



Using the fuzzy VIKOR method to rank the mental workload weights of an airline company employees

Bir havayolu şirketi çalışanlarının zihinsel iş yüklerinin ağırlıklarını sıralamak için bulanık VIKOR yönteminin kullanılması

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Received/Geliş Tarihi: 18.02.2025

Revision/Düzeltilme Tarihi: 31.12.2025

doi: 10.65206/pajes.46066

Accepted/Kabul Tarihi: 07.01.2026

Research Article/Araştırma Makalesi

Abstract

In recent years, air transportation has become increasingly popular because it saves time and offers more comfortable travel opportunities. Considering the competitive conditions and the risks brought by the job, high performance is expected from employees. In particular, the expectation of quality and correct work from the flight crews who are on duty during the flight is increasing, and this situation causes an increase in the mental workload on the employees. In this study, during the flight; it was aimed to determine which of the stages of preparing the aircraft and welcoming the passengers, preparations for departure, catering, preparations for landing and farewelling the passengers was more mentally challenging for the flight crew. As evaluation criteria in determining perceived workloads, the six dimensions of the NASA-TLX method, the mental workload measurement methods applied in many studies in the aviation sector, were used. In the process of determining the mental workload, the fuzzy VIKOR method was used in order to minimize individual regret and maximize group benefit in these stages where there are many decision makers and evaluated with fuzzy thoughts. The study found that the catering phase of the flight was when participants experienced the highest mental workload. However, when participants were evaluated by gender and crew roles, it was observed that the tasks which increased mental workload -aircraft preparation, departure preparations, catering, and landing preparations -differed.

Keywords: Aviation, Cabin crew, Multi criteria decision making methods, Fuzzy VIKOR, Mental workload.

Öz

Son yıllarda hava yolu taşımacılığı, zaman tasarrufu sağlaması ve daha konforlu seyahat imkânı sunması nedeniyle çok fazla tercih edilir hale gelmiştir. Rekabet koşulları ve işin getirdiği riskler göz önüne alındığında çalışanlardan yüksek performans beklenmektedir. Özellikle uçuş esnasında görev başında olan uçuş ekiplerinden kaliteli ve doğru iş beklentisi artmakta ve bu durum çalışanlar üzerindeki zihinsel iş yükünün artmasına neden olmaktadır. Bu çalışmada uçuş esnasında; uçağın hazırlanması ve yolcuların karşılanması, kalkış hazırlığı, ikram, iniş hazırlığı ve yolcuların uğurlanması aşamalarından hangisinin uçuş ekibi için zihinsel olarak daha zorlayıcı olduğunun belirlenmesi amaçlanmıştır. Algılanan iş yüklerinin belirlenmesinde değerlendirme kriteri olarak havacılık sektöründe birçok çalışmada uygulanan zihinsel iş yükü ölçüm yöntemlerinden olan NASA-TLX yönteminin altı boyutu kullanılmıştır. Zihinsel iş yükünün belirlenmesi sürecinde çok sayıda karar vericinin bulunduğu ve bulanık düşüncelerle değerlendirilen bu aşamalarda bireysel pişmanlığın en aza indirilmesi ve grup faydasının en üst düzeye çıkarılması amacıyla bulanık VIKOR yöntemi kullanılmıştır. Çalışma sonucunda, katılımcıların uçuş esnasında en fazla zihinsel yük hissettikleri aşama ikram olarak bulunmuştur. Ancak katılımcılar cinsiyet ve ekip içerisindeki rollerine göre değerlendirildiğinde zihinsel iş yükü hissedilen görevlerin (uçak hazırlığı, kalkış hazırlıkları, ikram hizmetleri ve iniş hazırlıkları) farklılık gösterdiği görülmüştür.

Anahtar kelimeler: Havacılık, Kabin ekibi, Çok kriterli karar verme yöntemleri, Bulanık VIKOR, zihinsel iş yükü.

1 Introduction

In the aviation industry and air transportation systems, which have many safety rules, procedures and standards, have experienced significant developments in recent years. Services offered by airlines, aircraft manufacturers, airports, air traffic management, etc. have positive effects on air transportation. However, depending on variables such as the legal requirements of the destination, the service level planned for the relevant flight, flight duration, and passenger profile, the practices preferred by the airline company cause different mental workload on employees, and it becomes compulsory to evaluate the perceived workload. Workloads that are too high or too low can negatively affect the employee's performance, reduce productivity and increase the possibility of making mistakes [1]. Mental workload is the workload resulting from

mental activities such as thinking, calculating, deciding, communicating, remembering and researching [2].

Mental workload can be evaluated as the amount of effort an individual spends to fulfill his/her tasks [3]. Mental workload cannot be directly observed because it depends on the task and the characteristics of the individual who will perform the task [4]. Mental activities performed to complete a task create fatigue and stress in the individual. This situation negatively affects the individual's performance, efficiency, quality and safety of the work done [5]. For this reason, it is necessary to determine the mental workload of the individual and measure the mental workload in order to improve human-system interaction, increase performance, reduce human errors and increase safety [6].

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One of the most widely used mental workload measurement methods is the NASA-TLX method. This method involves evaluating the employee's work according to six sub-dimensions and determining the total workload based on the weighted average. These sub-dimensions are mental demand, physical demand, temporal demand, performance, effort and frustration. Mental demand refers to how much mental activity is needed during the work being performed, physical demand refers to how much physical activity is required, and temporal demand refers to how much pressure the person feels due to the speed or pace at which tasks are performed. Completing the work as desired is considered performance, the mental and physical effort required for this is considered effort, and the level of satisfaction with the work in the process is considered frustration [1],[7]. When the workloads of many employees are desired to be obtained as a common result, multi-criteria decision-making methods suitable for group decision-making in which many criteria and alternatives are taken into account are used, in addition to the NASA-TLX method.

Multi-criteria decision-making methods are decision support tools designed to analyze decision problems and evaluate alternatives under different criterion priorities according to the decision maker's preferences in order to select the best alternative [8]. They are widely used to solve complex decision-making problems [9]. MacCrimmon (1968) produced in that multi-criteria decision-making methods could be used to solve problems. The methods enable the decision maker to reach the best solution by ranking and evaluating the alternatives [10]. Kaya et al. (2019) investigated the multi-criteria decision-making (MCDM) methods used to make decisions within energy policies in their manuscript. They conducted a literature review to answer questions such as which fuzzy multi-criteria decision-making method is used for which type of energy [11]. Multi-criteria decision making (MCDM) methods are used in different fields and applications such as chemical industry [12], health sector [13], software sector [14], port selection [15], Turkish aviation sector [16]. Huang et al. [17] developed a VIKOR model to prioritize alternatives in the presence of conflicting criteria in multi-criteria decision-making problems. Chang (2010) proposed an improved VIKOR method to eliminate the difficulties experienced in solving some special problems with VIKOR method where there are conflicting criteria [18]. Devi (2011) extended the VIKOR method to solve multi-criteria decision-making problems where the weights of criteria and alternatives are taken as a triangular fuzzy set [19]. Kaya (2021) reviewed the publications on the application of the VIKOR method to manufacturing field between 2018 and 2020 and classified the studies under the titles of material selection and production strategies [20]. In addition, the VIKOR method has been used in many applications such as the selection of airline companies based on service quality [21], airport performance evaluation [22], and investment project selection of a company operating in the air defense industry [23].

Bellman and Zadeh (1970), utilized fuzzy logic to mathematically express uncertainty in decision-making processes [24]. Fuzzy VIKOR method; planning water resources [25], supplier selection [26], new machine selection [27], analyzing risks in lean manufacturing applications [28], evaluation of treatment techniques in the health sector [29], in the selection of renewable energy sources [30], etc. used in areas. Vahdani et al. (2010) presented a new method based on fuzzy VIKOR to solve multi-criteria decision-making problems where the weights of the criteria are not equal [31]. Studies in

databases (e.g., WOS, Scopus, Wiley, Science Direct, IEEE) were examined using the keywords multi-criteria decision making; NASA Task Load; Mental Workload; Airline company employees; Fuzzy VIKOR Method, without any time restrictions. In the literature review conclusion, the fuzzy VIKOR method was not found to have been used for prioritizing mental workload dimensions.

In this study, it was aimed to determine the extent of workload felt by the personnel working as cabin crew in the airline industry, where service quality and safety are important, during tasks such as preparing the aircraft for the flight, welcoming passengers, departure preparations, catering, landing preparations and farewelling the passengers, and to prioritize the weights of these extents. The cabin crew is in direct communication with the passengers in situations such as greeting the passengers, helping to show the seats and place the luggage, serving the refreshments on time and as requested, and ensuring flight safety. The mental, physical and temporal demand, performance, effort and frustration dimensions of the NASA-TLX method were utilized to determine the mental workload felt by cabin crew in order to ensure that the service provided to passengers is error-free and passengers are satisfied. Weighting was made for each dimension by taking the averages of the values given by the employees for the dimensions. The priority rankings of the dimensions were obtained by applying fuzzy logic to the VIKOR method, one of the multi-criteria decision-making methods. The results of the analysis carried out with the Fuzzy VIKOR method were interpreted and solution suggestions were presented to reduce the workload. The airline company where the study was conducted requested that its name remain confidential, so it has not been mentioned in this study.

2 Material and method

2.1 Fuzzy VIKOR method

The VIKOR method, developed by Opricovic and Tzeng in 2004, produces solutions to determine the best alternatives by evaluating conflicting criteria. The method is widely used because it is easily understandable and usable and produces realistic solutions [32]. In the fuzzy VIKOR method, the importance levels of the criteria are evaluated by decision makers or experts and converted into fuzzy numbers with appropriate methods, and the criterion weights are calculated by taking their average. The steps to be followed in the method are given respectively.

Step 1: Decision makers (p), criteria (j) and alternatives (i) are identified and the fuzzy number equivalents of the verbal statements given by decision makers for criterion (j). are calculated by Eq. (1) and their averages are calculated by Eq. (2). Step 2: Each criterion and alternative is transformed into fuzzy numbers (Eq. 3) and Step 3: The averages of the decision makers' responses for criterion (j). and alternative (i). are calculated using Eq. (4). Step 4: The best value of (j) criterion is expressed as f_j^* , and the worst value is expressed as f_j^- . The value of f_j^* is obtained by Eq. (5) and the value of f_j^- is obtained by Eq. (6). Step 5: The fuzzy distance $\tilde{d}_{ij}$ of alternative (i). for criterion (j). is denoted by and calculated with the help of Eq. (7). Step 6: Fuzzy S_i ve R_i values are found with Eq. (8) and Eq. (9). Step 7: The Q_i^- value is calculated by taking the group utility (v) value and the max value of S_i^- as S^- and min value of S_i^+ and the max value of R_i as R^- and min value of R_i^+

(Eq. 10). $v > 0.5$ represents a majority preference, $v = 0.5$ represents a compromise, and $v < 0.5$ represents a veto. Considering the compromise situation in the study, $v = 0.5$ was adopted to achieve maximum group utility and minimum individual regret. Step 8: The ranking of $S_i^{\sim}$, $R_i^{\sim}$ and Q_i values are obtained by defuzzifying of these values (Eq. 11). For the alternative to be close to the desired solution, the value of Q_i should be small. Step 9: Advantage and stability conditions are required for the acceptance of the solution. The advantage condition is to determine that there is a difference between the smallest alternative (A') and the other alternative (A'') that is close to it when ranked according to Q values (Eq. 12). The DQ value here is found with Eq. (13).

$$\tilde{w}_{jp} = (A_{jp}, M_{jp}, B_{jp}) \quad (1)$$

$$\tilde{w}_j = \frac{1}{L} \left(\sum_{p=1}^L \tilde{w}_{jp} \right) \quad j = 1, 2, \dots, k \quad (2)$$

$$\tilde{x}_{pij} = (A_{pij}, M_{pij}, B_{pij}) \quad (3)$$

$$\tilde{y}_{ij} = \frac{\sum_{p=1}^L (x_{pij})}{L} \quad (4)$$

$$f_j^{*\sim} = \max \tilde{y}_{ij} \quad (5)$$

$$f_j^{-\sim} = \min \tilde{y}_{ij} \quad (6)$$

$$\tilde{d}_{ij} = (f_j^{*\sim} - \tilde{y}_{ij}) / (f_j^{*\sim} - f_j^{-\sim}) \quad (7)$$

$$\tilde{S}_i = \sum (\tilde{W}_j * \tilde{d}_{ij}) \quad (8)$$

$$R^{\sim}i = \max j (\tilde{W}_j * \tilde{d}_{ij}) \quad (9)$$

$$Q_i^{\sim} = \frac{V(S_i^{\sim} - S_*^{\sim})}{(S_i^{\sim} - S_*^{\sim})} + \frac{(1 - V)(R_i^{\sim} - R_*^{\sim})}{(R_i^{\sim} - R_*^{\sim})} \quad (10)$$

$$A^{\sim}duru = \frac{a_i + 4m_i + b_i}{6} \quad (11)$$

$$(A'') - Q(A') \geq DQ \quad (12)$$

$$DQ = \frac{1}{n-1} \quad (13)$$

(if $n \leq 4$ $DQ = 0,25$)

If the condition is met, (A') is the best alternative; if the condition is not met, all alternatives are accepted as a compromise solution set (Eq. 14).

$$Q(A^t) - Q(A') < DQ \quad (14)$$

The stability condition is that the smallest (A') alternative according to the Q_i value is the best alternative in the order of S and/or R values. Otherwise, the solution becomes unstable and alternatives (A') and (A'') are accepted as the same, regardless of the advantage condition [33].

2.2 Mental workload

Pressures that affect the effectiveness and efficiency of employees are defined as workload [34]. The level of perception of workload may differ from person to person. Perceived mental workload is a result of the interaction between human cognitive capacity and competencies and the requirements of the job. If the requirements and demands of the job performed exceed the individual's cognitive capacity and competence, it creates mental workload [35]. Mental workload is expressed as the amount of effort an individual spends to fulfill his/her tasks [3]. By measuring the mental workload, the mental cost of performing tasks is determined, and working conditions are improved in order to reduce the burden on the employee [36].

Subjective assessment methods are widely preferred in mental workload measurements [37]. The NASA-TLX method is used in workload measurement in many areas because it is more sensitive and effective in measuring low workloads compared to other methods [38]. In the method developed by Hart and Staveland in 1988, workload is divided into six dimensions: mental demand, physical demand, effort, performance level, temporal demand and frustration [39]. With the physical demand dimension; how much physical activity the employee needs during work and how much the activities strain the employee, with the mental demand dimension; how much mental activity the employee needs during work and the intensity of the activities are determined. In the effort dimension, the employee's level of physical and mental strain during work is evaluated while with also the feeling of failure dimension, the levels of unhappiness, anger and insecurity experienced by the employee during work are evaluated [40].

3 Application

The study was conducted with employees working as cabin crew and cabin supervisors in an airline company. The airline company requested that its name be kept confidential, so it has not been mentioned in this study. Cabin crews perform aircraft preparation, passenger welcoming, departure preparations, catering, landing preparations and passenger farewell activities. These activities consist of making the plane ready for travel, welcoming passengers and directing them to their seats, assisting them in placing their luggage and fastening their seat belts, preparing food and beverages and delivering them to passengers quickly, ensuring a comfortable and safe flight, checking the necessary security measures for landing and passengers farewell with a smile at the end of the trip. Cabin supervisors are employees who are responsible for the flight process. Cabin crews are required to perform these operations in a limited time and without errors. The cabin crew must act by taking into account any negative situations that may be encountered during the flight and make an effort to ensure that the passengers are satisfied with their flight from the moment they are boarded until they are sent off. This situation strains the employees mentally and physically.

In the study, an online survey was conducted to cabin crew members, and they were asked to evaluate their perceived mental workloads during their work. The gender distribution of cabin crew at the company, according to anonymized HR data, is 60% women and 40% men. The survey was sent to 185 cabin crew members, and responses were received from a total of 109 employees. Since 9 of the surveys were unusable, so 100

were included in the evaluation. The first part of the survey included demographic information, and the remaining part included questions to determine differences in perceived workload. In the survey, the employees were asked to rate their work depending on the criteria and to indicate with linguistic expressions such as very low, low, medium, high, and very high. The ethical suitability of the research was approved by the decision of Engineering Sciences Ethics Commission dated 22.02.2021 and numbered 2021/1. Of the employees who participated in the survey, 76% were women and 24% were men. Since the gender distribution of the cabin crew in the company is predominantly women, this difference was observed in the randomly selected sample pool. Considering that gender differences among employees may affect the perceived workload in NASA-TLX assessments, this imbalance has been recognized as a limitation. When conducting the assessments, women and men groups were taken into account alongside all employees, crew, and supervisor groups. When the age ranges of the employees are examined, it is seen that 9% of them are 18-25 years old, 83% are 26-35 years old, 6% are 36-45 years old, and 2% are 46 and over. Of the employees who responded to the survey, 90% are cabin crew members and 10% are cabin supervisors.

In the study, when the work done by the cabin crew is evaluated; the six dimensions of the NASA-TLX method were used to determine workload: mental demand, physical demand, temporal demand, performance, effort and frustration. The answers given by the participants to the survey questions were converted into fuzzy numbers, averaged and weighted, and alternative rankings were obtained with the Fuzzy VIKOR method, which is one of the multi-criteria decision-making methods. The criteria are independent of each other and one of them is positive. According to the results obtained, the first alternative will be the negative that will be the option that feels the most mental workload. In the manuscript, it was tried to determine the mental workloads perceived by cabin crew employees according to their gender and position and to interpret the differences in group decisions.

In the study, firstly, all employees were asked to answer the question "How much workload do the following factors make you feel while performing any task?". The workload perceived by employees is too complex to be described quantitatively. Employees can describe the workload they perceive due to a factor using linguistic variables such as "very low," "low," "medium," "high," and "very high." In this study, the five-scale linguistic variables are converted into triangular fuzzy numbers defined over the [0,1] interval, as shown in Table 1. The linguistic scale and corresponding triangular fuzzy number intervals used in this study were adopted from the multi-criteria decision-making literature [41]-[43]. It was anticipated

that the fuzzy numbers presented in Table 1 would effectively represent the "uncertainty" and "smooth transitions" in human perception because they are equally spaced (0.00, 0.25, 0.50, 0.75 ve 1.00), overlapping, and symmetrically distributed.

In Table 2, the fuzzy number equivalents of the answers given by the employees to evaluate each criterion were determined separately and the fuzzy weight of each criterion was calculated by taking the arithmetic average of these values. At the same time when the answers given to the survey were evaluated on the basis of the groups created, it was also determined by the calculated weights that each group gave different importance to the criteria. These values were used as input in the fuzzy VIKOR method. Microsoft Office Excel was used for the application steps of the fuzzy criterion weights and the VIKOR method.

Table 3 was created by taking into account the six dimensions of the NASA-TLX method and the steps of aircraft preparation, passenger welcoming, departure preparations, catering, landing preparations and passenger farewell in the internal company documents for the flight. In Table 3, the fuzzy number equivalents of the answers given by the employees participating in the study to evaluate each criterion are averaged and reduced to a single decision maker and presented as a combined matrix. Fuzzy best and fuzzy worst values were determined with Eq. 5 and Eq. 6 and are given in Table 4. Considering Table 3, the best values presented in Table 4 were determined as the intersection of aircraft preparation and temporal demand and mental demand; values at the intersection of treat and physical demand, effort and frustration; and were determined as the values at the intersection of passenger farewell and performance. For example, the values 0.48, 0.72, and 0.91 are where aircraft preparation intersects with temporal demand, while the values 0.39, 0.62, and 0.82 are where aircraft preparation intersects with mental demand. The worst values: values at the intersection of aircraft preparation and performance; values at the intersection of passenger farewell and temporal demand, mental demand, physical demand, effort and frustration. For example, the values at the intersection of aircraft preparation and performance criteria are 0.54, 0.79, and 0.95. When examining the responses based on the flight tasks and evaluation criteria, it was observed that the workload dimensions were similar in some tasks. This could be interpreted as employees' perception of similar workloads during the tasks.

The distances of the criterion-based values of the alternatives to the best and worst values were calculated with Eq. 7 and are given in Table 5.

Table 1. Fuzzy number equivalents of verbal expressions.

Linguistic Expressions		Fuzzy Numbers	
Very low	0.00	0.00	0.25
Low	0.00	0.25	0.50
Middle	0.25	0.50	0.75
High	0.50	0.75	1.00
Very High	0.75	1.00	1.00

Table 2. Fuzzy criterion weights by employees.

	Temporal Demand	Mental Demand	Physical Demand	Effort	Performance	Frustration
All	0.51	0.29	0.41	0.45	0.41	0.54
	0.75	0.52	0.65	0.69	0.65	0.78
	0.91	0.75	0.84	0.88	0.85	0.92
Crew	0.52	0.29	0.41	0.46	0.41	0.55
	0.76	0.53	0.65	0.69	0.65	0.79
	0.91	0.75	0.84	0.88	0.85	0.92
Women	0.53	0.31	0.44	0.48	0.43	0.56
	0.78	0.55	0.69	0.72	0.68	0.81
	0.93	0.77	0.87	0.90	0.88	0.94
Men	0.42	0.21	0.29	0.37	0.35	0.46
	0.65	0.44	0.51	0.58	0.57	0.68
	0.83	0.68	0.76	0.82	0.78	0.85
Supervisor	0.40	0.28	0.38	0.40	0.40	0.43
	0.65	0.50	0.63	0.65	0.65	0.68
	0.88	0.73	0.83	0.85	0.85	0.90

Table 3. Merged fuzzy matrix and fuzzy best worst values.

Alternative	Temporal Demand	Mental Demand	Physical Demand	Effort	Performance	Frustration
Aircraft Preparation	0.48	0.39	0.36	0.44	0.54	0.31
	0.72	0.62	0.60	0.69	0.79	0.54
	0.91	0.82	0.82	0.89	0.95	0.75
Passenger Welcoming	0.28	0.20	0.27	0.26	0.49	0.24
	0.51	0.42	0.49	0.50	0.74	0.44
	0.73	0.66	0.72	0.73	0.92	0.68
Departure Preparations	0.31	0.32	0.21	0.29	0.51	0.24
	0.54	0.56	0.44	0.53	0.76	0.45
	0.75	0.78	0.68	0.77	0.93	0.69
Catering	0.40	0.29	0.49	0.48	0.53	0.31
	0.64	0.52	0.74	0.73	0.78	0.54
	0.85	0.76	0.91	0.90	0.94	0.77
Landing Preparations	0.31	0.29	0.19	0.29	0.51	0.24
	0.56	0.52	0.43	0.53	0.76	0.45
	0.79	0.75	0.68	0.77	0.93	0.69
Passenger Farewell	0.09	0.08	0.07	0.10	0.42	0.10
	0.25	0.25	0.23	0.28	0.66	0.25
	0.49	0.50	0.47	0.52	0.85	0.49

Table 4. Fuzzy best worst values.

	Temporal Demand	Mental Demand	Physical Demand	Effort	Performance	Frustration
f_i^*	0.48	0.39	0.49	0.48	0.42	0.32
	0.72	0.62	0.74	0.73	0.66	0.54
	0.91	0.82	0.91	0.90	0.85	0.77
f_i^-	0.09	0.08	0.07	0.10	0.54	0.10
	0.25	0.25	0.23	0.28	0.79	0.25
	0.49	0.50	0.47	0.52	0.95	0.49
$(f_i^*) - (f_i^-)$	-0.02	-0.11	0.02	-0.05	-0.53	-0.17
	0.47	0.37	0.51	0.45	-0.13	0.30
	0.83	0.74	0.84	0.80	0.30	0.66

Table 5. Fuzzy S_i and R_i values of alternatives.

	Aircraft Preparation	Passenger Welcoming	Departure Preparations	Catering	Landing Preparations	Passenger Farewell
S_i	-1.91	-1.49	-1.58	-1.88	-1.59	-0.79
	0.90	1.95	1.77	0.84	1.77	3.39
	-10.67	-21.35	-15.75	-21.02	-15.09	-26.76
R_i	-0.16	-0.11	-0.09	-0.20	-0.09	0.01
	0.17	0.31	0.38	0.00	0.39	0.65
	26.40	30.72	33.60	20.04	34.44	40.08

After determining the smallest and largest S_i and R_i values and finding the values of S^* , S^- , R^* and R^- , Q_i values were calculated for each group using Eq. 10. Real numbers were obtained by defuzzifying the fuzzy numbers with the help of Eq. 11. The S , R and Q values obtained after the defuzzification process of the results obtained from the answers given for the stages of aircraft preparation, passenger welcoming, departure preparations, catering, landing preparations and passenger farewell for the group in which all participants, women and men employees in the study were evaluated are given in Table 6. The S , R and Q values obtained after the defuzzification process for employees working as cabin supervisors and cabin crews are shown in Table 7.

The 1st condition for accepting the solution in the Fuzzy VIKOR method: the ranking of alternatives created as a result of the calculations for the advantage condition is given in Table 8.

When the results obtained according to the answers given by the employees participating in the study are evaluated in Table 8, it is seen that the priorities may change in the whole group or in the men/women, supervisor/crew groups, and the mental workload felt varies according to the groups. Using Equations 12 and 13, the difference between the best and the second-best alternative for each group is examined. If this difference is not equal to the threshold value DQ , the solution set is created using Equation 14. Since a difference greater than DQ exists between the first and second-best alternatives in the "all group" and the "men's group," the recommended solution set consists of only first alternative. In these groups, the best Q_i value is 1, and there is an acceptable difference between this

value and the closest alternative. The recommended common solution sets for the other groups are shown in italics in the table. When considering only men, the passenger welcoming stage is identified as the phase with the highest mental workload. For the women's group, it is concluded that no single task stage creates a significantly higher mental workload than the others, and all stages are considered to have an equally important workload due to their closely clustered values. The important point here is that these results will also change when the number of decision makers and the sample population change. For this reason, the appropriate number and position of participants should be selected for each subject to be studied. In the groups consisting of women employees, supervisors and civil servants, common solution sets are italicized. The S_i , R_i and Q_i values of the alternatives for the groups are shown in Table 9.

When evaluating the stability condition criteria, stability is considered achieved in all groups except the male group, as the first alternative in the Q_i ranking is also ranked first in the S_i and/or R_i ranking. However, since this is not the case in the male group, stability is considered unachieved, and thus the best alternative and the second-best alternative for the male group are considered to have equal effect. For the stability condition, the alternative with the smallest Q_i value must also be the best alternative in the S and/or R value ranking. Although the Q_i value is the smallest (value 1) for passenger welcoming in the male group, it is not the best alternative in terms of S or R value. The best alternative for S and R values emerged the passenger farewell phase.

Table 6. Clarified S , R and Q values for all, women and men decision makers.

Alternative	All decision makers			Women decision makers			Men decision makers		
	S_i	R_i	Q_i	S_i	R_i	Q_i	S_i	R_i	Q_i
Aircraft Prep.	-1.5	4.5	0.1	-4.5	2.7	0.1	-8.4	0.1	0.2
Passenger Welcoming	-2.5	5.3	6.4	-6.3	3.3	-0.1	-9.7	0.1	-0.1
Departure Prep.	-1.7	5.8	5.4	-5.7	3.6	0.0	-10.1	0.2	0.1
Catering	-3.3	3.3	-0.4	-6.3	2.0	0.0	-7.4	0.2	0.28
Landing Prep.	-1.6	6.0	5.4	-5.6	3.8	0.0	-9.7	0.1	-0.1
Passenger Farewell	-2.3	7.1	15.1	-7.4	4.6	-0.1	-11.6	-0.1	2.4

Table 7. Clarified S , R and Q values for decision makers in the position of cabin supervisor and cabin crews.

Alternative	Cabin supervisor			Cabin crew		
	S_i	R_i	Q_i	S_i	R_i	Q_i
Aircraft Prep.	-1.6	0.2	-0.1	5.4	5.9	-0.3
Passenger Welcoming	-1.4	0.2	0.1	8.1	8.9	-0.0
Departure Prep.	-1.5	0.1	-0.1	8.4	8.7	-0.1
Catering	-1.5	0.2	-0.1	5.9	7.1	-0.2
Landing Prep.	-1.6	0.2	-0.1	8.4	8.7	-0.1
Passenger Farewell	-1.1	0.1	1.0	11.9	12.1	0.3

Table 8. Acceptable advantage condition results.

Alternative	Q_i				
	All	Women	Men	Supervisor	Crew
Aircraft Preparation	2	6	5	1	1
Passenger Welcoming	5	2	1	5	5
Departure Preparations	3	5	4	2	4
Catering	1	4	6	3	2
Landing Preparations	4	3	2	4	3
Passenger Farewell	6	1	3	6	6

Table 9. Ranking of alternatives by groups, and stability condition results. (Common solution sets are given in italics).

	All			Women			Men			Supervisor			Crew		
Alternatifive	S_i	R_i	Q_i	S_i	R_i	Q_i	S_i	R_i	Q_i	S_i	R_i	Q_i	S_i	R_i	Q_i
Aircraft Preparation	6	2	2	6	2	6	5	4	5	1	4	1	1	1	1
Passenger Welcoming	2	3	5	2	3	2	4	2	1	5	5	5	3	5	5
Departure Preparations	4	4	3	4	4	5	2	5	4	3	1	2	5	4	4
Catering	1	1	1	3	1	4	6	6	6	4	6	3	2	2	2
Landing Preparations	5	5	4	5	5	3	3	3	2	2	3	4	4	3	3
Passenger Farewell	3	6	6	1	6	1	1	1	3	6	2	6	6	6	6

4 Conclusions

In the study carried out in the airline company, it was asked to determine in which of the flight stages, namely aircraft preparation, passenger welcoming, departure preparations, catering, landing preparations and passenger farewell, the cabin crew felt more mental workload. When the men and women who participated in the study were evaluated together, it was found that they felt the most workload in the catering task during the flight. In catering, it is important that food and beverages are prepared quickly and accurately and served to passengers with a smile. The service car where food and drinks will be served should not disturb the passengers during the flight. It is important that drinks are served without spilling. In case of turbulence caused by irregular air movement, passengers' wishes must be met and satisfied. All these tasks challenge employees both physically and in terms of effort. At the same time, since these operations will be carried out within a certain period of time, they also create a mental burden on the employees. When women employees were evaluated, it was observed that the mental workload felt for all stages was close to each other. When men employees were evaluated, the stages where the most workload were felt because the stability condition could not be met were accepted as passenger welcoming and landing preparations. When the employees working as supervisor and crew are evaluated as a group, the stages of aircraft preparation, departure preparations, catering and landing preparations stand out. During the aircraft preparation task, the cabin crews check the oxygen, fire extinguishers and first aid kits on the aircraft. They also check passenger door pressures and initiate security search. After these procedures, the passengers are taken to the plane and they are ensured to sit in their seats, place their belongings, if any, fasten their seat belts, etc. for departure. Likewise, for the safety of passengers during landing, they pay attention to issues such as not getting up from their seats and keeping their seat belts fastened. Since the safe and comfortable flight depends on the guidance and information provided by the cabin crew, it brings great responsibility to the cabin crew. All employees stated in their answers that these tasks constitute the most workload for the flight. The survey results did not provide a detailed assessment of the similar mental workload women felt across all tasks. There may be different factors affecting the similarity of the mental workload women feel in all tasks. What these factors may be and the relationship between perceived mental workload and gender will be the subject of future research.

In this study, fuzzy answers in group decision-making situations were mathematically processed and their usability in the aviation industry, where safety and security is of high importance, was evaluated with methods that will provide the least individual regret and the most group benefit. Corrective and preventive measures should be taken by considering at which stage/stages difficulties occur and which groups they affect the most. Training programs should be planned that include the stages where difficulties arise and also develop the cabin crew. Considering which groups are most affected by these difficulties, measures such as shift planning and rotation should be implemented to enhance employee performance and motivation. This will ensure both flight safety and cabin crew satisfaction.

5 Acknowledgment

This study was produced from the master's thesis prepared by the first author under the supervision of the second author.

6 Author contribution statement

In the study, Mert Kurtgün contributed to the formation of the idea, literature review, data collection, analysis and evaluation of the results; Demet Gönen Ocaktan contributed to the design, evaluation of the obtained results, spelling check and checking the article in terms of content.

7 Ethics committee approval and conflict of interest

The ethical suitability of the research was approved by the decision of Balıkesir University Engineering Sciences Ethics Commission dated 22.02.2021 and numbered 2021/1. The authors declare that they have no conflict of interest.

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