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Research Article

Fuzzy Fine-Kinney Occupational Health and Safety Risk Analysis in Offices: An Application in a Public Institution in Istanbul

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Abstract In offices, there are numerous risks concerning the health and safety of employees, making it challenging to eliminate all risk factors at once. Risk analyses are conducted to prioritize risks based on urgency and to mitigate their danger levels. An occupational health and safety risk analysis was performed using the Fine-Kinney method for 330 hazard sources in a public institution conducting office activities in Istanbul. The uncertainty of parameters in the Fine-Kinney method complicates obtaining objective results; therefore, in the second phase, the parameters of probability, frequency, severity, and risk magnitude were processed according to the principles of fuzzy logic to achieve more objective and realistic outcomes. For the fuzzy analysis, two separate fuzzy models were developed using the same rule base. The difference between the models lies in the selection of membership functions; thus, the impact of membership function choice on the risk score has been explored. Lastly, by comparing Fine-Kinney and fuzzy model analyses, it was concluded that fuzzy models are more successful than the method, and the second fuzzy model, which uses triangular membership functions, was found to be more successful than the first fuzzy model which uses pi membership functions.

Keywords: Fuzzy Fine-Kinney, Risk analysis, Occupational health and safety, Office workplaces.

I. INTRODUCTION

Occupational safety is defined as systematic efforts to cleanse workplaces of hazards arising from work execution and conditions that may harm health, thereby providing a better working environment [1]. The World Health Organization (WHO) defines a work accident as 'an unplanned event, often leading to injuries, damage to machinery and equipment, or a temporary halt in production,' while the International Labor Organization (ILO) describes it as 'an unexpected, unplanned event causing specific damage or injury' [2]. The ILO estimates that approximately 2.3 million people globally succumb annually to work-related accidents or illnesses, equating to over 6000 deaths daily. Around 340 million occupational accidents occur worldwide each year, with 160 million people suffering from work-related diseases. While the ILO periodically updates these estimates, an increase in accidents and health issues over time has been observed [3]. According to the European Statistical Office (EUROSTAT), the EU experiences more than 5500 fatal work accidents annually, with 6.9 million workers suffering accidents and 23 million reporting work-related health problems [4]. In Turkey, according to the Social Security Institution's 2021 data [5], 1382 insured individuals died due to work accidents, and 35 due to occupational diseases. The difficulty in identifying occupational diseases is one of the most problematic areas in the field of Occupational Health and Safety (OHS) in Turkey. Reliable statistics on how many workers in Turkey contract occupational diseases and how many of these lead to chronic problems or deaths are unattainable [6].

Risk, or hazard, is defined as the danger or probability of loss or damage [7]. Risk analysis involves first identifying hazard sources and calculating and ranking the associated risks. In the second step, control measures are determined based on risk scores, and the resulting new situation is re-analyzed to complete the second step. The risk assessment process encompasses these two steps. In the context of occupational health and safety, risk assessment involves identifying potential hazards in the workplace or from external sources, assessing the harm they could cause to employees, the workplace, and the environment, and determining the necessary precautions [1]. Risk assessment methods can be categorized into three main types: quantitative (e.g., Risk Assessment Decision Matrix (RADM), John-Ridley risk assessment method, Failure Mode and Effects Analysis (FMEA), Fine-Kinney risk assessment method, etc.), qualitative (e.g., Preliminary Hazard Analysis (PHA), Primary Risk Analysis (PRA) using Checklists, What if Analysis, Job Safety Analysis, Hazard and Operability Study (HAZOP)), and mixed methods. There are over 150 risk assessment methods in the literature [8].

Offices are places where organizational and managerial activities are carried out. The increasing number of office workers today, along with working conditions, shows that ergonomics and an ergonomic approach significantly affect employee productivity [9]. Office work is not limited to a specific area of the business but spreads across all areas; therefore, defining an office as a place or certain activities is insufficient; it should rather be defined according to its functions [10]. In a business, an office can be a place where different operational activities like production, storage, logistics, etc., are carried out, as well as where all activities in sectors such as banking and insurance are conducted. Risks in offices can be divided into three main groups: physical risk factors, psychosocial risk factors, and ergonomic risk factors [11]. Office occupational diseases can be categorized into four groups: musculoskeletal system diseases, circulatory system diseases, allergic diseases, and psychological diseases; these are a group of multisystemic diseases caused by factors such as prolonged sitting, repetitive movements, computer work, excessive strain on wrists and fingers, ambient temperature, humidity, light, and other non-ergonomic conditions [12].

In this study, occupational health and safety risk analysis was conducted in a public institution engaged in office activities in Istanbul. The data for the study were collected through observations at the workplace. Hazard sources found in the literature were also included in the analysis to evaluate potential but unidentified hazards at the workplace. Initially, risk assessment for a total of 330 hazard sources was conducted using the Fine-Kinney method. The data were then re-analyzed using the Fuzzy Fine-Kinney method. The results obtained are discussed.

In the study, occupational health and safety risk analysis was conducted in a public institution operating in the province of Istanbul. The data of the study were collected by observation at the workplace. To evaluate the hazards that could not be detected at the workplace but could potentially be present, the hazard sources found in the literature were also included in the analysis. In the first stage, a risk assessment was made according to the Fine-Kinney method for a total of 330 hazard sources. Then, the risks were re-analyzed with Fuzzy Fine-Kinney. To conduct risk analysis using fuzzy logic, the probability, frequency, severity, and risk magnitude parameters of the Fine-Kinney method were fuzzified, and two separate fuzzy models were developed. These models employed the same rule base but were differentiated by the selection of membership function types. Subsequently, the analysis results obtained from both the Fine-Kinney and Fuzzy Fine-Kinney models were compared.

In the literature, there are limited studies on risk assessment in office workplaces; these studies are conducted in small offices with a limited number of hazard sources. Furthermore, no studies employing the Fuzzy Fine-Kinney method approach for risk analysis in offices have been found. Thus, this study is expected to contribute to the literature and provide a practical example for occupational health and safety (OHS) professionals working in the field.

The subsequent sections of the study include a review of the literature on risk analysis studies integrating the Fine-Kinney method with other methods, the methodology used in this study, the findings of the risk analysis method applied, and the results and discussions obtained.

II. LITERATURE REVIEW

Some of the studies integrating the Fine-Kinney method with different approaches in the literature include: Özfırat (2016) conducted a risk assessment for the longwall production method, one of the most used methods in underground coal mining. His risk assessment emphasized the need for controlled operation in Grizzly coal mines to prevent the dangerous concentration of methane during production [13]. Kokangül (2017) identified hazard sources in a large machinery manufacturing plant in Turkey and categorized these hazards into main and sub-categories. He prioritized each category using the AHP method and compared the risk scores obtained with the Fine-Kinney method after normalization. His study proposed a new approach that the class intervals of the Fine-Kinney method could be used for the results obtained with the AHP method [14]. Gul et al. (2017) analyzed the maintenance procedures of a ballast tank on a ship. The probability, frequency, and severity parameters of the Fine-Kinney method were weighted using fuzzy AHP, and the risk score was calculated using fuzzy VIKOR, identifying the highest risks as "high temperature inside the tank," "head injury at the manhole entrance of the tank," and "falling from height during welding or cutting operations in the ballast tank" [15]. Oturakçı and Dağsuyu (2017) evaluated 10 risks at a construction site using the Fine-Kinney method, then fuzzified the method's scales with triangular membership functions to create a fuzzy model. They found that the priority levels of 5 out of 10 risks changed after comparing the risk levels obtained from the Fine-Kinney and fuzzy models, arguing that the fuzzy model provided more precise results [16]. Gönen (2018) rescaled the musculoskeletal system discomfort survey developed by Cornell University, inspired by the Fine-Kinney method, and applied it to a company in the automotive sector producing cables, identifying the musculoskeletal discomforts of assembly line workers [17]. Gul (2018) applied the fuzzy analytic hierarchy process to weigh the parameters of the Fine-Kinney method and then used the fuzzy VIKOR method to prioritize the hazards. In his study, OHS experts in Turkey weighted risk parameters for an onshore wind turbine and evaluated the agreed rankings of hazards, revealing the most significant dangers during the construction and operation phases of the wind turbine. The most critical hazards during the construction of the turbine were identified as the lack of safety belts, falling from heights, panic in emergencies, and inability to respond quickly in emergencies. The risks during the operation of the wind turbine were identified as vehicle accidents due to damaged and uneven roads and the shock risk from unauthorized digging. The study concluded with control measures and potential corrective and preventive activities for the risks [18]. Ilbahar (2018) used a new integrated approach, the Pythagorean Fuzzy Proportional Risk Assessment (PFPRA), combining Fine-Kinney, Pythagorean Fuzzy Analytic Hierarchy Process, and Fuzzy Inference System for risk assessment during excavation operations at a construction site. The results identified the most critical factor as the undefined routes of excavation vehicles on-site and the least critical as the unlicensed drivers of excavation vehicles. Landslide risk due to the lack of proper slope or support was found to be a significant risk, while other critical factors were negligible. The proposed method was compared with Pythagorean fuzzy failure modes and effects analysis, showing that the proposed method provided more informative, reliable, and consistent results for decision-makers regarding uncertainty [19]. Weizhong (2018) proposed a new risk assessment approach based on the Fine-Kinney method, combining triangular fuzzy numbers, the MULTIMOORA method, and the Choquet integral. The study selected the maintenance of a ballast tank as a case to verify the effectiveness of the proposed risk assessment model through comparison and sensitivity analysis [20]. Taranushina and Popova (2019] assessed the risks involved in organizing loading and unloading operations using 20/5 ton capacity bridge cranes with the Fine-Kinney method [21]. Baç and Ekmekci (2020) assessed the psychosocial risks faced by employees in a metal processing plant using the COPSOQII questionnaire, with the data obtained from the COPSOQII survey used as input for Fine-Kinney analysis. Due to the uncertainty in the Fine-Kinney method, this was overcome using the ANFIS (adaptive neuro-fuzzy inference system) module. The model was compared with the actual risks, demonstrating that the ANFIS results predicted the risk scores with high accuracy [22]. Erdebilli and Gür (2020) evaluated a total of 8 risks, both man-made and natural disasters, for a dam in eastern Turkey using both the Fine-Kinney and fuzzy Fine-Kinney methods and compared the results. They found that the importance level of 5 out of the 8 risks changed in the analysis [23]. Aboubakar et al. (2021) identified significant risk factors in Chinese hydroelectric projects in Cameroon and ranked these factors based on their impact on project success, deriving from literature and experts, under four categories. They integrated the Fine-Kinney and SWARA-TOPSIS methods. As a result, the highest risk categories were identified as social and environmental risks; moreover, the highest risk factor was found to be social acceptance by the local population, while restrictions related to environmental issues were the lowest risk factors [24]. Güney and Kahraman (2022) conducted a risk assessment in environmental research laboratories using the Analytical Hierarchy Process (AHP) and Fine-Kinney method. They determined that the cost of implementing safety measures for each risk was approximately 10,000.00 EUR [25]. Tatar et al. (2023) proposed an approach integrating the Fine-Kinney and spherical fuzzy AHP-TOPSIS methods to assess the risks of musculoskeletal disorders in workers harvesting tea. In the first stage, the Fine-Kinney parameters were weighted using spherical fuzzy AHP (SF-AHP). Subsequently, the spherical fuzzy TOPSIS (SF-TOPSIS) method was used to rank the hazards. In the final stage, the proposed model was compared with the SF-CODAS (spherical fuzzy composite distance-based assessment) method based on Fine-Kinney. The results obtained from the SF-TOPSIS and SF-CODAS methods based on Fine-Kinney were analyzed using Spearman's rank correlation coefficient, and the similarity rate in risk rankings was determined to be 92% [26].

III. METHODOLOGY

"In this section, the Fine-Kinney method, fuzzy logic, fuzzy sets, membership functions, and fuzzy model design in MATLAB are described.

3.1. Fine-Kinney method

The Fine-Kinney method was developed by William T. Fine in 1971 for the American Naval Ordnance Laboratory in Maryland. The method was presented to management through a technical report titled 'Mathematical Evaluations for Controlling Hazards.' In the Fine-Kinney method, the Risk Magnitude (RM) is calculated using three parameters: the probability of the accident (P), the potential consequences of an accident (severity-S), and exposure (frequencies of the actions-F) [27].

$$RM = PxSxF \tag{1}$$

In Equation (1), P represents the probability that, once a hazardous event occurs, the complete sequence of events will follow with the necessary timing and coincidence to lead to an accident and its consequences [27]. These values are categorical, and their numerical magnitudes are selected from standard tables as shown in Table 1. a [28]. In Equation (1), S represents the most probable outcomes of a potential accident, including injuries and material damage. This is based on an assessment of the entire situation surrounding the hazard and on accident experience [27]. S signifies the possible outcomes of an accident that may occur, such as an electric shock leading to injury or death while a worker is operating an electrical panel. In the Kinney method, a verbal value such as death, injury, first aid, property damage, etc., is assigned to the severity parameter according to the characteristics of the possible accident. The S scale is shown in Table 1. b [16]. In Equation (1), F represents the frequency of occurrence of the hazardous event [27]. The F scale indicates that the more frequent the exposure to a potentially hazardous situation, the greater the risk. Therefore, when creating the F scale, a value of 1 is assigned for an exposure occurring once a year, and a value of 10 for continuous exposure, with interpolation providing the intermediate values between these two [28]. The frequency scale is displayed in Table 1. c, with reference points highlighted in bold [16].

Table 1. (a) Linguistic scale for probability; (b) Linguistic scale for severity; (c) Linguistic scale for frequency of occurrence

(a)

Description	Rating
Most likely	**10**
Quite possible	6
Unusual	3
Remotely possible	**1**
Extremely remote	0,5
Practically impossible	0,2
Almost impossible	**0,1**

(b)

Description	Rating
Catastrophe	**100**
Multiple fatalities	40
Fatality	15
Extremely serious	7
Disabling injuries	3
Minor cuts	**1**

(c)

Linguistic terms	Rating
Continuously	**10**
Frequently	6
Occasionally	3
Unusually	2
Rarely	**1**
Very rarely	0,5

In the Fine-Kinney method, the results obtained based on the probability, frequency, and severity parameters are evaluated using the linguistic scale provided in Table 2 [28].

Table 2. Linguistic scale for risk magnitude

Risk level	**Description**	**Risk value**
Critical	Immediate action	R>=400
Major Risk	Immediate improvement	200<=R<400
Medium Risk	Measures to be taken	70<=R<200
Minor Risk	Monitoring	20<=R<70
Negligible Risk	Acceptable risk	R<20

3.2. Fuzzy Logic

Traditional two-valued logic falls short in providing an appropriate conceptual framework for defining the meanings of fuzzy concepts like approximate and intense. Hence, the concept of fuzzy logic was developed. Fuzzy logic was first introduced by Lotfi A. Zadeh in 1965 in an article titled "Fuzzy Sets" published in the journal Information and Control [29,30]. Fuzzy logic offers some advantages in modeling complex processes where logic rules are expressed using linguistic variables, and information is often subjective, incomplete, or unreliable, with the problem typically being non-linear.

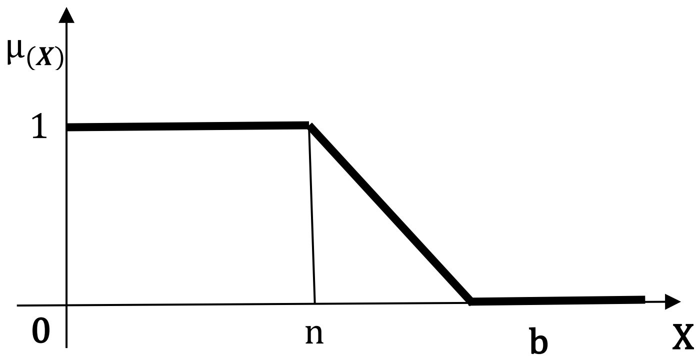

Figure 1. Linear Z Membership Function (Jevscek, 2016)

For example, in risk assessment, fuzzy logic holds good potential, especially in studies where probability assessment largely relies on expert opinion [31]. Fuzzy logic does not reject the concept of membership used in classical set theory; instead, it expands it by moving from two-valued to multi-valued membership [32, 33]. In fuzzy sets, there are many membership functions such as triangular fuzzy numbers, trapezoidal fuzzy numbers, Gaussian fuzzy numbers, and sigmoidal fuzzy numbers [34]. In this study, linear z, pi, triangular, and linear s membership functions have been used. The mathematical definitions of these membership functions are shown below.

Linear Z Membership Function: The linear Z membership function can be expressed as in equation (2) with two variables n and b [35]. Figure 1 shows the linear Z membership function.

$$\mu(\boldsymbol{x}) = \mu A(x; n, b) = \begin{cases} 1, & if\ x < n \\ \dfrac{n-x}{n-b}, & if\ n \le x \le b \\ 0, & if\ x > b \end{cases} \tag{2}$$

Triangular Membership Function: A triangular fuzzy number can be expressed with three variables a_1, a_2, and a_3 as in equation (3) [36]. Figure 2 shows the triangular membership function.

$$\mu_{\hat{A}} = \begin{cases} \dfrac{x-a_1}{a_2-a_1}, & if\ a_1 \le x \le a_3 \\ \dfrac{x-a_2}{a_3-a_2}, & if\ a_2 \le x \le a_3 \\ 0\ , & if\ x < a_1 veya\ x > a_3 \end{cases} \tag{3}$$

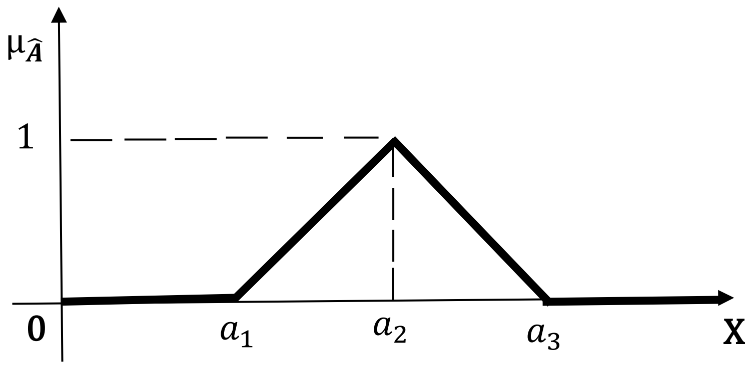

Figure 2. Triangular membership function (Guttorp, 1990).

Pi Membership Function: The fuzzy number Pi can be expressed with variables a, b, c, and d as in equation (4) [37]. Figure 3 shows the pi membership function for a=2, b=4, c=6, d=8.

$$\mu X = \begin{cases} 0 & , & if\ x \le a\ veya\ x \ge d \\ 2\left(\dfrac{x-a}{b-a}\right)^2 & , & if\ a \le x \le \dfrac{a+b}{2} \\ 1-2\left(\dfrac{x-b}{b-a}\right)^2 & , & if\ \dfrac{a+b}{2} \le x \le b \\ 1 & , & if\ b \le x \le c \\ 1-2\left(\dfrac{x-c}{d-c}\right)^2 & , & if\ c \le x \le \dfrac{c+d}{2} \\ 2\left(\dfrac{x-d}{d-c}\right)^2 & , & if\ \dfrac{c+d}{2} \le x \le d \end{cases} \tag{4}$$

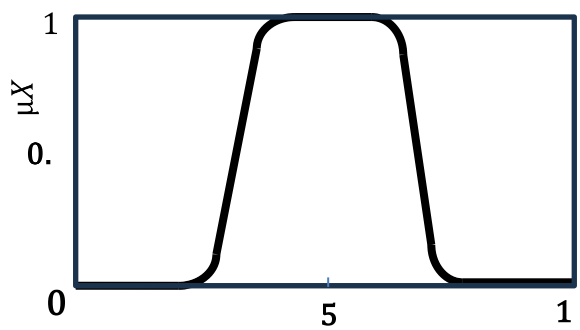

Figure 3. Pi membership function

Linear S Membership Function: The linear s membership function can be expressed with two variables a and m as in equation 5 [35]. Figure 4 shows the Linear s membership function.

$$\mu A(x) = \mu A(x; a, m) = \begin{cases} 0, & eğer\ x < a \\ \dfrac{x-a}{m-a}, & eğer\ a \le x \le m \\ 1, & eğer\ x > m \end{cases} \quad (5)$$

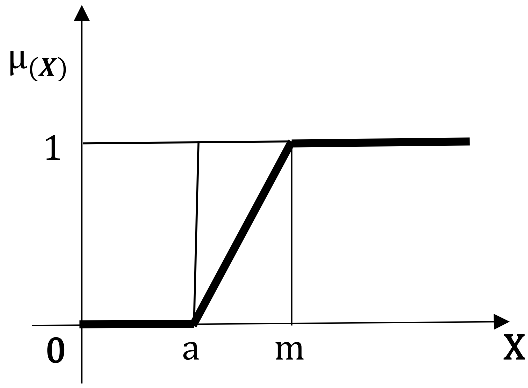

Figure 4. Linear S membership function [35].

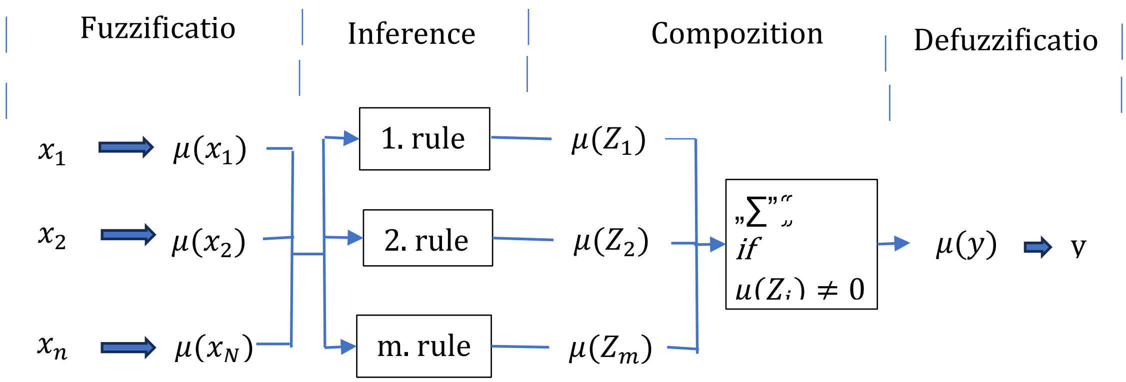

Figure 5. Fuzzy logic decision process [35]

3.3. Fuzzy Inference System

Fuzzy logic-based systems are a combination of four sub-processes: fuzzification, inference, aggregation, and defuzzification. The system uses several rules simultaneously in these processes. Figure 5 illustrates the operational stages of a fuzzy inference system [38].

In a fuzzy-based system, the first stage of the decision process is fuzzification, where the membership degrees of each input value, such as $x_1, x_2, \ldots x_n$, are calculated over fuzzy sets, denoted as $\mu(x_1)$, $\mu(x_2)$, … $\mu(x_n)$, thus completing the fuzzification process. In the second stage of the process, the system calculates the degree of truth (triggering power of the rule) for each membership degree expressed as; $\mu(x_1)$, $\mu(x_2)$, … $\mu(x_n)$ according to each rule in the rule base. The triggering power of each rule by the membership degrees is represented as $\mu(z_1)$, $\mu(z_2)$, … $\mu(z_n)$. In the third stage, the system aggregates the fuzzy set outputs; $\mu(z_1)$, $\mu(z_2)$, … $\mu(z_n)$ based on the principle of union (aggregation), hence the output of the third stage is not a clear value but a set of values. In the final stage, the defuzzification process is performed to obtain a crisp (precise) numerical value [38]. Among the fuzzy inference system (FIS) types, Mamdani and Sugeno, Mamdani is one of the first fuzzy control systems in the literature and is one of the most widely used inference systems [19].

IV. IMPLEMENTATION

In this study, risk analysis was conducted as part of the risk assessment process. A public institution in Istanbul, conducting office activities, was selected for the risk analysis. The workplace building consists of eight floors, including a basement and an attic. Additionally, there is a two-story annex building that houses a cafeteria and conference hall integrated with the main building. The workplace is situated within a large garden, featuring parking and green areas, located between a major public hospital and a university campus. Approximately 200 employees work at the site. Interviews with employees revealed that each worker receives an average of 10 visitors daily, leading to an estimate of around 2000 people visiting the office building daily for services. In Turkey, workplaces are classified into three hazard categories—less hazardous, hazardous, and highly hazardous—according to the "Workplace Hazard Classes Notification" published by the Ministry of Labor. Workplaces operating in the office, insurance, and banking sectors are considered less hazardous; however, especially in large offices, risks such as elevator accidents, slips and falls, and electrical shocks among employees are present, which can lead to injuries and even deaths, similar to those in highly hazardous workplaces. Therefore, like in other workplaces, risk analysis in office workplaces must be conducted with precision.

4.1. Fuzzy Pattern Design

The fuzzy model design was carried out using the fuzzy logic toolbox of the MATLAB program. The general view of the system is shown in Figure 6. In Figure 6, the input represents the entry point of the system; in this study, three inputs have been defined, one each for the parameters of severity, frequency, and probability. The output is the exit point of the system; in this study, one output has been defined to represent the Risk Priority Number (RPN). The "Mamdani Inference System" was used as the inference system in the design of the fuzzy model. For the Mamdani inference method, the operators selected are "min" for the and method, "max" for the Or method, "min" for Implication, "max" for Aggregation, and "centroid" for Defuzzification.

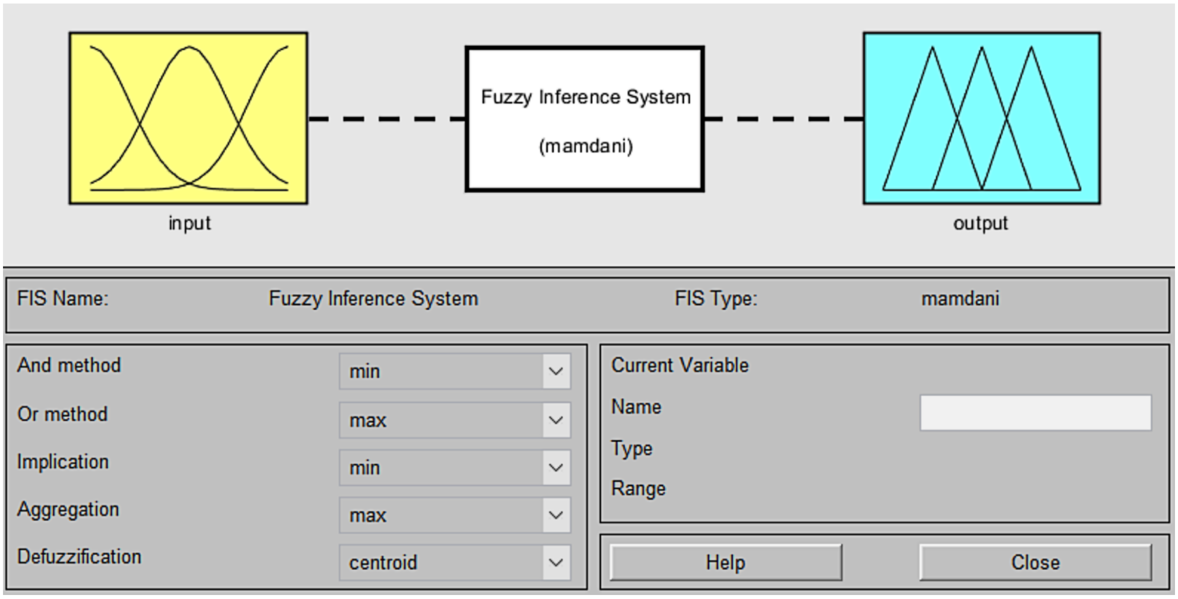

Figure 6. Fuzzy model overview

Table 3. First fuzzy model membership functions

Parameter	*Scale of Parameter*	*Label Given to the Function*	*Membership Function*
Probability	**Almost Impossible**	AI	zmf [0 0.2]
	Practically Impossible	PI	pimf [0.1 0.2 0.4 0.5]
	Extremely Remote	ER	pimf [0.4 0.5 0.9 1]
	Remotely Possible	RP	pimf [0.9 1 2.9 3]
	Unusual	U	pimf [2.9 3 5.9 6]
	Quite Possible	QP	pimf [5.9 6 9.9 10]
	Most Likely	ML	smf [9.9 10]
Frequency	Very Rarely	VR	zmf [0.5 1]
	Rarely	R	pimf [0.5 1 1.5 2]
	Unusually	U	pimf [1.5 2 2.5 3]
	Occasionally	O	pimf [2.5 3 5.5 6]
	Frequently	F	pimf [5.5 6 9.5 10]
	Continuously	C	smf [9.5 10]
Severity	**Minor Cuts**	MC	zmf [0 3]
	Disabling Injuries	DI	pimf [1 3 5 7]
	Extremely Serious	ES	pimf [5 7 13 15]
	Fatality	F	pimf [13 15 38 40]
	Multiple Fatalities	MF	pimf [38 40 98 100]
	Catastrophe	C	smf [98 100]
Risk Magnitude	Negligible Risk	NR	zmf [0 30]
	Minor Risk	MNR	pimf [0 30 60 90]
	Medium Risk	MDR	pimf [60 90 180 210]
	Major Risk	MJR	pimf [180 210 290 320]
	Critical	C	smf [290 720]

4.2. Rule Base

In the Mamdani inference system, each rule is defined as "if x is A, and if y is B, and … then z is C". The rule base was created in collaboration with an occupational safety specialist engineer. In the Fine-Kinney method, since the input parameters of severity, frequency, and probability can take 6, 6, and 7 different values respectively, a maximum of 6x6x7=252 rules can be defined. To ensure the evaluation of all combinations, all 252 rules have been defined in this study. The same rule base is used in both models; however, different membership functions have been selected.

4.3. First Fuzzy Model

In the first fuzzy model, linear z (linzmf), Pi (pimf), and linear s (linsmf) membership functions were used. Since the highest risk value in the Fine-Kinney analysis is 720, the system's output RPN value was set to 720. The membership functions for the parameters of the first fuzzy model, the labels given to the functions, and the values used in the membership functions are shown in Table 3.

In the designed first model, the graphical representations of the membership functions for the system's input parameters (probability, frequency, severity) and the output parameter RPN are shown in Figure 7, Figure 8, Figure 9, and Figure 10, respectively.

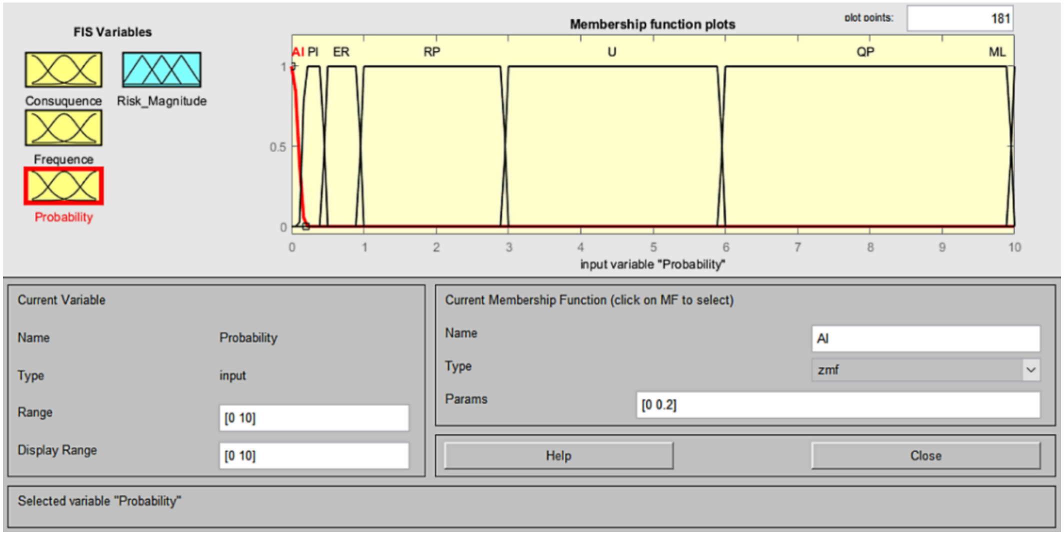

Figure 7. Probability membership functions in the first model

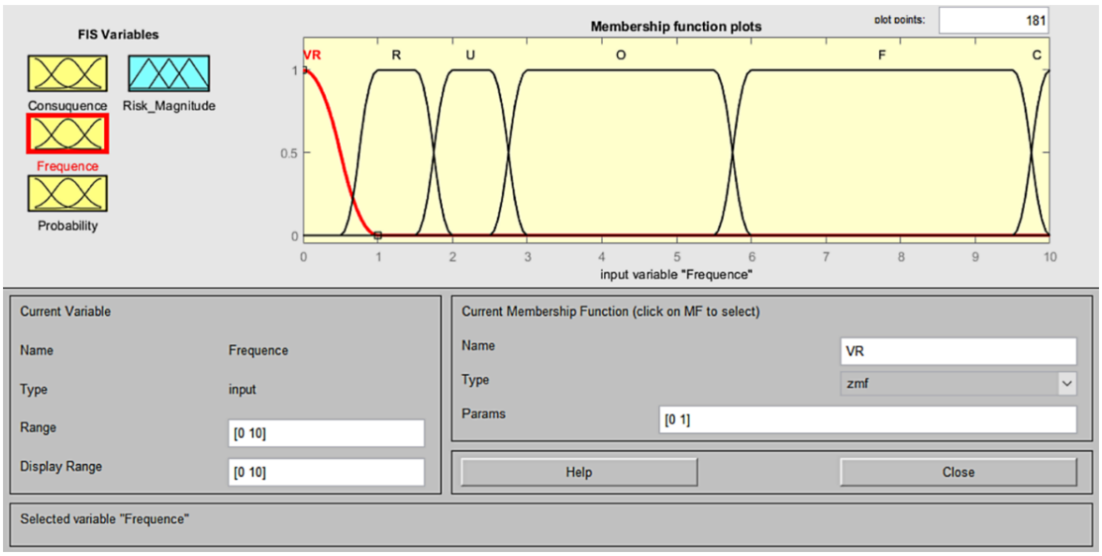

Figure 8. Frequency membership functions in the first model

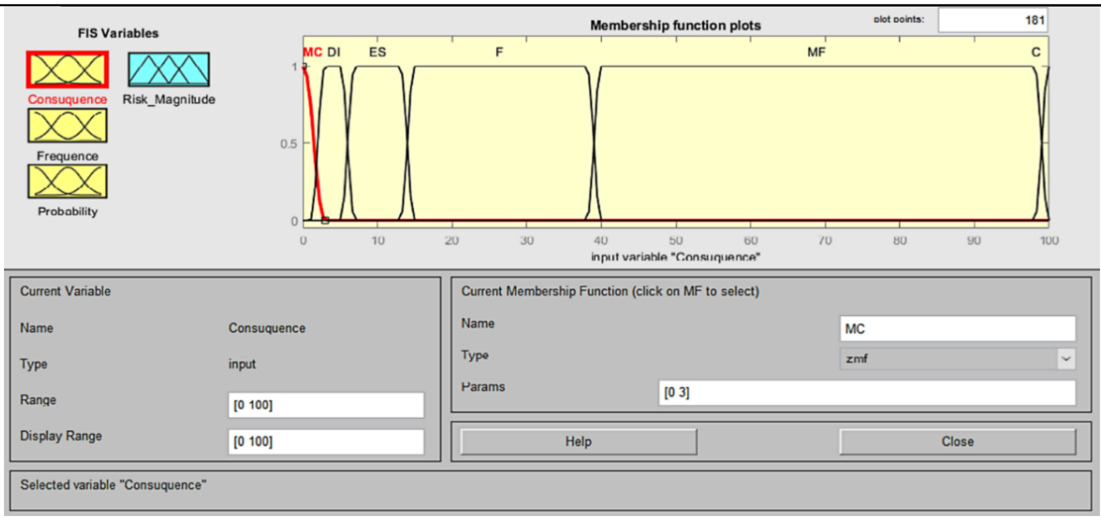

Figure 9. Severity membership functions in the first model

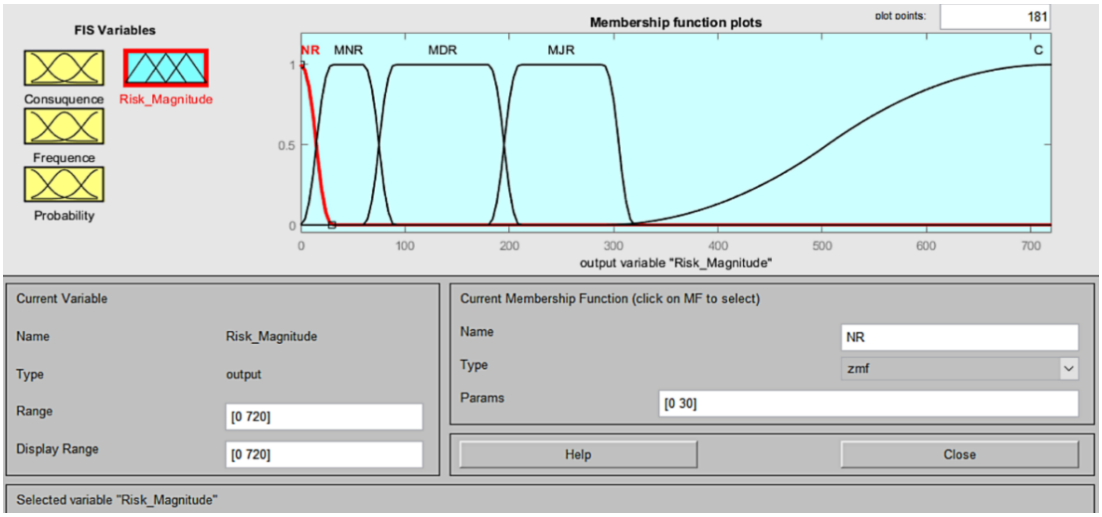

Figure 10. Risk magnitude membership functions in the first model

4.4. Second Fuzzy Model

In the second fuzzy model, linear z (linzmf), triangular (trimf), and linear s (linsmf) membership functions were used. Since the highest risk value in the Fine-Kinney analysis is 720, the range value for the system's output (RPN) was set to 720. The membership functions for the parameters of the first fuzzy model, the labels given to the functions, and the values used in the membership functions are shown in Table 4.

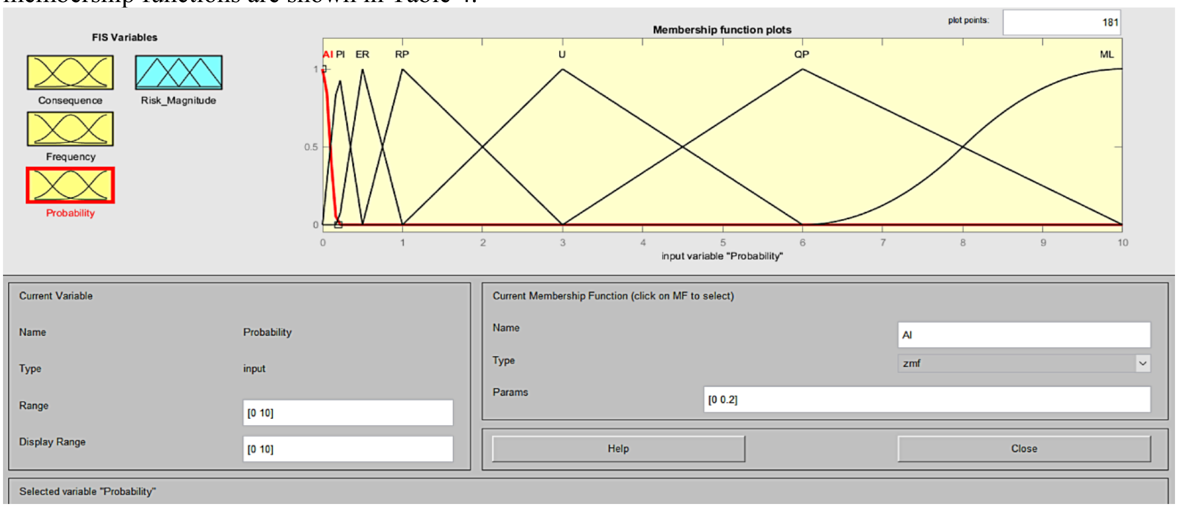

Figure 11. Probability membership functions in the second model

In the designed second model, the graphical representations of the membership functions for the system's input parameters (probability, frequency, severity) and the output parameter RPN are shown in Figure 11, Figure 12, Figure 13, and Figure 14, respectively.

Table 4. Second fuzzy model membership functions

Parameter	*Scale of Parameter*	*Label Given to the Function*	*Membership Function*
Probability	**Almost impossible**	AI	zmf [0 0.2]
	Practically impossible	PI	trimf [0.1 0.2 0.5]
	Extremely remote	ER	trimf [0.2 0.5 1]
	Remotely possible	RP	trimf [0.5 1 3]
	Unusual	U	trimf [1 3 6]
	Quite possible	QP	trimf [3 6 10]
	Most likely	ML	smf [6 10]
Frequency	Very rarely	VR	zmf [0 1]
	Rarely	R	trimf [0 1 2]
	Unusually	U	trimf [1 2 3]
	Occasionally	O	trimf [2 3 6]
	Frequently	F	trimf [3 6 10]
	Continuously	C	smf [6 10]
Severity	**Minor cuts**	MC	zmf [0 3]
	Disabling injuries	DI	trimf [0 3 7]
	Extremely serious	ES	trimf [3 7 15]
	Fatality	F	trimf [7 15 40]
	Multiple fatalities	MF	trimf [15 40 100]
	Catastrophe	C	smf [40 100]
Risk Magnitude	Negligible Risk	NR	zmf [0 70]
	Minor Risk	MNR	trimf [0 70 200]
	Medium Risk	MDR	trimf [70 200 300]
	Major Risk	MJR	trimf [200 300 400]
	Critical	C	smf [300 400]

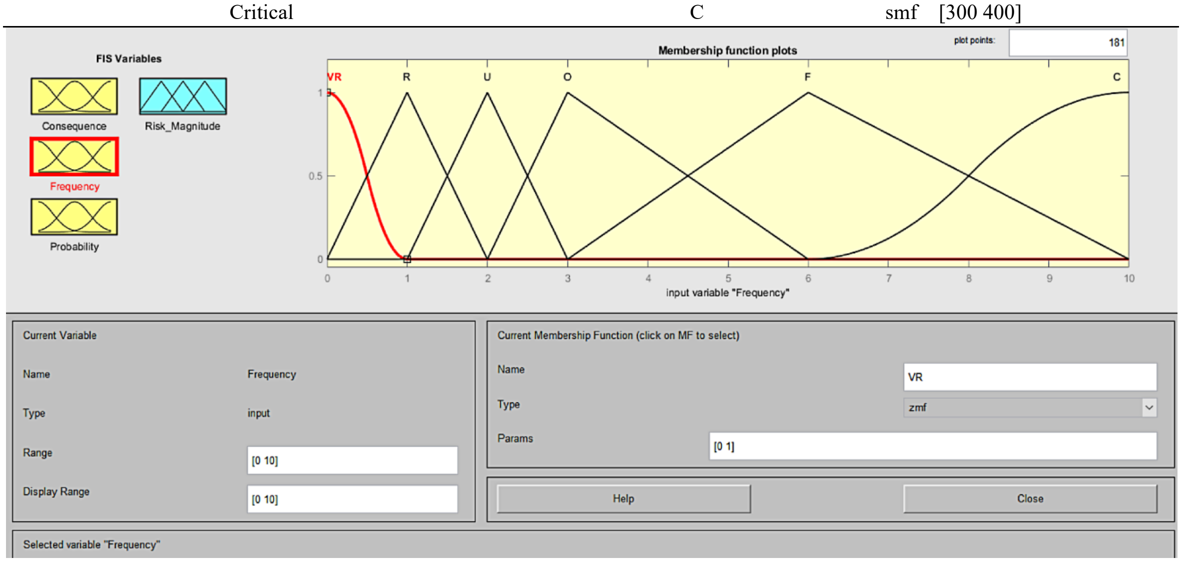

Figure 12. Frequency membership functions in the second model

4.5. Analysis in Matlab

The input parameters (probability, frequency, and severity) of the Fine-Kinney method were saved in an Excel file named parameters. The designed fuzzy models were digitally named and saved as the first model and the second model. To perform the fuzzy analyses, the Excel file named inputs parameters containing the input parameters was first imported into the MATLAB screen. Then, fuzzy analysis results were obtained by entering the following code snippet into the command line. The code below uses the fuzzy model named the first model in the analysis. To use the second model in the analysis, the same steps are followed, and only the first model needs to be replaced with the second model. The blue parts starting with // on the right side of the code snippet are not part of the code but are merely explanatory. input=parameters; // It defines the file named parameters as input to Matlab fis=readfis('first_model');// Selects the model to be used (first model or second model) output = evalfis(fis , input)// Evaluates inputs with the selected model

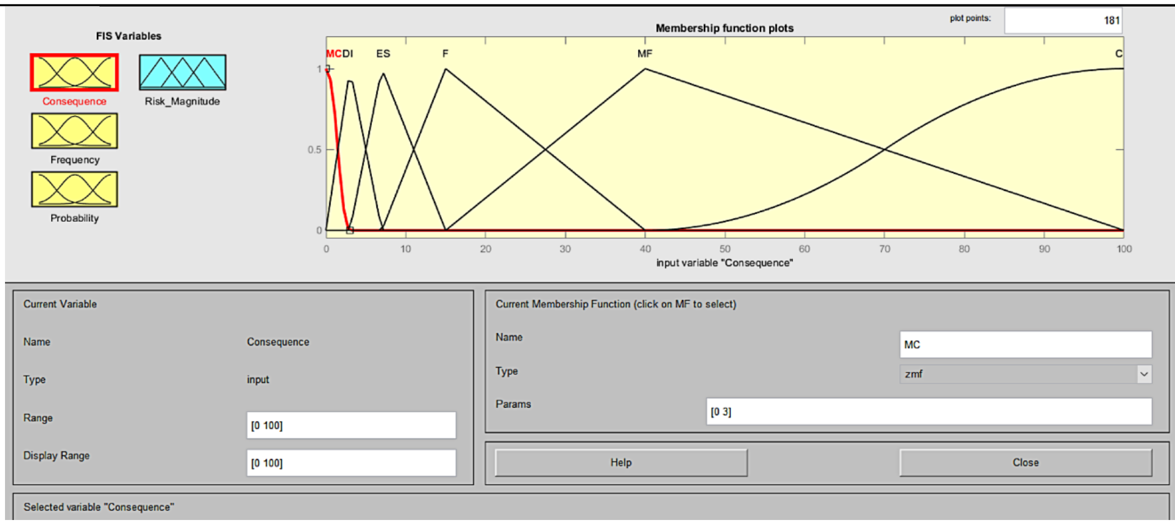

Figure 13. Severity membership functions in the second model

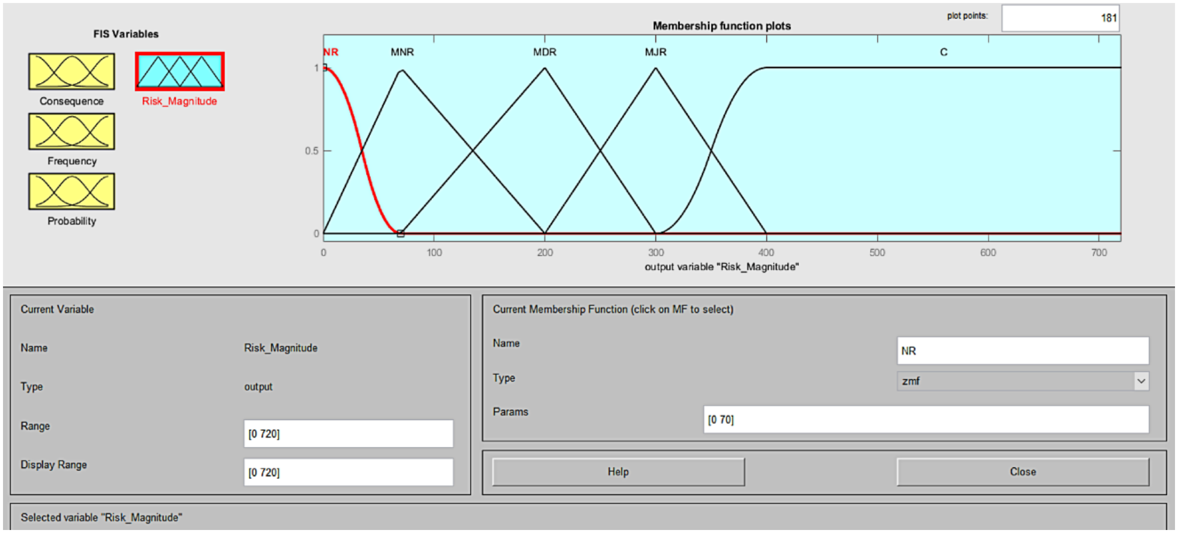

Figure 14. Risk magnitude membership functions in the second model

V. RESULTS

The RM and RPN levels obtained from the analyses for Fine-Kinney and fuzzy Fine-Kinney are comparatively shown in Table 7 attached below. In Table 7, hazard sources are named from H1 to H330, and the probability parameter is abbreviated as P, the frequency parameter as F, and the severity parameter as C. In Table 7, the risk levels vary between 1 and 5. Level 1 is assigned a light green color, level 3 an orange color, and level 5 a dark red color. Levels 2 and 4 are intermediate values, represented by shades of the mentioned colors (a green-orange shade for level 2 and an orange-red shade for level 4).

5.1. Fine-Kinney Analysis

In the analysis conducted with the Fine-Kinney method, risk levels were distributed between 1 and 5. The analysis observed all risk levels from "acceptable risk" to "very high risk".

Table 5. Numerical distribution of risks to levels in Fine-Kinney analysis

Risk Level	Risk Class	Risk Number
1	Acceptable risk	102
2	Possible risk	87
3	Significant risk	49
4	High risk	49
5	Very high risk	43

Most of the level 5 risks arise from electrical hazards. These risks are followed by those related to elevators, ergonomics, lifting loads, and personnel service vehicles, respectively. Table 5 shows the numerical distribution of **risk levels** according to the Fine-Kinney method analysis.

5.2. First Fuzzy Model Analysis

In the analysis conducted with the first fuzzy model, risk levels were distributed between 1 and 5. The analysis observed all risk levels from "acceptable risk" to "very high risk". Most of the level 5 risks arise from electrical hazards. In this analysis, other risks contributing to the density at level 5 were identified as elevator, ergonomics, lifting loads, and personnel service vehicle-related risks, in order.

When the risks evaluated by the Fine-Kinney Method were assessed using the first fuzzy model, it was observed that the level of 76 out of 330 risks (approximately 23%) changed. Risks with at least three levels of change include: The risk of electric shock in elevator number H97 rose from level 1 to level 5. The risk associated with elevator number H98 stopping before reaching the floor and the intervention by individuals who have not received the relevant training dropped from level 5 to level 2. The risk due to insufficient cabin lighting in elevator number H102 rose from level 1 to level 4. The risk of electric shock in the machine room of elevator number H107 dropped from level 5 to level 1. The risk of personnel from authorized companies maintaining elevator number H113 not using appropriate personal protective equipment dropped from level 5 to level 2.

5.3. Second Fuzzy Model Analysis

In the analysis conducted with the second fuzzy model, risk levels were distributed between 1 and 5. The analysis observed all risk levels from "acceptable risk" to "very high risk". A significant portion of the level 5 risks were due to electrical hazards. In this analysis, other predominant risks at level 5 were identified as those related to the boiler room, elevators, ergonomics, and lifting loads, in order.

When the risks evaluated by the Fine-Kinney Method were assessed using the second fuzzy model, it was observed that the level of 196 out of 330 risks (approximately 59%) changed. The risk of electric shock in elevator number H97 rose from level 1 to level 5. The risk due to insufficient cabin lighting in elevator number H102 rose from level 1 to level 4. The risk of electric shock in the machine room of elevator number H107 dropped from level 5 to level 2.

5.4. Comparison of Analysis

a) It is observed that all three analyses can differentiate risk levels up to the maximum level of 5. From this perspective, it can be said that all three analyses are successful in risk assessment.

b) In the analyses conducted with fuzzy models, it has been observed that the level of some risks identified in the Fine-Kinney analysis increased by 2, 3, or even 4 levels. For example, the risk of electric shock in elevator H97, calculated as level 1 in the Fine-Kinney analysis, was assessed as level 5 in the fuzzy models, moving from an acceptable risk level to a very high-risk level, thereby increasing the urgency for taking control measures for risk H97. Other significant changes from the Fine-Kinney method to fuzzy models include the following: The risk of panic, tripping, falling, and injury due to insufficient lighting in elevator cabin H102 increased from level 1 to level 4. The risk of falling into the elevator shaft, being severely injured, or dying due to the opening of floor and cabin doors of elevator H105 before reaching the floor rose from level 2 to level 4. The risk of overheating, malfunction, fire, and material damage due to inadequate ventilation of the elevator machine room H112 increased from level 3 to level 5. Meanwhile, the levels of some risks decreased. For instance, the risks of workplace accidents, injuries, material damage, and death due to untrained persons intervening in stopped elevator H98 and the risks of workplace accidents, electric shock, falling into the elevator shaft, severe injury, and death due to personnel of authorized companies maintaining elevator H113 not using appropriate personal protective equipment dropped from level 5 to level 2 according to the first fuzzy model, and to level 3 according to the second fuzzy model. The risk of electric shock in the machine room of elevator H107 decreased from level 5 to level 1 according to the first fuzzy model, and to level 2 according to the second fuzzy model.

c) Fuzzy models are observed to be more successful than the Fine-Kinney method because they can prevent the possibility of having the same risk levels in different combinations of Fine-Kinney parameters for risks that may have different levels of importance depending on the nature of the workplace. For example, the risk scores for hazards H158, H172, H185, H209, H245, and H280 were calculated with different combinations of probability, frequency, and severity values, resulting in an RPN value of $R=0.5x1x3=1.5$, and these risks were assessed as level 1 risks; however, in the analysis with the second fuzzy model, the risk of neglecting cleanliness and hygiene rules during food production H185 rose to level 2, differentiating it from the other risks.

d) Fuzzy models are considered to be more successful than the Fine-Kinney method because they make subjective evaluations, which can lead to quite different results depending on the experience and opinions of the analyst, are more objective, and allow for more realistic results.

e) The impact of the input parameters on the risk score (RPN) in the designed fuzzy models is shown below in two and three dimensions; on the left for the first fuzzy model, and on the right for the second fuzzy model. In the graphs, the median value of the parameter not shown is used; for example, in Figure 15-26, while plotting the impact of the probability parameter on the RPN, the severity parameter is set to a value of 50, and the frequency parameter to a value of 5, as shown in the Ref Input box, considering these values as references.

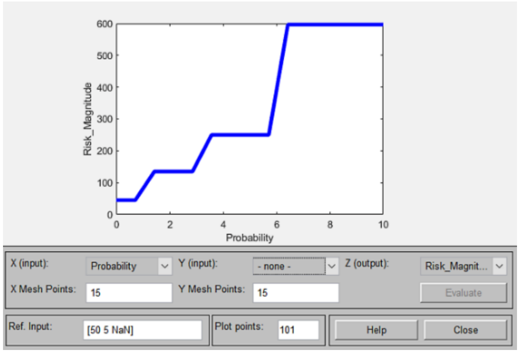

Figure 15. The effect of probability on risk magnitude at First Fuzzy Model

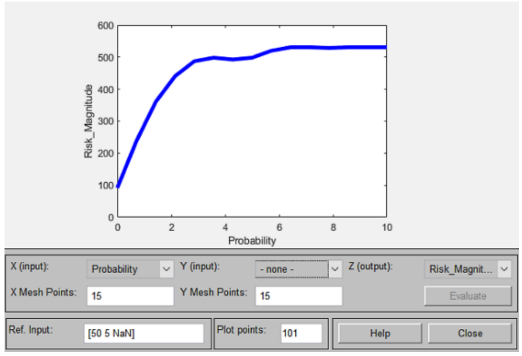

Figure 16. The effect of probability on risk magnitude at Second Fuzzy Model

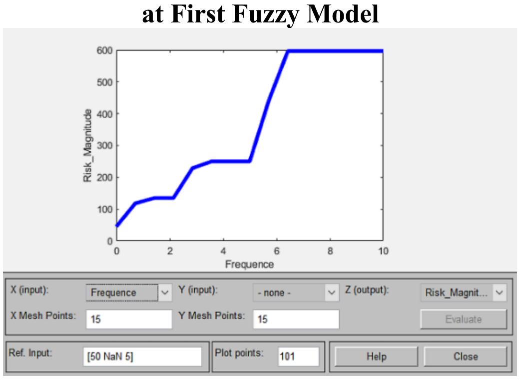

Figure 17. Effect of frequency on risk magnitude at First Fuzzy Model

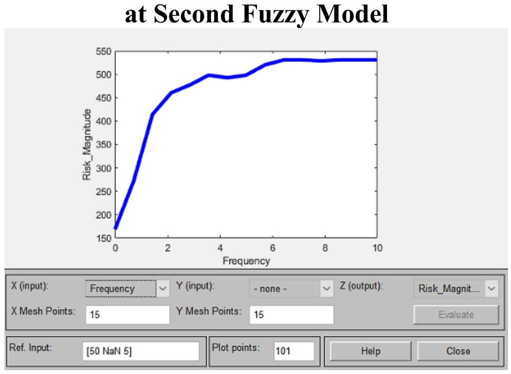

Figure 18. Effect of frequency on risk magnitude at Second Fuzzy Model

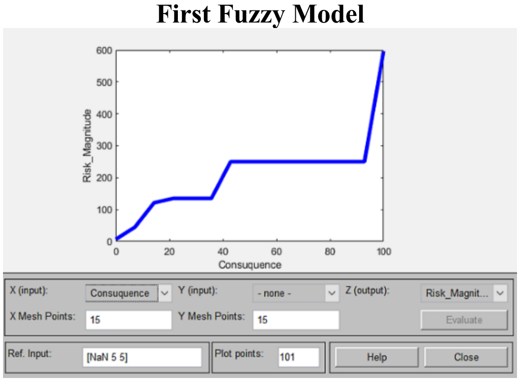

Figure 19. The effect of violence on risk magnitude at First Fuzzy Model

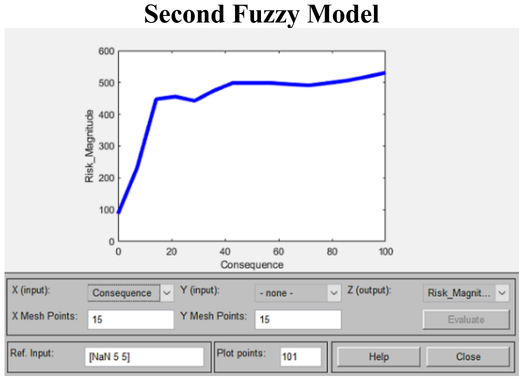

Figure 20. The effect of violence on risk magnitude at Second Fuzzy Model

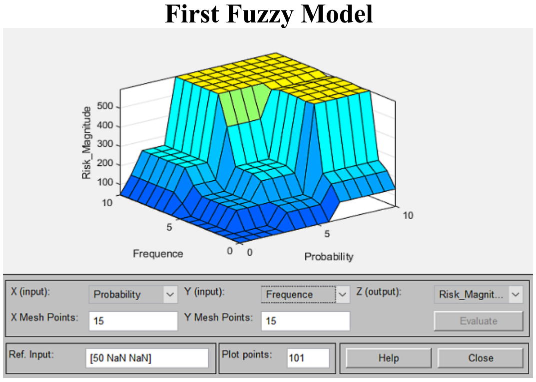

Figure 21. Variation of risk magnitude according to probability and frequency at First Fuzzy Model

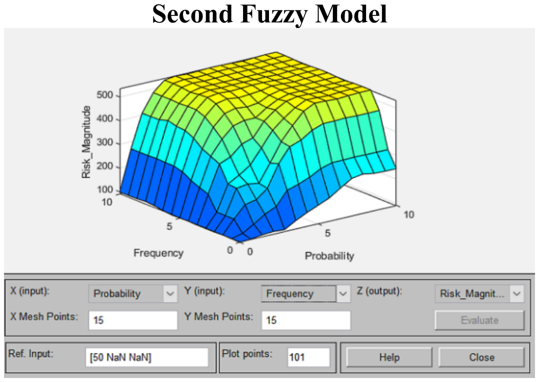

Figure 22. Variation of risk magnitude according to probability and frequency at the Second Fuzzy Model

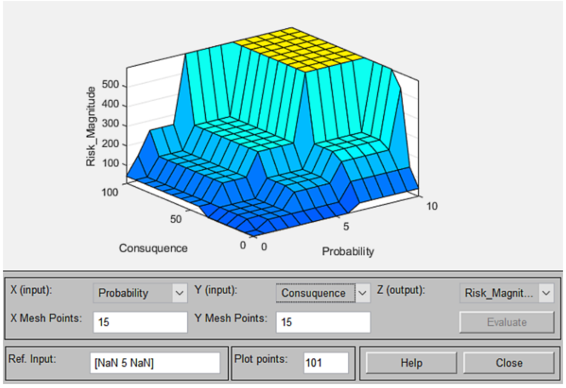

Figure 23. Variation of risk magnitude according to probability and severity at the First Fuzzy Model

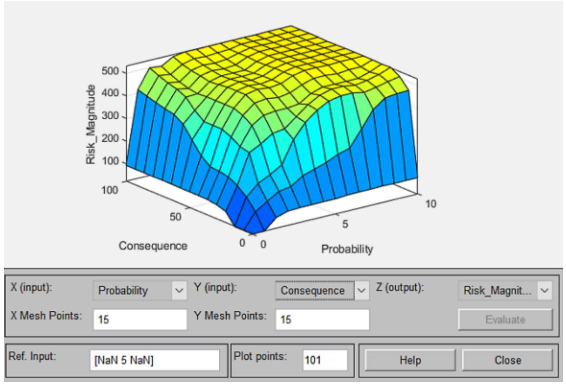

Figure 24. Variation of risk magnitude according to probability and severity at the Second Fuzzy Model

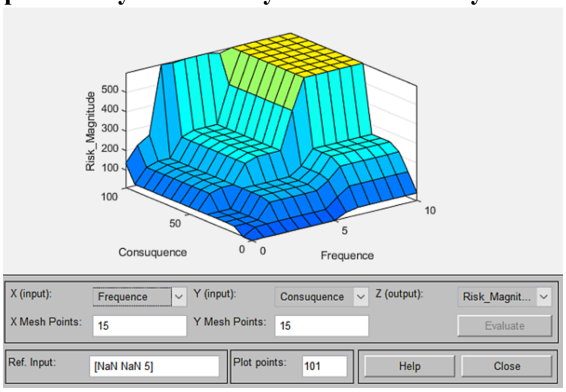

Figure 25. Variation of risk magnitude according to frequency and severity at First Fuzzy Model

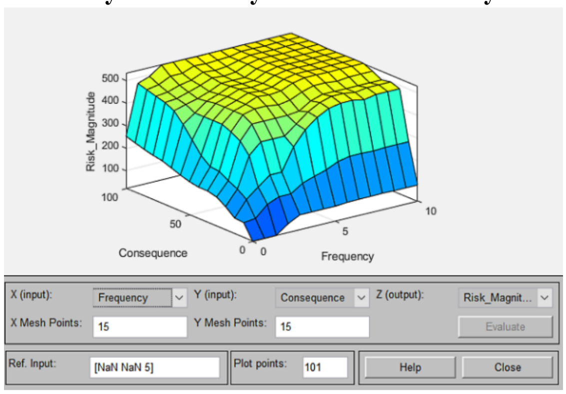

Figure 26. Variation of risk magnitude according to frequency and severity at Second Fuzzy Model

Upon examining the graphs representing the characteristics of the fuzzy models, it is observed that the first fuzzy model (on the left) has sharp transitions, whereas the transitions in the second fuzzy model (on the right) are smoother. This situation is related to the selection of membership functions and threshold values; it has been observed, as seen in Table 6 and Figure 27, resulted in a concentration of risk distribution at the medium level (level 3) and a more balanced distribution of risks across other levels in the second fuzzy model. This distribution is common and realistic; in this respect, the second fuzzy model has produced more successful results than both the Fine-Kinney method and the first fuzzy model.

In natural processes, it is a normal result that the number of 'medium level' situations is higher than the number of 'low level' and 'high level' situations. Therefore, it is an expected result that the risks are concentrated at the medium level in the analysis made with the second fuzzy model. In addition, this result can be considered as a strong sign of the closeness of the analysis made with the second fuzzy model to reality. The reason for reaching this result is that the triangular membership functions used to represent the intermediate levels of the second fuzzy model cover most of the input values of the system as subsets and trigger the triangular membership functions to which these subsets belong, thus affecting the output of the system mostly in favor of the intermediate levels. As a result, the second fuzzy model evaluates most of the risks as medium risk. In contrast, in the first fuzzy model, Pi membership functions were used to represent medium-level risks. The use of Pi Membership Function in fuzzy model design involves some difficulties, namely, Pi membership function is defined with the help of 4 variables, such as a, b, c, and d. These variables determine the boundaries of the right, left, and middle openings. Therefore, it is possible to talk about 3 relationships between the variables. A value assigned to one of the variables will also determine the relationship of this variable with other variables. Although it is possible to determine these relationships, as the number of membership functions used in the system design increases, the operations become longer and more puzzling, and the convenience provided by fuzzy logic loses its importance. However, the Triangle Membership Function can be defined with the help of 3 variables, such as a, b, c. There are only right and left openings here, this shows that it will be sufficient to determine only 2 relationships between the variables. It is easier to determine 2 relations instead of 3; the main reason why the second fuzzy model created using the triangular membership function produces more successful results is this convenience. This situation is because fuzzy logic is closer to human thought and language than classical logic. In the first fuzzy model, although the Pi Membership Functions represent fuzzy sets, they are designed with the design difficulties mentioned above; however, this design has a structure similar to crisp sets as seen in the graphs between Figure 7 and Figure 10; therefore, in the analysis made with the first fuzzy model, relatively similar results were obtained with the classical Fine-Kinney analysis. In the second fuzzy model, the Triangular Membership Functions are easily designed to represent fuzzy sets without the difficulties mentioned above.

Table 6. Comparison of the numerical distribution of risk levels according to the analysis

	Number of risks		
Risk Level	Fine-Kinney	First fuzzy model	Second fuzzy model
1	102	74	36
2	87	115	35
3	49	66	171
4	49	38	47
5	43	37	41

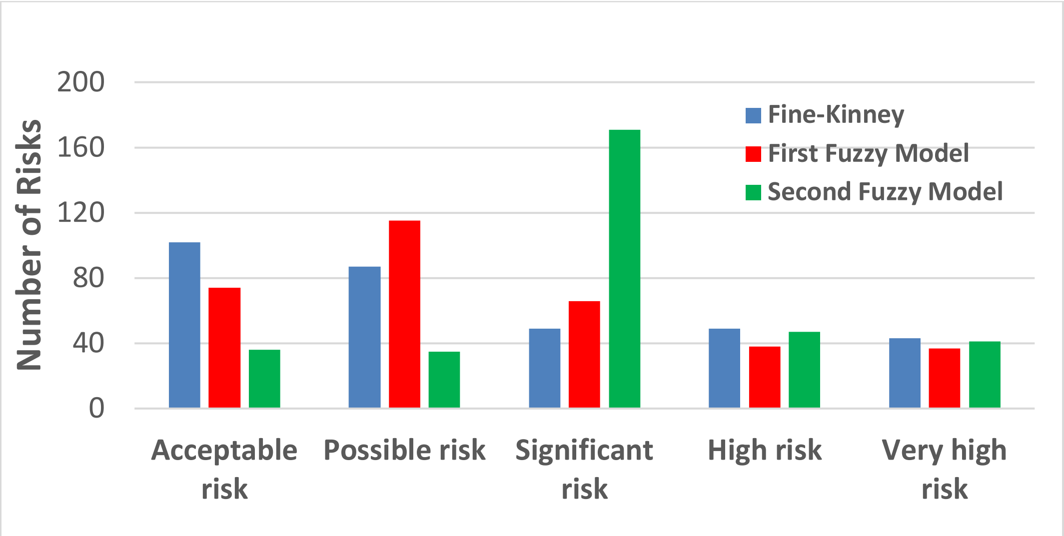

Figure 27. Numerical distribution of risks to levels in analysis

VI. CONCLUSIONS

In this study, an occupational health and safety risk analysis was conducted at a public institution's office engaged in office activities in Istanbul. The analysis found that, similar to construction, mining, shipyard, and other industrial facilities, office workplaces also contain numerous very high-risk (level 5) elements, primarily arising from electrical issues, elevators, boiler rooms, ergonomic incompatibilities, lifting activities, and personnel service vehicles. Level 5 risks require immediate action. Risks due to ergonomic issues can be mitigated over a longer term, but other level 5 risks need urgent measures to be addressed. The study also performed an occupational health and safety risk analysis for office workplaces using the Fine-Kinney method. One of the disadvantages of the Fine-Kinney method, the issue of obtaining quite different (subjective) risk scores depending on the assessor's experience and opinion, was addressed by fuzzifying the method's parameters. Another disadvantage is the possibility of obtaining the same risk score with different combinations of probability, frequency, and severity parameters; this second issue was tackled by creating a rule base that attributed different levels of importance to the parameters. Furthermore, in fuzzy models, the rule base allowed for the reflection of workplace characteristics in the results, considering the relationships between parameters.

It has been shown that fuzzy models based on Fine-Kinney, with a systematically constructed rule base (where the output parameter value increases or at least remains constant in response to increasing values of input parameters) and appropriately selected types and middle-boundary values of membership functions, provide more realistic results than the Fine-Kinney method and can be successfully used in office workplaces. Moreover, the type of membership functions used in fuzzy models and the selection of values assigned to these functions are crucial; this selection should be made based on the scale of the method to be used and the characteristics of the workplace, as evidenced by the better performance of the second fuzzy model compared to the first.

In the literature, there has been no detailed study on the selection of the type of membership functions and the assignment of boundary and middle values for fuzzy risk assessment based on Fine-Kinney. There is a perceived need for further research in this area. Additionally, in subsequent studies in office workplaces, fuzzy logic modeling could be employed to prioritize control measures based on criteria such as feasibility, and benefit/cost analysis.

Authors' Contributions
In this study, authors contributed equally to the study.

Competing Interests
The authors declare that they have no conflict of interest. The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission

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Additional

Table 7: Analysis Results

Hazard	Input Parameters			Fine-Kinney		First Fuzzy Model		Second Fuzzy Model		Hazard	Input Parameters			Fine-Kinney		First Fuzzy Model		Second Fuzzy Model	
No	P	F	C	RM	RPN	RM	RPN	RM	RPN	No	P	F	C	RM	RPN	RM	RPN	RM	RPN
H1	3	6	40	720	5	597	5	536	5	H214	0.5	6	15	45	2	45	2	90	3
H68	3	6	40	720	5	597	5	536	5	H251	6	0.5	15	45	2	45	2	147	3
H69	3	6	40	720	5	597	5	536	5	H289	6	0.5	15	45	2	45	2	147	3
H70	3	6	40	720	5	597	5	536	5	H290	6	0.5	15	45	2	45	2	147	3
H74	3	6	40	720	5	597	5	536	5	H298	6	0.5	15	45	2	45	2	147	3
H75	3	6	40	720	5	597	5	536	5	H270	1	6	7	42	2	45	2	90	3
H77	3	6	40	720	5	597	5	536	5	H91	0.5	2	40	40	2	45	2	90	3
H82	3	6	40	720	5	597	5	536	5	H41	6	6	1	36	2	45	2	129	3
H88	6	3	40	720	5	597	5	536	5	H266	6	6	1	36	2	45	2	129	3
H93	3	6	40	720	5	597	5	536	5	H13	0.5	10	7	35	2	45	2	90	3
H94	3	6	40	720	5	597	5	536	5	H26	0.5	10	7	35	2	45	2	90	3
H98	6	3	40	720	5	45	2	93	3	H173	0.5	10	7	35	2	45	2	90	3
H107	3	6	40	720	5	9	1	22	2	H234	10	0.5	7	35	2	45	2	147	3
H117	3	6	40	720	5	597	5	536	5	H159	10	3	1	30	2	45	2	129	3
H130	3	6	40	720	5	597	5	536	5	H190	1	2	15	30	2	45	2	90	3
H228	10	10	7	700	5	597	5	536	5	H194	1	2	15	30	2	45	2	90	3
H232	10	10	7	700	5	597	5	536	5	H195	1	2	15	30	2	45	2	90	3
H233	10	10	7	700	5	597	5	536	5	H196	1	2	15	30	2	45	2	90	3
H96	6	1	100	600	5	597	5	536	5	H197	1	2	15	30	2	45	2	90	3
H120	6	1	100	600	5	597	5	536	5	H203	1	2	15	30	2	45	2	90	3
H121	6	1	100	600	5	597	5	536	5	H217	3	10	1	30	2	45	2	129	3
H161	3	2	100	600	5	597	5	536	5	H225	10	3	1	30	2	45	2	129	3
H325	3	2	100	600	5	597	5	536	5	H246	1	10	3	30	2	135	3	190	3
H326	3	2	100	600	5	597	5	536	5	H250	1	2	15	30	2	45	2	90	3
H329	3	2	100	600	5	597	5	536	5	H150	3	3	3	27	2	45	2	90	3
H59	6	6	15	540	5	597	5	536	5	H151	3	3	3	27	2	45	2	90	3
H236	6	6	15	540	5	597	5	536	5	H34	0.5	0.5	100	25	2	45	2	93	3
H238	6	6	15	540	5	597	5	536	5	H36	0.5	0.5	100	25	2	45	2	93	3
H255	6	6	15	540	5	597	5	536	5	H44	0.5	0.5	100	25	2	45	2	93	3
H256	6	6	15	540	5	597	5	536	5	H45	0.5	0.5	100	25	2	45	2	93	3
H86	0.5	10	100	500	5	597	5	536	5	H46	0.5	0.5	100	25	2	45	2	93	3
H104	0.5	10	100	500	5	135	3	190	3	H50	0.5	0.5	100	25	2	45	2	93	3
H113	6	2	40	480	5	45	2	90	3	H61	0.5	0.5	100	25	2	45	2	93	3
H17	3	10	15	450	5	250	4	300	4	H80	0.5	0.5	100	25	2	45	2	93	3
H43	3	10	15	450	5	250	4	300	4	H83	0.5	0.5	100	25	2	45	2	93	3
H100	3	10	15	450	5	597	5	536	5	H84	0.5	0.5	100	25	2	45	2	93	3
H254	10	3	15	450	5	597	5	536	5	H89	0.5	0.5	100	25	2	45	2	93	3
H230	6	10	7	420	5	250	4	300	4	H116	0.5	0.5	100	25	2	45	2	93	3
H258	6	10	7	420	5	250	4	300	4	H138	0.5	0.5	100	25	2	45	2	93	3
H71	1	10	40	400	5	250	4	300	4	H142	0.5	0.5	100	25	2	45	2	93	3
H73	1	10	40	400	5	250	4	300	4	H52	3	0.5	15	23	2	45	2	93	3
H95	1	10	40	400	5	250	4	300	4	H54	3	0.5	15	23	2	45	2	93	3
H127	10	1	40	400	5	250	4	300	4	H57	3	0.5	15	23	2	45	2	93	3
H76	3	3	40	360	4	597	5	536	5	H66	3	0.5	15	23	2	45	2	93	3
H294	3	3	40	360	4	250	4	300	4	H72	3	0.5	15	23	2	45	2	93	3
H295	3	3	40	360	4	250	4	300	4	H111	3	0.5	15	23	2	45	2	147	3
H296	3	3	40	360	4	250	4	300	4	H212	0.5	3	15	23	2	45	2	90	3
H27	6	0.5	100	300	4	250	4	474	5	H4	0.5	6	7	21	2	45	2	90	3
H31	6	0.5	100	300	4	250	4	474	5	H12	0.5	6	7	21	2	45	2	90	3
H115	3	1	100	300	4	250	4	300	4	H30	6	0.5	7	21	2	45	2	93	3
H125	3	1	100	300	4	250	4	300	4	H67	3	1	7	21	2	45	2	90	3
H126	6	0.5	100	300	4	250	4	474	5	H90	0.5	6	7	21	2	45	2	90	3
H131	3	1	100	300	4	597	5	536	5	H135	0.5	6	7	21	2	45	2	90	3
H132	6	0.5	100	300	4	250	4	474	5	H213	1	3	7	21	2	45	2	90	3
H137	0.5	6	100	300	4	250	4	300	4	H235	3	1	7	21	2	45	2	90	3
H162	6	0.5	100	300	4	597	5	536	5	H267	0.5	6	7	21	2	45	2	90	3
H199	10	2	15	300	4	250	4	300	4	H268	0.5	6	7	21	2	45	2	90	3
H313	0.5	6	100	300	4	250	4	300	4	H275	6	0.5	7	21	2	45	2	93	3
H314	0.5	6	100	300	4	250	4	300	4	H279	6	0.5	7	21	2	45	2	93	3
H315	0.5	6	100	300	4	250	4	300	4	H122	1	0.5	40	20	2	45	2	93	3
H328	3	1	100	300	4	250	4	300	4	H128	0.5	1	40	20	2	45	2	90	3
H20	3	6	15	270	4	250	4	300	4	H141	1	0.5	40	20	2	45	2	93	3
H109	3	6	15	270	4	597	5	536	5	H160	10	2	1	20	2	7	1	72	3
H134	3	6	15	270	4	250	4	300	4	H273	6	3	1	18	1	45	2	91	3
H193	6	3	15	270	4	250	4	300	4	H307	6	3	1	18	1	45	2	91	3
H210	3	6	15	270	4	250	4	300	4	H308	6	3	1	18	1	45	2	91	3
H241	3	6	15	270	4	250	4	300	4	H330	3	2	3	18	1	7	1	18	1
H252	6	3	15	270	4	250	4	300	4	H2	0.5	10	3	15	1	45	2	90	3
H253	6	3	15	270	4	250	4	300	4	H157	0.5	2	15	15	1	7	1	18	1
H287	6	3	15	270	4	250	4	300	4	H170	0.5	2	15	15	1	7	1	18	1
H260	6	6	7	252	4	250	4	300	4	H242	0.5	2	15	15	1	7	1	18	1
H262	6	6	7	252	4	250	4	300	4	H243	0.5	2	15	15	1	7	1	18	1
H311	6	6	7	252	4	250	4	300	4	H249	0.5	2	15	15	1	7	1	18	1
H324	3	2	40	240	4	135	3	190	3	H143	1	2	7	14	1	7	1	18	1
H25	3	10	7	210	4	135	3	190	3	H198	1	2	7	14	1	7	1	18	1
H224	10	3	7	210	4	135	3	190	3	H152	3	0.5	7	11	1	9	1	83	3
H237	3	10	7	210	4	135	3	190	3	H226	0.5	3	7	11	1	7	1	18	1

H239	3	10	7	210	4	135	3	190	3	H227	0.5	3	7	11	1	7	1	18	1
H282	10	3	7	210	4	135	3	190	3	H278	3	0.5	7	11	1	9	1	83	3
H283	3	10	7	210	4	135	3	190	3	H92	0.5	0.5	40	10	1	45	2	93	3
H14	0.5	10	40	200	4	135	3	190	3	H97	0.2	0.5	100	10	1	597	5	536	5
H19	0.5	10	40	200	4	135	3	190	3	H108	0.5	0.5	40	10	1	45	2	90	3
H23	0.5	10	40	200	4	135	3	190	3	H133	0.5	0.5	40	10	1	45	2	93	3
H78	10	0.5	40	200	4	135	3	238	4	H139	0.5	0.5	40	10	1	45	2	93	3
H79	0.5	10	40	200	4	135	3	190	3	H140	0.5	0.5	40	10	1	45	2	93	3
H85	0.5	10	40	200	4	135	3	190	3	H216	0.5	0.5	40	10	1	45	2	93	3
H136	10	0.5	40	200	4	135	3	238	4	H220	0.5	0.5	40	10	1	45	2	93	3
H297	1	2	100	200	4	250	4	300	4	H221	0.5	0.5	40	10	1	45	2	93	3
H299	0.5	10	40	200	4	135	3	190	3	H222	0.5	0.5	40	10	1	45	2	93	3
H304	10	0.5	40	200	4	135	3	238	4	H223	0.5	0.5	40	10	1	45	2	93	3
H305	10	0.5	40	200	4	135	3	238	4	H261	0.5	0.5	40	10	1	45	2	93	3
H306	10	0.5	40	200	4	135	3	238	4	H49	6	0.5	3	9	1	9	1	22	2
H301	6	2	15	180	3	250	4	300	4	H174	1	3	3	9	1	7	1	18	1
H35	3	0.5	100	150	3	135	3	238	4	H63	1	0.5	15	8	1	45	2	83	3
H37	3	0.5	100	150	3	135	3	238	4	H145	1	0.5	15	8	1	45	2	83	3
H55	3	0.5	100	150	3	135	3	238	4	H181	1	0.5	15	8	1	45	2	83	3
H56	3	0.5	100	150	3	135	3	238	4	H191	1	0.5	15	8	1	45	2	83	3
H112	1	10	15	150	3	597	5	536	5	H192	1	0.5	15	8	1	45	2	83	3
H155	1	10	15	150	3	135	3	190	3	H204	0.5	1	15	8	1	7	1	18	1
H319	0.5	3	100	150	3	135	3	190	3	H205	1	0.5	15	8	1	45	2	83	3
H322	3	0.5	100	150	3	135	3	238	4	H163	0.5	2	7	7	1	7	1	18	1
H323	3	0.5	100	150	3	135	3	238	4	H164	0.5	2	7	7	1	7	1	18	1
H284	3	3	15	135	3	135	3	190	3	H165	0.5	2	7	7	1	7	1	18	1
H285	3	3	15	135	3	135	3	190	3	H166	0.5	2	7	7	1	7	1	18	1
H286	3	3	15	135	3	135	3	190	3	H167	0.5	2	7	7	1	7	1	18	1
H276	6	3	7	126	3	135	3	190	3	H168	0.5	2	7	7	1	7	1	18	1
H302	3	6	7	126	3	135	3	190	3	H184	0.5	2	7	7	1	7	1	18	1
H310	3	6	7	126	3	135	3	190	3	H240	0.5	2	7	7	1	7	1	18	1
H28	3	1	40	120	3	135	3	190	3	H272	0.5	2	7	7	1	7	1	18	1
H42	0.5	6	40	120	3	135	3	190	3	H47	3	0.5	3	5	1	9	1	22	2
H53	3	1	40	120	3	135	3	190	3	H48	3	0.5	3	5	1	9	1	22	2
H81	0.5	6	40	120	3	135	3	190	3	H264	0.5	3	3	5	1	7	1	18	1
H110	3	1	40	120	3	45	2	93	3	H5	0.5	1	7	4	1	7	1	18	1
H124	3	1	40	120	3	135	3	190	3	H11	0.5	0.5	15	4	1	45	2	83	3
H129	0.5	6	40	120	3	135	3	190	3	H33	0.5	0.5	15	4	1	45	2	83	3
H292	6	0.5	40	120	3	135	3	238	4	H169	0.5	0.5	15	4	1	45	2	83	3
H293	6	0.5	40	120	3	135	3	238	4	H175	1	0.5	7	4	1	9	1	22	2
H316	0.5	2	100	100	3	135	3	190	3	H188	0.5	0.5	15	4	1	45	2	83	3
H9	1	6	15	90	3	135	3	190	3	H189	0.5	0.5	15	4	1	45	2	83	3
H10	6	1	15	90	3	135	3	190	3	H206	0.5	0.5	15	4	1	45	2	83	3
H16	3	10	3	90	3	135	3	190	3	H269	1	0.5	7	4	1	9	1	22	2
H18	3	10	3	90	3	135	3	190	3	H277	1	0.5	7	4	1	9	1	22	2
H99	3	10	3	90	3	45	2	93	3	H309	1	0.5	7	4	1	9	1	22	2
H101	10	3	3	90	3	45	2	90	3	H156	1	3	1	3	1	7	1	20	1
H171	3	2	15	90	3	135	3	190	3	H177	0.5	6	1	3	1	7	1	20	1
H215	3	2	15	90	3	135	3	190	3	H263	1	3	1	3	1	7	1	20	1
H218	6	1	15	90	3	135	3	190	3	H317	6	0.5	1	3	1	9	1	22	2
H219	6	1	15	90	3	135	3	190	3	H22	0.5	0.5	7	2	1	9	1	22	2
H257	1	6	15	90	3	135	3	190	3	H123	0.1	0.5	40	2	1	45	2	93	3
H312	1	6	15	90	3	135	3	190	3	H144	0.5	0.5	7	2	1	9	1	22	2
H321	3	2	15	90	3	135	3	190	3	H148	0.5	0.5	7	2	1	9	1	22	2
H327	1	6	15	90	3	135	3	190	3	H149	0.5	0.5	7	2	1	9	1	22	2
H200	6	2	7	84	3	135	3	190	3	H158	0.5	3	1	2	1	7	1	20	1
H281	6	2	7	84	3	135	3	190	3	H172	0.5	3	1	2	1	7	1	20	1
H60	0.5	10	15	75	3	45	2	90	3	H182	0.5	0.5	7	2	1	9	1	22	2
H146	10	0.5	15	75	3	135	3	188	3	H185	1	0.5	3	2	1	9	1	22	2
H147	10	0.5	15	75	3	135	3	188	3	H186	0.5	0.5	7	2	1	9	1	22	2
H179	10	0.5	15	75	3	135	3	188	3	H187	0.5	0.5	7	2	1	9	1	22	2
H180	10	0.5	15	75	3	135	3	188	3	H207	0.5	0.5	7	2	1	9	1	22	2
H3	1	10	7	70	3	135	3	190	3	H208	0.5	1	3	2	1	7	1	18	1
H274	1	10	7	70	3	135	3	190	3	H209	0.5	1	3	2	1	7	1	18	1
H259	3	3	7	63	2	45	2	90	3	H229	0.5	0.5	7	2	1	9	1	22	2
H87	3	0.5	40	60	2	45	2	147	3	H231	0.5	0.5	7	2	1	9	1	22	2
H103	10	2	3	60	2	135	3	190	3	H244	0.5	0.5	7	2	1	9	1	22	2
H105	3	0.5	40	60	2	250	4	300	4	H245	3	0.5	1	2	1	9	1	22	2
H114	0.5	3	40	60	2	135	3	190	3	H248	0.5	0.5	7	2	1	9	1	22	2
H300	3	0.5	40	60	2	45	2	147	3	H265	1	2	1	2	1	7	1	20	1
H303	3	0.5	40	60	2	45	2	147	3	H271	0.5	0.5	7	2	1	9	1	22	2
H51	1	0.5	100	50	2	45	2	147	3	H280	3	0.5	1	2	1	9	1	22	2
H106	0.5	1	100	50	2	135	3	190	3	H288	0.5	0.5	7	2	1	9	1	22	2
H118	1	0.5	100	50	2	45	2	147	3	H6	0.5	0.5	3	1	1	9	1	22	2
H119	0.5	1	100	50	2	45	2	90	3	H7	0.5	0.5	3	1	1	9	1	22	2
H320	0.5	1	100	50	2	45	2	90	3	H24	0.1	10	1	1	1	9	1	22	2
H8	1	3	15	45	2	45	2	90	3	H32	0.1	0.5	15	1	1	9	1	22	2
H15	0.5	6	15	45	2	45	2	90	3	H40	0.5	1	1	1	1	7	1	20	1
H29	6	0.5	15	45	2	45	2	147	3	H102	0.5	0.5	3	1	1	250	4	300	4
H38	6	0.5	15	45	2	45	2	147	3	H153	0.5	2	1	1	1	7	1	20	1
H39	6	0.5	15	45	2	45	2	147	3	H154	0.5	2	1	1	1	7	1	20	1
H58	0.5	6	15	45	2	45	2	90	3	H176	1	0.5	1	1	1	9	1	22	2
H62	6	0.5	15	45	2	45	2	147	3	H183	0.5	2	1	1	1	7	1	20	1

H64	6	0.5	15	45	2	45	2	147	3	H247	0.5	0.5	3	1	1	9	1	22	2
H178	6	0.5	15	45	2	45	2	147	3	H291	1	0.5	1	1	1	9	1	22	2
H201	6	0.5	15	45	2	45	2	147	3	H318	0.5	2	1	1	1	7	1	20	1
H202	6	0.5	15	45	2	45	2	147	3	H21	0.1	0.5	1	0	1	9	1	22	2
H211	1	3	15	45	2	45	2	90	3	H65	0.5	0.5	1	0	1	9	1	22	2