SELECTION OF AN APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT USING THE ANALYTIC HIERARCHY PROCESS

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Abstract

The main principles of safety risk reduction are elimination, substitution, and engineering controls. Hazardous conditions, safe work practices, and other forms of managerial controls should be provided for a safe work environment. For this reason, the use of personal protective equipment (PPE) is inevitable for employees. PPE can help mitigate accidents and injuries associated with hazardous materials or other potentially unsafe working conditions. Thus, the selection of a suitable PPE is a significant step in a safe working environment. PPE selection process is complex and involves multiple criteria decision making since several parameters affect PPE selection. In this study, factors affecting PPE selection were determined as Safety Features, Comfort and Efficiency, Design Principles, and Customer Support. In the present study, a systematic methodology to select an appropriate PPE was performed using the Analytic Hierarchy Process (AHP). The results indicate that Safety Features main criterion is the most significant factor, followed by Comfort and Efficiency, Design Principles, and Customer Support main criteria, respectively.

ANALİTİK HİYERARŞİ PROSESİ METODU İLE UYGUN KİŞİSEL KORUYUCU EKİPMAN SEÇİMİ

Anahtar Kelimeler

Kişisel koruyucu ekipman
Analitik hiyerarşi prosesi
Sağlık ve güvenlik
Karar verme

Öz

Emniyet riskinin azaltılmasının ana ilkeleri eleme, ikame ve mühendislik kontrolleridir. Güvenli çalışma ortamını sağlamak için tehlikeli koşullar, güvenli çalışma uygulamaları ve diğer yönetimsel kontrol biçimleri gözden geçirilmelidir. Bu nedenle çalışanlar için kişisel koruyucu ekipman (KKD) kullanımı kaçınılmazdır. KKD, tehlikeli maddelerle veya diğer potansiyel olarak güvenli olmayan çalışma koşullarıyla ilişkili kazaları ve yaralanmaları azaltmaya yardımcı olabilir. Bu nedenle, uygun bir KKD'nin seçimi, güvenli bir çalışma ortamında önemli bir adımdır. KKD seçim süreci karmaşıktır ve çeşitli parametreler KKD seçimini etkilediği için birden çok kriterli karar vermeyi içerir. Bu çalışmada KKD seçimini etkileyen faktörler; Güvenlik Özellikleri, Konfor ve Verimlilik, Tasarım İlkeleri ve Müşteri Desteği olarak belirlenmiştir. Bu çalışmada, Analitik Hiyerarşi Prosesi (AHP) kullanılarak uygun bir KKD seçmek için sistematik bir metodoloji uygulanmıştır. Çalışma sonuçları, Güvenlik Özellikleri ana kriterinin en önemli faktör olduğunu ve bunu sırasıyla Konfor ve Verimlilik, Tasarım İlkeleri ve Müşteri Desteği ana kriterlerinin izlediğini göstermektedir.

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1. Introduction

It is well known that PPE should be used to minimize the effects of hazards on employees' health. The adverse effects of hazards cannot be completely removed by PPE, yet the risk of employee health can be largely mitigated. Employers need to be aware of using PPE. Health expenditures of employers' can be reduced using an appropriate PPE (Yarpuz-Bozdogan, 2018). Occupational safety and health (OSH) has a multidisciplinary characteristic that tends to the improvement of the safety and health of societies that existed in the workplace. According to the International Labour Organization (ILO), 2.3 million persons die each year due to occupational incidents or disease, and 350.000 of these losses are ascribable to work-related accidents. Moreover, ILO guesses that there are 264 million non-death events annually that result in labor-sourced diseases, causing almost 3 days of lack of work. In recent research, ILO highlighted that 860.000 work-related accidents take place every day and direct or indirect cost for work-related diseases and incidents is predicted at $2.8 trillion worldwide (Amponsah-Tawiah and Mensah, 2016). Considering the magnitude of the problem, it is significant to understand the OSH approach which mainly focuses on issues related to the behavior of employees.

PPE may give a false sense of security leading to ignorance of even simple precautions (selection and use). Although elimination of hazard is the first step, it has been estimated that industrial injuries originate from employee-related errors in 84% to 94% and one of the most common faults is disregarding PPE (Olson, Grosshuesch, Schmidt, Gray and Wipfli, 2009). Inappropriate use of PPE can cause injuries and diseases in workplaces. Research, based on 1986-88 United States Occupational Safety and Health Administration (OSHA) indicated that occupational injuries and diseases can be prevented by up to 37.6% with the regular usage of PPE. Based on OSHA statistics, about 12-14% of total occupational injuries originate due to employees do not wear appropriate PPE (Akbar-Khanzadeh and Bisesi, 1995). Thus, PPE selection is an essential task. The methods that have already been used to select a PPE are mainly focused on risk evaluation and identifying hazards in workplaces. However, many parameters affect PPE selection, therefore, the problem of PPE selection can be evaluated using a decision-making methodology. A Multiple Criteria Decision Making (MCDM) strategy can be used to carry out this process. The basic goal of MCDM is to assist a decision-maker in selecting a suitable alternative from a set of alternatives (Saaty, 1990). Choosing the right PPE is a multi-criteriave decision making problem that takes into account constraints, preferences, and priorities. AHP could be a viable option for resolving this type of situation. The AHP technique has gained favor among decision-makers because it is simple to use. The AHP technique aids in the development of a systematic decision-making process based on various criteria and the subjective preferences of the decision-makers. For this reason, the AHP is convenient in a wide variety of practices in the literature (Aminbakhsh, Gunduz and Sonmez, 2013; Kursunoglu and Onder, 2015; Li, Díaz and Soares, 2021; Liu, Cheng, Yu and Xu, 2018; Wang, Dong, Dong, Yang, Ju, Huang and Ren, 2013). AHP has been substantially used in several disciplines including mining and metallurgy, occupational safety systems, production prediction, selecting industrial robots (Alpay and Yavuz, 2009; Breaz, Bologa, and Racza, 2017; Chan, Kwok and Duffy, 2004; Geng, Li, Zhu and Han, 2018; Janackovic, Stojiljkovic and Grozdanovic, 2017; Kursunoglu and Onder, 2015; Kursunoglu, Ichlasb and Kaya, 2017; Yavuz, Iphar and Once, 2008).

The main object of the present study is to choose an appropriate PPE for different mining firms by using the AHP method. The decision-making criteria of this study which is efficient for the selection process were evaluated according to the Personal Protective Equipment Regulation prepared by the Turkish Ministry of Labour and Social Security (PPER, 2013). After determining alternative PPE firms, the selection process was performed according to the manufacturers' catalogs on the basis of consensus decisions reached by occupational health and safety experts, and the most appropriate PPE was selected.

2. Literature Review

Employers have the responsibility to provide a safe work environment taking the necessary precautions associated with OSH. The use of PPE is one of these measures. Risk is the probability of an incident affecting the activity's objectives. It is a function of both consequences and likelihood. Therefore, hazards indicate the basis of damage or loss, but the risk is the possibility of the existence of the damage or loss (Caputo, Pelagagge and Salini, 2013). The greater the consequences, the greater the workplace risk. Similarly, the more certain the event occurs, the greater the risk (UOW, 2014). There are several studies in the literature regarding the use of PPE in risk conditions. Andrade-Rivas and Rother (2015) investigated employees' PPE compliance as a risk reduction measure by analyzing their risk perceptions of herbicide use, working conditions, and socio-cultural context. Balkhyour, Ahmad and Rehan (2018) assessed the suitability and usage of PPE in addition to reported occupational exposures between employees in researched minor industries in Jeddah. The research was carried out to collect data on sociological and demographic features, occupational exposures, and incidence of PPE used by employees. Oh and Uhm (2016) determined the status of occupational exposures between medical employees to infectious risks and their use of PPE in prehospital environments.

The first crucial step to form an extensive health and safety environment is to determine physical and health hazards in the working place. This process is named hazard assessment (OSHA, 2004). PPE can provide an efficient barrier between the body and a potential hazard. However, malfunctioning, ill-fitting, or inappropriate PPE can cause unnecessary exposure.

3. The Analytic Hierarchy Process

The AHP technique is based on a series of binary judgments that take into account decision-makers perceptions and evaluations. The evaluations are carried out utilizing a scale of specific decisions that show how much one aspect is superior to another based on a given feature (Saaty, 2008). The AHP methodology was described below (Saaty, 1990).

1. Determine judgment measure C_i to rank and evaluate alternatives.

2. Determine the number of alternatives to be sorted.

3. A binary comparing matrix *a x a* is created, where *a* is the number of components to be compared.

X(*xij*) with (*i,j* = 1,2, . . .,*a*)

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1a} \\ x_{21} & x_{22} & \cdots & x_{2a} \\ \cdots & \cdots & \cdots & \cdots \\ x_{a1} & x_{a2} & \cdots & x_{aa} \end{bmatrix}$$

where $x_{ij} > 0$, $x_{ij} = 1/x_{ji}$, $x_{ii} = 1$, and x_{ij} is the comparative significance of criterion *i* respect criterion *j*. The relative relevance of the two components is determined using Saaty's nine-point scale (Saaty, 2008).

4. Determine the relative priorities of criteria or alternatives. The comparative importance is performed using the eigenvector theory. The matrix A's relative weight is determined.

$$W = [w_1, w_2, \ldots, w_a] \quad (1)$$

where *W* is the normalized main eigenvector of matrix X.

5. Calculating the consistency index of matrix X defines its consistency (CI).

$$CI = (\lambda_{max} - a) / (a - 1) \quad (2)$$

where λ_{max} is the maximum eigenvalue and *a* is the dimension of the matrix. The consistency ratio (CR) is calculated.

$$CR = CI / RI \quad (3)$$

where RI signifies Saaty's random index values for several matrix dimensions. The decision-judgments makers are suitable if the CR values of the matrices are less than or equal to 0.10. If results more than 0.10 are achieved, the decision-comparisons makers are verified. (Kursunoglu and Onder, 2015).

6. A binary judgment matrix is constructed between alternatives to determine the degree to which one alternative dominates another based on a criterion.

7. Determine the alternatives' final ratings.

The authors declare that research and publication ethics were followed in this study.

4. Application of the AHP

4.1. Development of the AHP

Considering the factors that can be influential to select a suitable PPE, four main criteria were determined as Design Principles, Safety Features, Comfort and Efficiency, and Customer Support, with their sub-criteria. The main criteria and sub-criteria were presented in Table 1.

In the first step of the AHP model, a hierarchical structure was constituted. This includes the objective, all decision criteria, and alternatives. The main objective is involved in Level 1. The main criteria and sub-criteria are situated in Level 2. Level 3 demonstrates the alternatives that influence the choice of PPE (Figure 1).

Table 1

Definitions of Criteria and Sub-criteria

Criteria	Sub-criteria	Definitions
Design Principles (A)	Ergonomics (A_1)	Describes the design and manufacture to protect the user at the highest possible level.
	Maximum possible protection level (A_2)	Describes the point that the effectiveness of PPE begins to decline when the user is exposed to risks arising from the use of PPE or during common working conditions.
	Proper protection classes for different risk levels (A_3)	Describes considering selecting appropriate protection classifications in the case of conditions of use vary.
Safety Features (B)	Absence of discomfort risks caused by the structure of PPE (B_1)	Describes being manufactured in such a way as not to cause hazards and any other disturbing factors that may arise from its structure.
	Manufacture of appropriate materials (B_2)	Describes PPE material and its components including deterioration-causing substances, not to affect the health and hygiene of the user negatively.
	Compliance of PPE to the user-contacted surface (B_3)	Describes any PPE element in contact with or likely to contact the user not to have hard, sharp edges and protrusions that may cause irritation or injury.
	Non-blocking feature (B_4)	Describes minimizing the loss of sensitivity in sensory organs and limitations of posture and movements. It also describes not causing movements that may be dangerous to the user or other persons.
Comfort and Efficiency (C)	Conformity to body structure (C_1)	Describes the adaptation of different body structures with adjustable and attachable systems
	Lightness and durability (C_2)	Describes the ability to withstand the effects of working conditions and also describes to be as light as possible so as not to reduce its functionality.
	Adaptation of different PPE classes (C_3)	Describes the different types and classes of PPE to be compatible with each other to protect simultaneously close parts of the body against multiple risks.
Customer Support (D)	Name and address of the manufacturer or its authorized representative (D_1)	Describe the PPE manufacturer company or its authorized agent
	Technical test and performance results to measure the class or level of protection (D_2)	Describes the product conformity tests performed by the certified organization.
	Features of suitable accessories and spare parts (D_3)	Describe the compatibility of used accessories with PPE
	Useful life (D_4)	Describes the expected durability of PPE in the considered working environment.
	Cost (D_5)	Describes the purchase cost

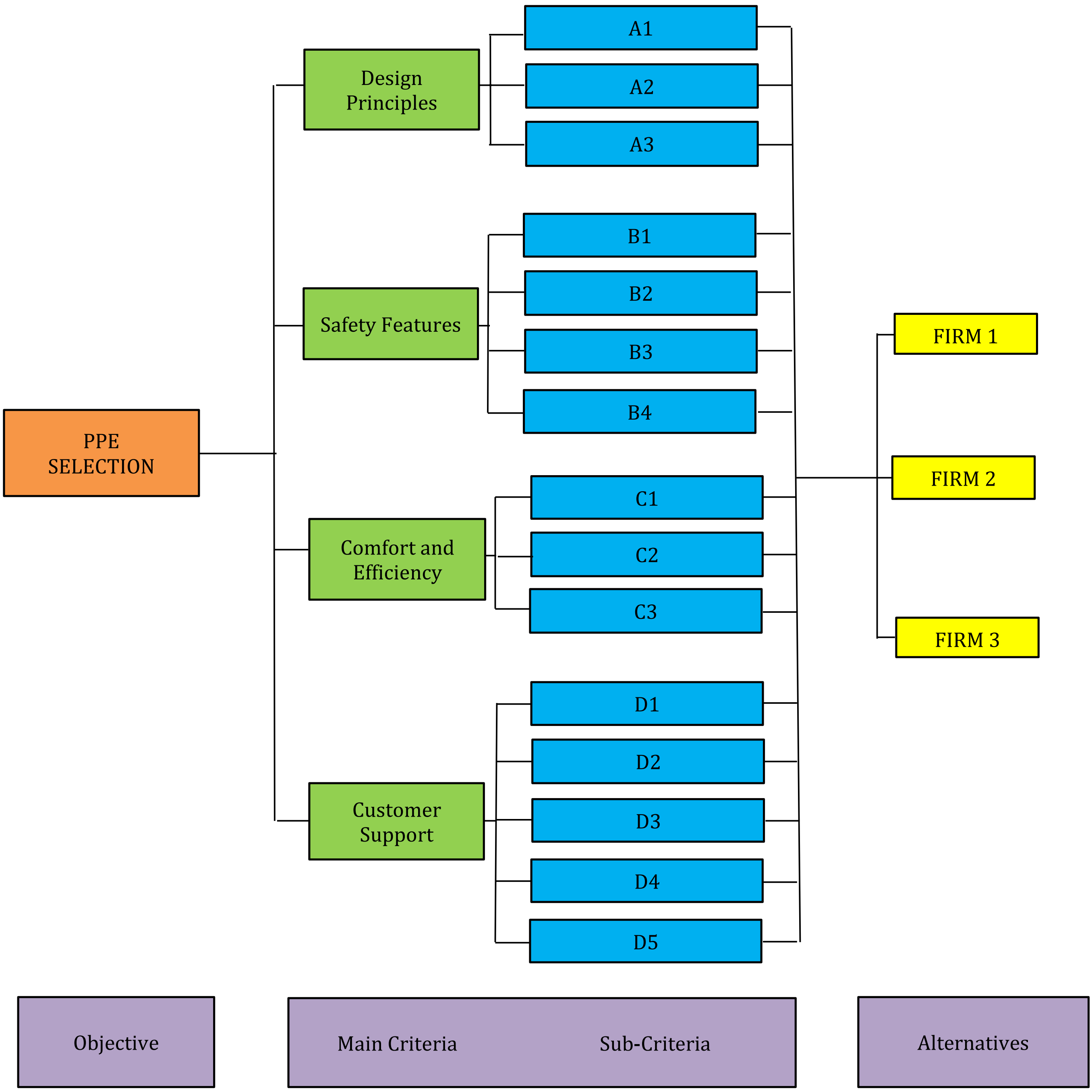

Figure 1. The Hierarchical Structure Of PPE Selection

4.2. Identification of the Alternatives

Many guidelines and technical standards (ANU, 2011; EIGA, 2017; OSHA, 2004) are mainly related to preventing injuries and hazards, identifying the various types, and showing the correct practice of PPE. However, they are inadequate to offer users a better solution among the available alternatives. Therefore, a methodology was developed in the present study to choose an appropriate PPE based on the opinions of expert in occupational health and safety field. For the purpose of selecting the firms, the general manager, project manager, and site engineers who are experts in occupational health and safety were consulted. The technical PPE descriptions of the firms were given in Table 2.

Table 2

The Technical PPE Descriptions of The Firms

Type of PPE	Firm 1	Firm 2	Firm 3
Ear protection	• Re-usable. • Comfortable to wear	• Washable. • Have additional systems in place to notify the user in the event of an emergency. • Comfortable to wear adjustable ear muffs	• Re-usable. • Adjustable ear muffs.

Noise is one of the most important environmental problems of our age. Industrial equipment-related noise can cause significant damage to employees if adequate and efficient measures are not taken. Therefore, the present study focused on the problem of hearing loss. Noise-induced hearing loss is an invisible disease that affects almost 14 million employees in the United States. According to the National Health and Nutrition Examination Survey, it has been estimated that 22 million employees are exposed to dangerous stages of noise, which cause occupational hearing loss. Hearing loss is over 20% for employees in the mining, railroad, and principal metal production industries. Among noise-exposed employees, prevalence rates of 25% for mining and construction sectors and 20% for the manufacturing sector are in Figure 2 (Murphy, 2016).

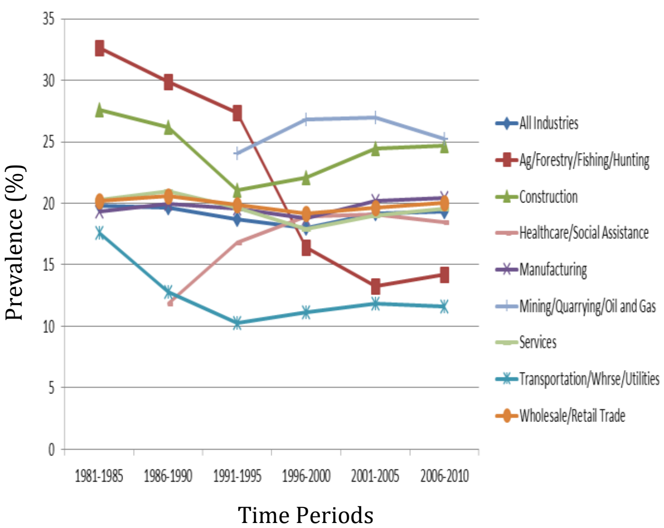

Figure 2. Prevalence Of Hearing Loss According To Different Sectors (Masterson, Deddens, Themann, Bertke and Calvert, 2015).

Considering that the explanations above, three prominent companies were identified (Firm 1, Firm 2, and Firm 3) among PPE manufacturers to select ear protection. Alternatives were evaluated by examining the manufacturer catalogs by occupational safety and health experts in the deciding process.

4.3. Binary Comparisons

The principal objective of the present study is to determine the most appropriate PPE. A hierarchical structure was formed for the selection problem. ExpertChoice® 2000 program was utilized for this purpose. The pair-wise comparison matrices were obtained based on occupational safety and health experts' opinions. The pair-wise matrices were constructed concerning Saaty's 9-point scale (Table 1). The matrices are reciprocal. When assessing the criteria *i* and *j*, the reciprocal value represents the judgment between *j* and *i*. Determination of λ_{max}, *CR*, and *CI* was performed according to the explanations given in Section 3. The values of *CR* vary between 0 and 0.10 in the present study. This indicates that comparisons between the factors are consistent. Table 3 depicts the binary comparison matrix of the main criteria.

Table 3

Binary Comparison Matrix For The Main Criteria.

PPE Selection	A	B	C	D	Local Priorities	
A	1	1/6	1/5	2	0.088	λ_{max}= 4.143
B	6	1	3	7	0.572	CR=0.048
C	5	1/3	1	4	0.279	CI= 0.05 ≤ 0.10
D	1/2	1/7	1/4	1	0.062	

Considering the results displayed in Table 4, Safety Features (B) main criterion is the most significant factor (weight value: 0.572), followed by Comfort and Efficiency (C), Design Principles (A), and Customer Support (D) main criteria, respectively. Matrices given in Tables 4-7 were constructed to evaluate the sub-criteria determined in the main criteria.

Table 4

Evaluation Of Sub-criteria According To "Design Principles" Criteria.

Design Principles	A_1	A_2	A_3	Local Priorities	
A_1	1	5	1/2	0.364	λ_{max}= 3.094
A_2	1/5	1	1/4	0.099	CR=0.047
A_3	2	4	1	0.537	CI= 0.09 ≤ 0.10

Table 5

Evaluation Of Sub-criteria According To "Safety Features" Criteria.

Safety Features	B_1	B_2	B_3	B_4	Local Priorities	
B_1	1	1/5	1/3	1/4	0.066	λ_{max}= 4.252
B_2	5	1	5	3	0.538	CR=0.084
B_3	3	1/5	1	1/4	0.116	CI= 0.09 ≤ 0.10
B_4	4	1/3	4	1	0.279	

Table 6

Evaluation of Sub-criteria According To "Comfort and Efficiency" Criteria.

Comfort and Efficiency	C_1	C_2	C_3	Local Priorities	
C_1	1	7	4	0.696	λ_{max}= 3.076
C_2	1/7	1	1/4	0.075	CR=0.038
C_3	1/4	4	1	0.229	CI= 0.07 ≤ 0.10

Table 7

Evaluation Of Sub-criteria According To "Customer Support" Criteria.

Customer Support	D_1	D_2	D_3	D_4	D_5	Local Priorities	
D_1	1	1/7	1/2	1/3	1/3	0.061	
D_2	7	1	3	2	6	0.453	λ_{max}= 5.416
D_3	2	1/3	1	3	4	0.246	CR=0.104
D_4	3	1/2	1/3	1	2	0.151	CI= 0.09 ≤ 0.10
D_5	3	1/6	1/4	1/2	1	0.089	

Tables 4-7 show the weight values of every sub-criterion. A3 is the most significant sub-criterion (weight value: 0.537) in Design Principles main criterion; B2 is the most significant sub-criterion (weight value: 0.538) in Safety Features main criterion. C1 is the most significant sub-criterion (weight value: 0.696) in Comfort and Efficiency main criterion. D2 is the most significant sub-criterion (weight value: 0.453) in the Customer Support main criterion. The comparisons of alternatives were formed based on each sub-criterion. Table 8 displays the expert team's judgments for alternatives.

The AHP result is shown in Figure 3. It is clear that Firm 2, with a score of 0.445, is the most favored, followed by Firm 1 and Firm 3. Firm 2, Firm 1, and Firm 3 have percentage significances of 44.50%, 40.50%, and 15.00%, respectively.

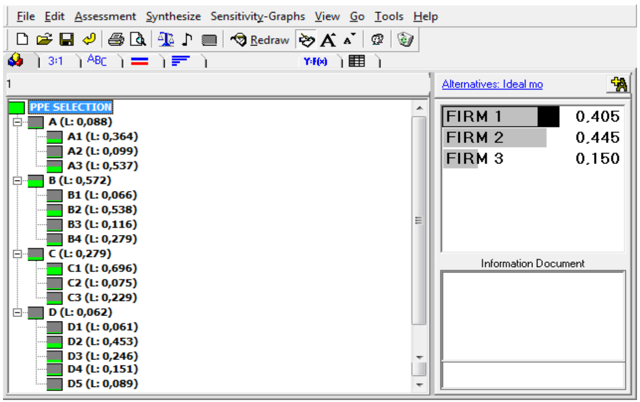

Figure 3. The Outcome Of the Selection Of PPE

Figure 4 depicts the rankings of alternatives concerning the main criteria. If Design Principles main criterion is considered, Firm 3 is preferable to Firm 1 and Firm 2. If Customer Support main criterion is preferred, Firm 1 is preferable to Firm 2 and Firm 3.

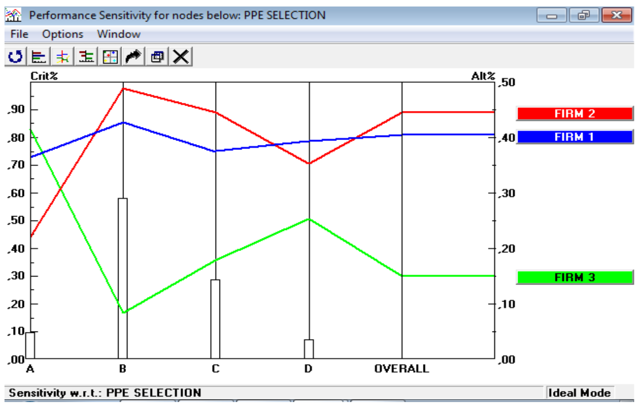

Figure 4. Performance Graph Of PPE Considered

Table 8

Binary Comparison Matrices Based On Subcriteria.

Sub-criteria	FIRMS	FIRM 1	FIRM 2	FIRM 3	Local Priorities	
A_1	FIRM 1	1	1	5	0.481	λ_{max}= 3.029 CR=0.015 CI= 0.03 ≤ 0.10
	FIRM 2	1	1	3	0.405	
	FIRM 3	1/5	1/3	1	0.114	
A_2	FIRM 1	1	3	1/3	0.258	λ_{max}= 3.039 CR=0.019 CI= 0.04 ≤ 0.10
	FIRM 2	1/3	1	1/5	0.105	
	FIRM 3	3	5	1	0.637	
A_3	FIRM 1	1	5	1/3	0.279	λ_{max}= 3.065 CR=0.032 CI= 0.06 ≤ 0.10
	FIRM 2	1/5	1	1/7	0.072	
	FIRM 3	3	7	1	0.649	
B_1	FIRM 1	1	2	7	0.592	λ_{max}= 3.014 CR=0.007 CI= 0.01 ≤ 0.10
	FIRM 2	1/2	1	5	0.333	
	FIRM 3	1/7	1/5	1	0.075	
B_2	FIRM 1	1	1	5	0.455	λ_{max}= 3.000 CR=0.000 CI= 0.00 ≤ 0.10
	FIRM 2	1	1	5	0.455	
	FIRM 3	1/5	1/5	1	0.091	
B_3	FIRM 1	1	1	7	0.487	λ_{max}= 3.013 CR=0.006 CI= 0.01 ≤ 0.10
	FIRM 2	1	1	5	0.435	
	FIRM 3	1/7	1/5	1	0.078	
B_4	FIRM 1	1	1/3	5	0.279	λ_{max}= 3.065 CR=0.032 CI= 0.06 ≤ 0.10
	FIRM 2	3	1	7	0.649	
	FIRM 3	1/5	1/7	1	0.072	
C_1	FIRM 1	1	1	3	0.405	λ_{max}= 3.029 CR=0.015 CI= 0.03 ≤ 0.10
	FIRM 2	1	1	5	0.481	
	FIRM 3	1/3	1/5	1	0.114	
C_2	FIRM 1	1	1/3	3	0.243	λ_{max}= 3.007 CR=0.004 CI= 0.01 ≤ 0.10
	FIRM 2	3	1	7	0.669	
	FIRM 3	1/3	1/7	1	0.088	
C_3	FIRM 1	1	1	1	0.333	λ_{max}= 3.000 CR=0.000 CI= 0.00 ≤ 0.10
	FIRM 2	1	1	1	0.333	
	FIRM 3	1	1	1	0.333	
D_1	FIRM 1	1	5	7	0.731	λ_{max}= 3.065 CR=0.032 CI= 0.06 ≤ 0.10
	FIRM 2	1/5	1	3	0.188	
	FIRM 3	1/7	1/3	1	0.081	
D_2	FIRM 1	1	1	1	0.333	λ_{max}= 3.000 CR=0.000 CI= 0.00 ≤ 0.10
	FIRM 2	1	1	1	0.333	
	FIRM 3	1	1	1	0.333	
D_3	FIRM 1	1	3	5	0.637	λ_{max}= 3.039 CR=0.019 CI= 0.04 ≤ 0.10
	FIRM 2	1/3	1	3	0.258	
	FIRM 3	1/5	1/3	1	0.105	
D_4	FIRM 1	1	1/3	1	0.200	λ_{max}= 3.000 CR=0.000 CI= 0.00 ≤ 0.10
	FIRM 2	3	1	3	0.600	
	FIRM 3	1	1/3	1	0.200	
D_5	FIRM 1	1	1	3	0.429	λ_{max}= 3.000 CR=0.000 CI= 0.00 ≤ 0.10
	FIRM 2	1	1	3	0.429	
	FIRM 3	1/3	1/3	1	0.143	

5. Sensitivity Analysis

Sensitivity analysis is conducted to analyze the flexibility of the final judgment. A better decision can be made by a decision-maker to determine a critical criterion. In other words, the sensitivity of the alternatives depends on the changes in the current weight of a criterion. Considering the subjective nature of the judgment, small variations in the priorities can cause important changes in the last rankings. The coherence of the ranking based on changing criteria weights can be verified (Kursunoglu and Onder, 2015). ExpertChoice® 2000 software can allow the sensitivity analysis of the decision-making problem. The dynamic sensitivity of the main criteria and alternatives are shown in Figures 5-6.

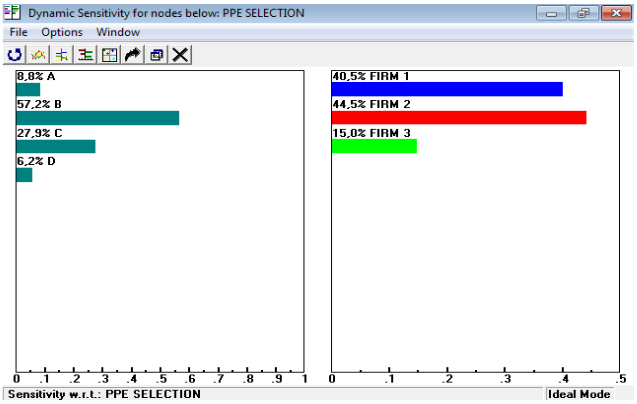

Figure 5. Main Criteria And Dynamic Sensitivity

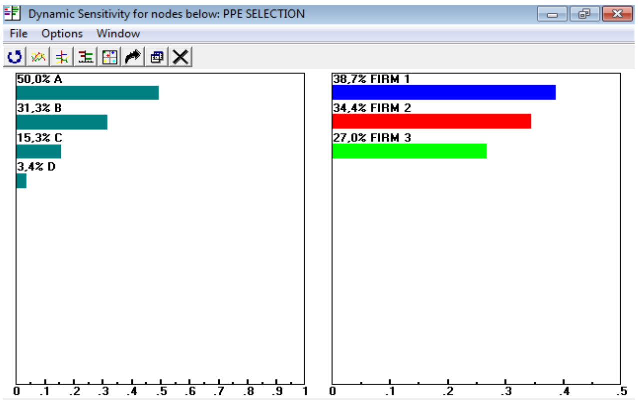

Figure 6. Main Criteria And Dynamic Sensitivity Variations

As can be seen in Figure 5 and Figure 6, when the weight of Design Principles (A) main criterion increased from 8.8% to 50.00%, Safety Features (B) main criterion decreased from 57.2% to 31.3%, and the weight of Comfort and Efficiency (C) main criterion decreased from 27.9% to 15.3%. These changes lead to the decrease of Firm 2 performance in the model from 44.5% to 34.4%, while Firm 3 is increased from 15.0% to 27.0%. Analyzing these conclusions, it was obtained that Firm 1 is the most preferred, followed by Firm 2 and Firm 3 when the weight of Design Principles (A) main criterion is increased to 50.00%.

6. Conclusions

In this study, the problem of selecting an appropriate PPE was examined. Due to the flexible structure of the AHP method, it can be implemented with diverse criteria and alternatives to select a suitable PPE. The technique is easy to apply by users. A comprehensive set of criteria was determined to compare factors and AHP was used to provide a consistent ranking of alternatives. As a wide-ranging impact on the practical applicability of the suggested method, pair-wise comparison matrices were performed. In the proven AHP method, three alternatives (Firm 1, Firm 2, and Firm 3) were assessed concerning four main criteria and their sub-criteria.

The assessment resulted that the most appropriate PPE is Firm 1. The chosen company is capable of providing enterprises with washable, additional systems in place to notify the user in the event of an emergency, and comfortable to wear adjustable ear muffs. The assessment also resulted that Safety Features main criterion has the highest importance weight in the decision process. This is followed by Comfort and Efficiency, Design Principles, and Customer Support, respectively. Manufacture of appropriate materials sub-criterion in Safety Features main criterion is the most significant factor. Additionally, conformity to body structure in Comfort and Efficiency, proper protection classes for different risk levels in Design Principles, and technical test and performance results to measure the class or level of protection in Customer Support are the most important factors. Decision-makers place more emphasis on Safety Features criteria than the economical condition (cost), which is believed to be the main influential factor in PPE selection. Using an appropriate PPE, the health expense of employers' can be mitigated. The AHP consequences were also examined using sensitivity analyses and it was found that Firm 1 is eligible as the most suitable based on the sensitivity analyses. Firms can reliably select the appropriate PPE for different risks that employees exposed using the AHP method. Different multi-criteria decision making approaches can be applied to the problem.

Contribution of Researchers

Nilufer KURSUNOGLU: Conceptualization, Methodology, Investigation, Writing - original draft, Writing- review &

editing. Seyhan ONDER: Conceptualization, Methodology, Investigation, Writing - original draft, Writing-review & editing, Visualization. Mustafa ONDER: Conceptualization, Methodology, Investigation, Visualization, Supervision

Conflict of Interest

No conflict of interest was declared by the authors.

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