sensors (electro-optical sensors and radar) used in the mine detection process and developed a system that performs MCDM methods to determine which sensor should be selected under which circumstances. Primarily, ORESTE one of the MCDA methods was chosen to prevent quantitative assessments from experts. Then, the ORESTE methodology results were compared with simple additive sum and PROMETHEE methodology results separately.

Strategic Operations and Organizations Planning

The military operation and organization planning process deals with the simultaneous actions, resource allocation problem and conflicting costs under time pressure. Moreover, this process requires making the right choice among multiple scenarios, where each decision has different critical consequences with different costs. Therefore, a decision support system to be used in the planning process ensures that hundreds of tasks carried out by many personnel to be coordinated quickly and robustly (Aberdeen et al., 2004). Schubert and Hörling (2014) identified an MCDM methodology to evaluate military plans in defense planning. The plans were evaluated by a simulation system with various effectiveness measures. The decision support methodology performed Pareto analysis, followed by preference analysis of measures of effectiveness and Monte Carlo weighting of measures within the given preference order. Through this methodology, the ranking of each plan can be estimated and the parameters that lead to the most successful plan can be determined and combinations of these parameters can be analyzed. Yağlı and Arıkan (2018) conducted a study to provide a mathematical approach that is expected to guide decision-makers in this field, by ranking the material requirement planning (MRP) results based on their importance level to give the most accurate procurement decision. For this purpose, AHP and TOPSIS were applied in an integrated manner.

Examined MCDM studies in the literature are summarized based on their author, application area, methodology and main criteria in Table 2.

Table 2: Summary table for conducted MCDM studies in both military and health field

Author and Year	Application Area	Methodology	Main Criteria
Öztürk and Tozan (2015)	Medical device and equipment selection	AHP, FAHP, ANP, FANP	Cost, membrane material, medical assessment, technical infrastructure, knowledge, clearance, ultrafiltration coefficient, and toxin removal mechanism
Ivlev et al. (2015)	Medical device and equipment selection	AHP	Main magnet system, gradient system, patient comfort, patient table, RF transmission and receipt, etc.

Barrios et al. (2016)	Medical device and equipment selection	Integration of AHP and TOPSIS	Performance, patient safety, technology level, financial aspects and technical aspects
Peregrin and Jablonsky (2016)	Medical device and equipment selection	AHP	Portability, internal memory, integrated diagnostic program, output quality/number of channels, quality of display
Improta et al. (2018)	Medical device and equipment selection	AHP	Technical and technological, organizational, economic, ethical and legal, clinical
Dehe and Bamford (2015)	Hospital site selection	Evidential Reasoning (ER) and AHP	Environment and safety, size, total cost, accessibility, design, risks and population profile
Senvar et al. (2016)	Hospital site selection	Hesitant Fuzzy TOPSIS	Cost, demographics, market conditions, business, transportation, workers, building structure
Adalı and Tuş (2019)	Hospital site selection	TOPSIS, EDAS, and CODAS	Economic, environmental, and technical
Miç and Antmen (2019)	Hospital site selection	Fuzzy TOPSIS	Demographic structure, investment costs, travel time and travel costs, environmental factors, infrastructure, location

Tsai et al. (2010)	Healthcare Performance Assessment and Service Quality	Fuzzy AHP	Quality, efficiency and financial performance
Kuo et al. (2012)	Healthcare Performance Assessment and Service Quality	HFMEA and Fuzzy TOPSIS	Severity assessment and occurrence assessment
Karadayı and Karsak (2014)	Healthcare Performance Assessment and Service Quality	Fuzzy VIKOR and Fuzzy TOPSIS	Beds, clinical-staff, non-clinical staff, operating expenses, outpatients, discharged patients, adjusted surgeries
Singh and Prasher (2019)	Healthcare Performance Assessment and Service Quality	Fuzzy AHP and SERVQUAL	Tangibles, responsiveness, reliability, assurance, empathy, trustworthiness
Sennaroglu and Celebi (2018)	Military airport location selection	AHP integrated PROMETHEE and VIKOR	Military, expansion potential, cost, environmental and social effects, climatic conditions, infrastructure facilities, land, geographical features, needs

De Leeneer and Pastijn (2002)	Equipment Evaluation and Selection in Military	PROMETHEE	Environmental criteria which includes pure wet soil, saline wet soil and dry sand
Lin and Hung (2011)	Equipment Evaluation and Selection in Military	Fuzzy weighted average algorithm	Mission flexibility operational suitability and operational assessment
Gyarmati and Zentay (2013)	Equipment Evaluation and Selection in Military	AHP	Rate of fire, range fragment effect, displacement time, battlefield and mobility
Göleç et al. (2016)	Equipment Evaluation and Selection in Military	AHP, SAW, ELECTRE and TOPSIS	Operational effectiveness, the country's share in the project, maintainability, maintenance easiness and cost-effectiveness
Wibowo et al. (2016)	Equipment Evaluation and Selection in Military	AHP and TOPSIS	Radar, weapon, operating radius of action, maneuvering capability, electrical warfare system and operating performance

Karadayi et al. (2019)	Equipment Evaluation and Selection in Military	Hierarchical Fuzzy TOPSIS	Basic capabilities, operational capabilities, costs and technical effects
Schubert and Hörling (2014)	Strategic Operations and Organizations Planning	Pareto analysis and Monte Carlo weighting of the measures within the given preference order	Blue Platoons in scenario, Blue Unit Losses" (BUL), Red Platoons in scenario" (RPI), Red Unit Losses (RUL), Red Units Finish successfully (RUF)
Yağlı and Arıkan (2018)	Strategic Operations and Organizations Planning	AHP and TOPSIS	Taking part in basic configuration, track waits history, place of use, maintenance status, usage status in modernization projects, price, expendability, repairability, recoverability code (ERRC) of nano stock number (NSN), source of supply for NSN

MCDM in Military Healthcare

Military health services are not just a supportive (logistical) service of an army; they are one of the main services directly affecting the outcome of the war. By looking from a broad perspective; it is a military necessity to plan the military health system. The military maintain public health programs to control, prevent and treat any infections that may pose a risk to the operational effectiveness of their forces. Military forces can extend their public health capabilities to civil populations that are not adequately presented by civil public health programs to advance mission objectives or wider national objectives (Chretien et al.,2007). In this system, making the right decision under critical situations especially in terms of time management affects the operation of the whole system and the status of all stakeholders involved in this service (Uçar and Deniz, 2012). In this manner, MCDM methods provide an effective approach for making the best selection under the specified criteria in such a case. Bahadori et al. (2017) stated that there are uncertainties and unexpected conditions in the supply chain management process of medical devices, and one of the biggest challenges of hospitals was the evaluation and selection of suppliers in such an environment. Hence, a study was conducted to provide a decision model that can be used by hospital managers and the staff of purchasing a unit in the selection of the best supplier in a hospital by a combination of artificial neural network and fuzzy VIKOR methodology. At the end of the present study, the quality was identified as the most important factor influencing the supplier selection under the determined criteria set.

Military personnel are constantly changing positions and may encounter aggravated and risky circumstances. In such a case, the health equipment carried with them should be suitable for risky and dangerous situations. Moreover, the medical equipment they carry must also be light in weight to be able to move quickly. Therefore, the selection of these medical equipment requires MCDM and a well-evaluated decision process.

With the contribution of technology, homecare has become the focus of health services in the healthcare field by aiming to raise the awareness of the patients to follow their situation. In the military area, both military personnel and their relatives should be in a state of constant control due to their continuous movement. Hence, the home care system is transforming into patient-centered care and these individuals should be able to control their health status. In such a case, artificial neural networks (ANN) and MCDM methods can be jointly organized to create and evaluate this kind of system. For example, Fashoto et al. (2016) developed a decision support model for the selection of suppliers in healthcare service delivery by AHP and ANN. Initially, the hierarchical model was constructed by the determination of criteria and supplier alternatives. Then, the neural network module was developed to perform a constructed model. Consequently, the systematic study of the supplier selection was carried out.

MCDM methods, which are frequently applied in the selection of hospital locations, can also be used in determining the location of military hospitals for timely intervention in the field of military healthcare and in determining the location of emergency medical intervention since facilities to be established for performing the emergency medical interventions military hospital locations are determined according to zones or locations of bases and the number of military personnel working at each base. Furthermore, medical devices that should be available in military hospitals and their distribution can be considered as another application area for MCDM methods.

To sum up, the decision processes in which MCDM methods can be implemented are listed as follows:

- Determination of the most suitable location for a military hospital from a location set

- Determination of the content of the healthcare kit

- Allocation of medical equipment and resources in the military system

- Planning the health services to be provided to ensure the well-being of both individuals and society after any military operation

- The selection of the best medical devices and medical equipment from a variety of alternatives to be used in the military healthcare field

-Health technology assessment of medical devices used in the military healthcare field

DISCUSSION AND CONCLUSION

MCDM methods are one of the most effective methods in the decision-making process. It has become a frequently used method in many different areas due to its easy applicability and implementation. The healthcare and military fields are the areas in which MCDM methods are performed due to substantial and critical evolutions in these fields (Turgut et al.,2011; Aplak, 2018). However, it is observed that there are insufficient number of studies related to military healthcare in literature. To overcome this situation, the studies conducted in the field of military and health during the last decade have been examined and summarized separately through the research databases including PubMed, Springer, Science Direct and Google Scholar. When the present studies in the literature for both fields have been categorized according to their methodologies, it has been observed that most applied methodologies in these two areas are AHP and TOPSIS (Gyarmati and Zentay, 2013; Öztürk and Tozan, 2015; Peregrin and Jablonsky, 2016; Yağlı and Arıkan, 2018; Karadayi et al., 2019). This finding can be related to the common point of the two methods, that is, they are easy to apply, powerful methodologies and have simple calculations. Moreover, it has been determined that the criteria, which are the basic evaluation parameter in the application of multi-criteria decision-making methods, can be similar in both fields. Namely, especially with the development of technology, offering different alternatives both in the field of health and military has necessitated the comparison of these alternatives technologically, economically and effectively. With all these outcomes, the decision-making processes in which MCDM methods can be performed in the field of military health have been deduced and indicated. To the best of our knowledge, there is no study in the published literature concerning and pointing out the importance of MCDM in military healthcare yet. Hence, this study is expected to be a source of motivation by guiding other studies in the field.

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