



Düzce University Journal of Science & Technology

Research Article



Workplace Safety Control and Risk Management in a Denim Factory Using the Fine Kinney Method

Zeynep ÖZMEN BOL ^{a,*}, Murat OK ^b

^a Department of Occupational Health and Safety, Gümüşova Vocational School, Düzce University, Düzce, TÜRKİYE

^b Department of Mechanical and Metal Technologies, Gümüşova Vocational School, Düzce University, Düzce, TÜRKİYE

* Corresponding author's e-mail address: muratok@düzce.edu.tr

DOI: 10.29130/dubited.1608749

ABSTRACT

This article presents a detailed risk assessment conducted in 2023 at a denim factory operating in the textile fiber and yarn bleaching and dyeing services sector with NACE code 13.30.02, located in Bartın, employing 400 workers. Using the Fine-Kinney method, hazards were analyzed in terms of likelihood, severity, and frequency, facilitating the prioritization of risks. The assessment identified a total of 20 risk sources. Prominent hazards included electric shock risks from exposed electrical cables, fire risks due to improper storage, and working-at-height risks arising from insufficient equipment. Most of these hazards were categorized as intolerable risks, and specific corrective actions were recommended for each. For instance, fire risks were mitigated by installing proper firefighting equipment, reorganizing storage areas, and enhancing safety measures for chemical storage. By the end of the study, preventive measures reduced the risks to acceptable levels, and the second risk analysis conducted in 2024 showed a significant improvement, with the accident frequency rate decreasing from 52.76 in 2023 to 28.26 in 2024. This article provides guidance on risk management for similar enterprises in the textile sector while highlighting the effectiveness of the Fine-Kinney method, offering a valuable contribution to the literature.

Keywords: Fine Kinney, Occupational health and safety, Textile industry, Risk management

Fine Kinney Yöntemi Kullanılarak Bir Denim Fabrikasında İşyeri Güvenliği Kontrolü ve Risk Yönetimi

ÖZ

Bu makale, Bartın'da 400 çalışanı bulunan ve 13.30.02 NACE koduyla tekstil elyaf ve ipliklerini ağartma ve boyama hizmetleri sektöründe faaliyet gösteren bir denim fabrikasında 2023 yılında gerçekleştirilen ayrıntılı bir risk değerlendirmesini sunmaktadır. Çalışmada, Fine-Kinney metodu kullanılarak tehlikeler olasılık, şiddet ve sıklık açısından analiz edilmiş ve bu yöntemle risklerin önceliklendirilmesi sağlanmıştır. Değerlendirme sonucunda toplam 20 risk kaynağı tespit edilmiştir. Belirlenen tehlikeler arasında açıkta bulunan elektrik kablolarından kaynaklanan elektrik çarpması, düzensiz depolama nedeniyle oluşabilecek yangın riskleri ve uygun ekipman eksikliğinden kaynaklanan yüksekte çalışma riskleri öne çıkmıştır. Bu tehlikelerin büyük bir kısmı tolerans gösterilemez riskler

kategorisine girerken, her biri için spesifik düzeltici faaliyetler önerilmiştir. Örneğin, yangın risklerini azaltmak için uygun yangın söndürme ekipmanları yerleştirilmiş, depolama alanları düzenlenmiş ve kimyasalların depolanmasına yönelik çalışma güvenliği artırılmıştır. Çalışmanın sonunda alınan önlemlerle 2024 yılında yapılan ikinci risk analizinde risklerin kabul edilebilir seviyelere indirildiği ve kaza sıklık oranının 2023 yılında 52.76 iken 2024 yılında 28.26'ya düşürüldüğü görülmüştür. Bu makale, tekstil sektöründeki benzer işletmelere risk yönetimi konusunda rehberlik ederken, Fine-Kinney yönteminin etkinliğini vurgulayarak literatüre değerli bir katkı sunmaktadır.

Anahtar Kelimeler: Fine Kinney, İş sağlığı ve güvenliği, Tekstil endüstrisi, Risk yönetimi

I. INTRODUCTION

The textile sector, one of Türkiye's most significant industries, operates across almost every region of the country. For instance, yarn production is concentrated in cities such as Kahramanmaraş, Istanbul, Adıyaman, Gaziantep, and Bursa. Denizli stands out for the manufacturing of towels, bathrobes, and home textiles; Uşak specializes in yarn, blankets, and recycling; Çorlu and Çerkezköy focus on finishing processes; Adana excels in cotton weaving and finishing; Gaziantep is prominent in polypropylene production, nonwoven fabrics, and machine-made carpets; while Istanbul leads in garment and knitwear production [1].

Thanks to the advantages offered by the Customs Union Agreement, its strategic location, skilled workforce, and robust supply chain, Türkiye holds a competitive edge in the global textile and ready-to-wear sectors. The textile industry significantly contributes to the Turkish economy through its high production capacity, job creation, value-added generation, and export potential [2]. As of 2023, Türkiye is the largest producer in the textile finishing sub-sector in Europe and ranks third globally after China and India. In home textiles, Türkiye stands as the largest producer in Europe and the fourth-largest globally [3]. According to the Turkish Exporters Assembly (TİM), Türkiye's textile and ready-to-wear sector achieved exports worth \$28.8 billion in 2023, holding a significant share in the country's total exports [1].

However, the share of textile exports in Türkiye's total exports, which was 40.7% in 1995, decreased to around 10% by 2023. Similarly, the sector's share in the global market has also declined compared to previous years [3].

The production process in the textile industry involves a complex chain, starting from the acquisition of raw fibers, continuing through yarn production and weaving, and culminating in "finishing processes," which impart specific characteristics to the fabric. Finishing processes enhance the durability, appearance, and functionality of textile products, making them suitable for end-user needs [4]. These processes directly affect the product's durability, appearance, texture, and performance. For instance, dyeing gives the fabric the desired color, while printing adds patterns. Coating and finishing processes can provide properties such as water resistance, fire retardancy, or wrinkle resistance. Thus, finishing processes play a critical role in tailoring textile products to their intended purposes [5].

According to the Turkish Statistical Institute (TÜİK) [6], the textile fiber bleaching and dyeing services sector maintained its position within the manufacturing industry between 2019 and 2023, although its share among all business sectors remained limited. In 2019, this sector accounted for 0.14% of enterprises across all business sectors and 1.10% within the manufacturing sector, while comprising 18.74% of enterprises in the textile manufacturing sector. By 2022, these proportions had risen to 0.14%, 1.11%, and 18.91%, respectively. Despite the increase in enterprise numbers, growth plateaued in 2023, with the ratios stabilizing.

In terms of employment, the textile fiber bleaching and dyeing services sector accounted for 0.52% of total employment across all sectors, 1.99% of manufacturing sector employment, and 17.80% of textile

manufacturing employment in 2019. By 2022, these figures had slightly declined to 0.51%, 1.90%, and 17.74%, respectively. In 2023, the sector experienced a further reduction in employment, representing 0.48% of all employment, 1.79% of manufacturing employment, and 18.08% of textile manufacturing employment. The total number of employees in the sector was recorded as 90985 in 2023 (Table 1). Overall, while the textile fiber bleaching and dyeing services sector constitutes a small share in terms of enterprises and employees, it remains a significant sub-sector within the textile manufacturing industry.

Table 1. Number of enterprises and employees by sector [6]

Year	Initiative				Employee			
	All business lines	Manu-facturing sector	Manu-facture of textile products	Textile fiber and yarn bleaching and dyeing services sector	All business lines	Manu-facturing sector	Manu-facture of textile products	Textile fiber and yarn bleaching and dyeing services sector
2019	3228421	403018	23713	4443	15656571	4084281	456034	81233
2020	3304054	409495	24099	4547	15953915	4308982	478427	84739
2021	3578877	444101	26054	4871	17495511	4713664	519079	91855
2022	3784760	465755	27238	5154	18648027	5017701	538247	95492
2023	3723681	462246	27038	5392	19099165	5067423	503349	90985

According to 2023 Social Security Institution data [7], the sectoral distribution and outcomes of workplace accidents in Türkiye reveal a significant risk profile in terms of occupational health and safety. The sectors with the highest number of workplace accidents include building construction, fabricated metal product manufacturing, and food and beverage service activities. As shown in Table 2, the building construction sector ranks first with 45996 workplace accidents, followed by the fabricated metal product manufacturing sector with 37699 accidents. The textile manufacturing sector recorded 31258 workplace accidents, highlighting the need to strengthen occupational health and safety measures in sectors with high hazard potential in their production processes.

Additionally, fatal workplace accidents remain a significant concern. Table 3 shows that the building construction sector reported 316 fatal accidents, followed by land transportation and pipeline transportation with 277 cases. The textile manufacturing sector recorded 36 fatal accidents in 2023. These figures highlight the need for targeted safety measures to address varying risk levels across industries.

The Social Security Institution publishes workplace accident statistics classified according to the NACE code system. The NACE code is a six-digit classification system used to determine the hazard classes of workplaces. Within the framework of the European Union harmonization efforts initiated in 2005, workplaces in Türkiye began to be categorized by the NACE system based on their sectors of activity. The classification includes 99 main headings and their corresponding subcategories, according to the production activities of workplaces [8].

Table 2. Sectors with the highest number of occupational accidents in Türkiye in 2023 and the number of accidents [7]

Field of Activity	Number of Accidents
Building construction	45996
Manufacture of fabricated metal products	37699
Food and beverage service activities	36755
Manufacture of food products	36089
Manufacture of textile products	31258

The textile manufacturing sector, although a field with occupational health and safety risks, was not among the top five sectors with the highest number of fatal occupational accidents in 2023 (Table 3). According to data from 2023, 36 people lost their lives in this sector [7]. The main reasons for this include differences in the nature of work and working conditions, a relatively lower fatality rate of workplace accidents, the widespread implementation of mechanization and occupational safety measures, and the sector's employment structure [9]. While the textile sector generally operates in enclosed environments with more controlled production processes, sectors such as building construction, land transportation, and pipeline transportation involve open environments, heavy equipment, and significant risks such as falls from heights [10]. In construction and transportation sectors, accidents are more commonly associated with falls, heavy object impacts, or traffic accidents, which have a higher fatality risk, whereas in the textile sector, accidents are more likely to result in injuries and occupational diseases. Additionally, increased automation and the higher applicability of occupational safety measures in textile factories may have contributed to a reduction in fatal workplace accidents [1].

Table 3. Sectors with the highest number of fatal occupational accidents and number of accidents in Türkiye in 2023 [7]

Field of Activity	Number of Fatal Accidents
Building construction	316
Land transportation and pipeline transportation	277
Construction of non-building structures	120
Private construction activities	116
Manufacture of other non-metallic mineral products	69

As shown in Table 4, there has been a general upward trend in the total number of workplace accidents in Türkiye between 2019 and 2023. The textile manufacturing sector has followed this trend, with the number of workplace accidents in the sector rising from 20274 in 2019 to 31258 in 2023. In terms of fatal workplace accidents, the total number across all sectors increased from 1147 in 2019 to 1966 in 2023. Specifically, in the textile manufacturing sector, the number of fatal accidents rose from 20 in 2019 to 36 in 2023. These figures indicate a rising trend in both overall workplace accidents and those occurring in the textile manufacturing sector. The share of workplace accidents in the textile manufacturing sector relative to total workplace accidents decreased slightly, from 4.8% in 2019 to 4.6% in 2023. However, the proportion of fatal workplace accidents in the sector increased from 1.7% to 1.8% over the same period. This highlights the textile manufacturing sector as a critical area requiring attention in terms of occupational health and safety.

Table 4. Between 2019-2023 in the textile products manufacturing sector number of employees involved in work accidents and fatal work accidents [7]

Year	Work Accident		Death	
	All business lines	Manufacture of textile products sector	All business lines	Manufacture of textile products sector
2019	422463	20274	1147	20
2020	384262	19399	1231	17
2021	511084	28816	1382	32
2022	588823	30294	1517	21
2023	681401	31258	1966	36

Under the textile finishing activities, dyeing and finishing processes are classified as high-risk in terms of occupational health and safety, as they involve numerous hazards stemming from chemical use.

Prolonged exposure to chemicals through ingestion, inhalation, or skin contact can lead to mild health issues such as skin irritation or severe conditions such as poisoning, chemical burns, and cancer cases [11]. In this context, the Fine-Kinney risk analysis method emerges as a critical tool for systematically evaluating hazards in the sector, preventing workplace accidents, and improving working conditions [12]. Studies conducted across various sectors [5], [12], [13], provide foundational references for this research by detailing the application and effectiveness of the Fine-Kinney method. Additionally, some studies have explored integrating modern technological tools such as fuzzy logic, Bayesian techniques, and clustering algorithms into risk assessment processes to overcome the limitations of traditional methods and achieve more effective outcomes [14], [15]. The Fine-Kinney method quantitatively evaluates potential hazards, their frequency of exposure, and possible consequences, thereby enabling systematic risk management [12], [15].

This article aims to examine a risk assessment conducted using the Fine-Kinney method in a denim factory in Türkiye, exploring how the method can be applied and its benefits in the textile fiber and yarn bleaching and dyeing services sector. The Fine-Kinney method has been widely used in various industries to evaluate and mitigate risks effectively. For instance, analyses conducted in large-scale apparel manufacturing facilities to assess ergonomic risks and prevent workplace accidents highlight the importance of this method [9]. Findings suggest that reducing ergonomic risks enhances both employee health and safety and improves operational efficiency. Other studies in the textile sector have identified high-risk practices using the Fine-Kinney method and emphasized the importance of critical measures such as health screenings, occupational health and safety training, and first aid [10]. Moreover, risk analyses encompassing human, mechanical, and general hazards in integrated textile facilities have shown significant reductions in risk levels due to implemented measures [16]. For example, effective training programs and improvement measures reduced the accident frequency rate from 67.40 in 2013 to 62.13 in 2014.

Additionally, risk analyses of chemical storage in the textile sector using the Fine-Kinney method have facilitated the evaluation of hazards based on parameters such as likelihood, severity, and frequency, leading to a significant reduction in overall risk levels [17]. These studies demonstrate that unacceptable and critical risks were completely eliminated, all risks were reduced to acceptable levels, and factors threatening the health and safety of workers in chemical storage areas were effectively mitigated.

While these studies primarily focus on specific areas such as ergonomic risks, chemical storage, and general hazard assessments in the textile sector, this article contributes to the literature by comprehensively analyzing risks specific to the textile fiber and yarn bleaching and dyeing services sector. In this study, the risks associated with the denim production process were analyzed using the Fine-Kinney method, and the sector-specific hazards were evaluated in detail. Concrete solutions were proposed to enhance worker health and safety, prevent workplace accidents, and optimize operational processes.

The article's primary contribution to the literature lies in demonstrating the applicability and effectiveness of the Fine-Kinney method in the textile fiber and yarn bleaching and dyeing services sector, thereby expanding the limited body of research in this area. After the introduction, the article reviews the literature and theoretical framework, focusing on risk assessment methods, particularly the theoretical foundations of the Fine-Kinney method. In the second section, the methodology, application process, and findings of a risk assessment conducted in a denim factory are analyzed. The article proceeds with a findings and discussion section, evaluating risk management strategies and occupational safety practices based on the data obtained. Finally, the conclusion highlights how the comprehensive risk assessment process conducted in the denim factory in Bartın enhanced occupational health and safety standards, reduced identified risks to acceptable levels through effective interventions, and serves as a guide for similar enterprises in the sector.

II. MATERIALS AND METHODS

A. GENERAL INFORMATION ABOUT THE WORKPLACE

This risk assessment was conducted in 2023 at a denim factory located in Kurtköy, Bartın province, employing 400 workers. The factory operates under the NACE code 13.30.02 and is classified as hazardous. The risk assessment was performed in accordance with Articles 4 and 10 of Law No. 6331 on Occupational Health and Safety, as well as the provisions of the Regulation on Occupational Health and Safety Risk Assessment published in the Official Gazette No. 28512 on December 29, 2012.

The objective of the assessment is to identify and eliminate risks and hazards arising from the nature of the work, the tools, equipment, and machinery used, work methods, personnel qualifications, and processes carried out during activities. This ensures the mitigation of negative impacts throughout the process, aiming to protect employees and company assets while minimizing workplace accidents and occupational diseases.

B. PRODUCTION FLOW, OPERATIONS, AND EQUIPMENT AND CHEMICALS USED

The textile and ready-to-wear industry are one of the longest and most comprehensive industrial chains within the manufacturing sector. This industry encompasses several sub-production branches, spanning from raw materials to finished products. The process includes fiber and yarn production from raw materials (spinning), fabric production from yarn (weaving or knitting), textile finishing processes where desired properties are imparted to textile products, and garment manufacturing, where fabric is cut and sewn into ready-to-use products [18]. Textile finishing is a specialized industrial sector aimed at modifying and enhancing the properties of textile products according to their intended applications, adding quality and value to the final product. This area primarily involves dyeing, printing, and finishing processes. With its substantial production capacity, Türkiye is home to Europe's largest textile finishing industry [19]. However, textile finishing processes are the most chemical-intensive stages within textile and garment manufacturing, potentially adversely affecting worker health. Considering the extensive use of chemicals in the textile finishing industry and Türkiye's significant production capacity in this sector, examining workers' chemical exposure is of paramount importance [20]. Textile finishing processes are generally divided into three main stages based on their objectives and structures: pre-treatment, coloring (dyeing and printing), and finishing processes [11]. Figure 1 provides a summarized flowchart categorizing workflows according to the type of operations performed.

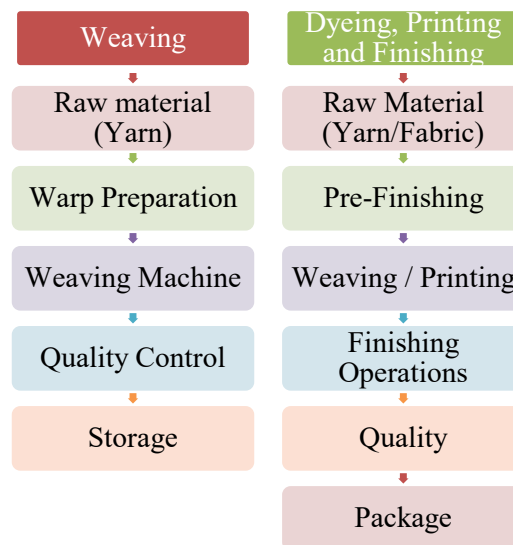


Figure 1. Example Production Flow Chart for Manufacturing of Textile Products [7]

Table 5 and Table 6 list the main equipment and chemicals used in the workplace. These tables aim to facilitate the management and supervision of the equipment and chemicals required to maintain a safe and efficient working environment. Table 5 provides an overview of the various equipment utilized in the workplace. In the textile fiber and yarn bleaching and dyeing services sector, the correct use of these tools is crucial for ensuring the efficiency and safety of production processes.

Table 5. *List of major work equipment used in the workplace*

No	Type of Equipment (Yarn Production Machines)	No	Equipment Type (Printing Machines)
1	Threshing machine	13	Film ruck printing machine
2	Traction machine	14	Rotary printing machine
3	Combing machine	15	Digital printing machine
4	Roving machine	16	Flock printing
5	Ring spinning machine	17	Transfer printing machine
6	Fibre mixing machine	18	Finishing and finishing machines
7	Yarn twisting machine	19	Fixing boiler
8	Yarn doubling machine	20	Gaze burning machine
9	Ribbon and roving spinning wheel	21	Rough machine
10	Yarn transfer machine	22	Continue washing machine
11	Yarn bobbin dyeing machine	23	Sanforizing machine
12	Coil drying machine	24	Raising machine

Table 6. *List of major chemicals used in the workplace*

No	Chemical Type	No	Chemical Type
1	Dust-coloring agents	5	Ammonia
2	Sulfuric acid	6	Hydrogen peroxide
3	Hydrochloric acid	7	Sodium hypochlorite
4	Acetic acid	8	Formic acid

For example, blending and carding machines, as well as roving and drawing frames, are critical components of the yarn production process. Ring spinning and twisting machines are used to enhance the quality and durability of the yarns. Equipment such as fiber blending machines and sliver and roving reels ensure homogeneity in production, while yarn winding, bobbin dyeing, and drying machines play a significant role in streamlining workflows.

Among printing machines, film screen, rotary, and digital printers are used for fabric coloring and patterning. Machines for flock, transfer printing, and finishing processes provide the desired final characteristics to the products. Additionally, equipment such as singeing burners, causticizers, fixation tanks, and sanforizing machines are employed to improve the dimensional and surface properties of textile products.

Table 6 lists the main chemicals used in the workplace. Powder dyes, sulfuric acid, hydrochloric acid, and acetic acid play a critical role in textile dyeing and bleaching processes. Hydrogen peroxide and sodium hypochlorite are widely used in bleaching and cleaning operations, while chemicals like ammonia and formic acid serve as supportive agents in various textile processing applications [20]. Proper management of this equipment and these chemicals is essential not only for maintaining production efficiency but also for protecting worker health and enhancing workplace safety.

C. RISK ANALYSIS AND THE FINE-KINNEY METHOD

C. 1. Risk Analysis

Every workplace involves various risks arising from working conditions and operational activities. These risks can lead to accidents resulting in injuries or fatalities for employees, as well as damage to equipment and financial losses [21]. Risk analysis in occupational health and safety relies on two fundamental approaches: reactive and proactive. The reactive approach focuses on analyzing the causes of past incidents to prevent their recurrence, while the proactive approach aims to anticipate, evaluate, and mitigate risks before accidents occur [22].

Risk analysis involves several key stages, including the identification of workplace hazards, analysis of the factors that may turn these hazards into risks, and the development of control measures [23]. Moreover, the experiences and insights of employees contribute significantly to identifying sources of hazards more effectively. Once hazards are identified, they are analyzed by considering the likelihood and severity of associated risks [24]. During this analysis, both the potential impacts of hazards and the frequency of their occurrence are evaluated. After ranking and prioritizing risks, appropriate control measures are identified and implemented.

To ensure effective application of the risk analysis process, certain steps are followed systematically. Figure 2 summarizes the risk control steps to be taken in the workplace. The process begins with hazard identification and continues with risk evaluation. Suitable control measures are then determined and implemented to reduce or eliminate risks. In the final stage, the effectiveness of the implemented measures is monitored, and a continuous improvement cycle is maintained through periodic reviews [25].

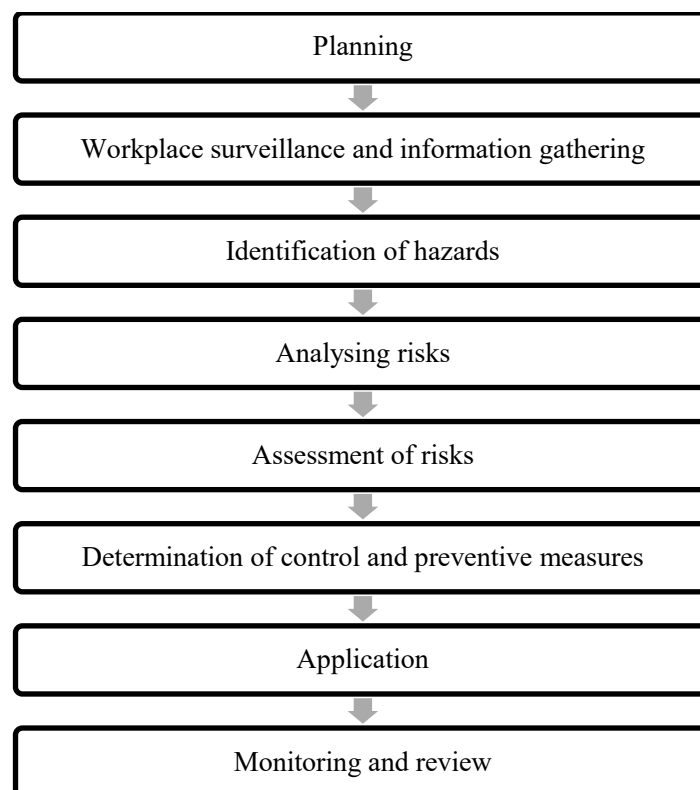


Figure 2. Risk Control Steps.

C. 2. Fine-Kinney Method

The Fine-Kinney method is a risk assessment tool designed to rank risks and guide prioritization efforts based on the results of this ranking. Originally developed in 1976 by G.F. Kinney and A.D. Wiruth for use in the U.S. Navy, the method evaluates risks using three key parameters: the severity of consequences, the frequency of exposure, and the likelihood of occurrence. The risk score, calculated as the product of these parameters, enables the prioritization of risks and directs resources toward the most critical areas [26]. This analytical structure supports decision-makers in formulating effective and accurate strategies [15].

Beyond its standard applications, qualitative elements such as fuzzy logic have been incorporated into the Fine-Kinney method to enhance its flexibility[22]. These hybrid approaches combine quantitative and qualitative methods, providing a more comprehensive evaluation. For example, when integrated with multi-criteria decision-making (MCDM) methods, this system more accurately identifies the significance of risk parameters and optimizes prioritization [27].

The method begins with the identification of potential hazards. Each hazard is then assessed in terms of its likelihood, frequency of exposure, and severity of consequences. These numerical evaluations generate risk scores for each hazard, enabling managers to make data-driven decisions [28]. One of the primary advantages of the Fine-Kinney method is its ability to quantify risk analysis, allowing for objective ranking based on clear criteria. This makes it particularly effective in complex work environments with numerous potential hazards [29].

Compared to other risk assessment methods, the Fine-Kinney method stands out for its speed and minimal resource requirements. Methods like HAZOP (Hazard and Operability Study) and FMEA (Failure Modes and Effects Analysis), while thorough, are time-consuming and require specialized expertise. In contrast, the Fine-Kinney method delivers actionable results with less time and resource investment, making it a preferred choice across various sectors [5]

The Fine-Kinney method's core calculation formula relies on three main parameters: likelihood, severity, and frequency [26]. Likelihood indicates how probable it is for a hazard to occur under current conditions. Severity represents the extent of damage or harm that could result if the hazard materializes, while frequency refers to how often the hazard is encountered. The product of these parameters generates a risk score, which determines the priority level of the hazard (Table 7).

The Fine-Kinney method is a quantitative risk analysis method widely used in occupational health and safety risk assessments. This method considers three basic parameters to determine risk: likelihood (L), severity (S) and frequency of exposure (F). The risk value is calculated by multiplying these three factors ($R = L \times S \times F$). As shown in Table 7, the scales established for each parameter allow for a systematic assessment of risk. Likelihood refers to the likelihood of an event occurring, while severity describes the estimated impact of the event on human health or the environment. Exposure frequency indicates the duration of exposure to the hazard. According to the risk assessment results in Table 7, when the calculated risk value exceeds certain thresholds, the measures to be taken and their priority levels are determined. This method is used to analyze hazard sources and identify risk reduction strategies, especially in workplaces [26].

In the Fine-Kinney risk assessment method, the likelihood parameter represents the likelihood of a hazard occurring over time. This parameter is assigned specific numerical values based on descriptive categories. The standard scale for likelihood includes values such as 0.1, 0.2, 0.5, 1, 3, 6, and 10, corresponding to qualitative descriptors ranging from “Virtually impossible” to “Constantly (multiple times a day)” [26].

Regarding the possibility of a likelihood value exceeding 1, it's important to note that in the Fine-Kinney method, the likelihood scale is not a direct representation of statistical likelihood (which ranges from 0 to 1) but rather a scoring system for risk assessment purposes. Therefore, assigning values greater than

1 is standard practice within this method. For example, a value of 10 indicates a hazard that is expected to occur constantly, multiple times per day. This approach allows for a nuanced differentiation between varying levels of risk beyond the 0 to 1 range [30], [31], [32].

Table 7. *Fine-Kinney method impact-harm consequence scale (likelihood, severity and frequency values) [26]*

Likelihood Value	Likelihood (Likelihood of Loss Realisation)	Severity Value	Severity (Estimated Harm to Human and/or Environment)	Frequency Value	Frequency (Repeated Exposure to Hazard over Time)
10	Expected, for sure	100	Multiple Fatality Accident/Environmental Disaster	10	Almost Continuously (Several times in one hour)
6	High, quite possible	40	Fatal Accident / Serious Environmental Damage Permanent Damage/ Injury, Job Loss/ Environmental Obstacle, Complaint from Close Neighbourhood Significant Damage/ Injury, External First Aid Needed/ Environmental Damage Outside the Territorial Limits	6	Frequent (Once or Several Times a Day)
3	Possible	15	Minor Damage/ Injury, Internal First Aid/ Limited Environmental Damage within the Terrain	3	Occasionally (Once or Several Times a Week)
1	Possible, but unlikely	7	Cheap Dodge / No Environmental Damage	2	Not Frequent (Once or Several Times a Month)
0.5	Unlikely but possible	3		1	Infrequent (Several times a year)
0.2	Not expected	1		0.5	Very Infrequently (Once a Year or Less)

Risk scores are categorized based on specific threshold values in the risk rating table (Table 8). This classification helps determine which risks require immediate action and which are considered acceptable. For instance, hazards with a risk score exceeding 400 necessitate immediate intervention, while risks with scores below 20 are deemed manageable with continuous monitoring and control [26].

Table 8. Risk rating table [26]

Risk Value	Risk Assessment Result
R>400	Intolerable Risk (Very High Risk) (Necessary measures should be taken immediately or the work should be stopped, the facility, the building should be closed, etc. should be considered)
200<R≤400	High Risk (Substantial Risk) (Should be optimised as soon as possible "within a week")
70<R≤200	Significant Risk (Short Term Improvement "Within Two Weeks")
20<R≤70	Definite Risk (Probable Risk) (Must be applied under supervision)
R≤20	Acceptable Risk (Insignificant Risk) (Not Prioritised)

Risk assessment reports prepared based on the Fine-Kinney method provide a detailed account of hazard sources, identified risks, and control measures. These reports play a critical role in enhancing workplace safety standards and improving working conditions. Furthermore, such assessments should be updated regularly and adjusted to reflect any changes made in the workplace [20].

III. FINDINGS AND EVALUATION

This risk assessment covers the closed storage areas, building extensions (dormitories, restrooms, bathrooms, cafeterias, offices, dressing rooms, etc.), visitors, and the surrounding environment of a denim factory located in Bartın province.

During the risk analysis, 20 different hazards were identified, and corrective and preventive actions were planned for each (Table 9 and Table 10).

In the packaging area, outdated fire extinguishers and the lack of regular inspections increased the risk of delays in responding to fires. This issue was resolved by replacing the extinguishers with modern ones and establishing a regular inspection mechanism. Additionally, anti-slip tapes were added to the stairs in the same area, minimizing the risk of slips and falls.

In the production area, significant safety concerns were identified, such as unstable stairs and the absence of insulating mats in front of electrical panels. These issues were addressed by stabilizing the stairs and placing insulating mats in front of the panels, enhancing worker safety. Forklift pathways were also marked according to regulations, and an aspiration system was installed to reduce accidents and health risks.

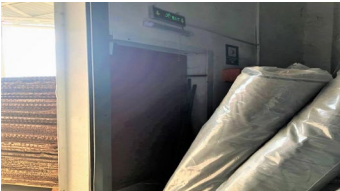
In general areas, several improvements were made, including installing sensors on automatic roller shutter doors, modifying emergency exit doors to open outward, and forming a fire response team. These measures helped prevent panic and delays during emergencies, significantly improving employee safety. Escape routes were also cleared of obstructing materials and placed under continuous supervision.

In the office section, the insufficient number of first aid kits was identified as a risk that could delay emergency responses. Following the risk analysis, first aid kits compliant with regulations were procured and distributed to all sections, and first aid teams were assigned for regular inspections. Furthermore, the regular cleaning and recording of water dispensers helped mitigate the risk of microbial diseases.

Table 9. Risk assessment table.

No	Location	Danger	Photo	Risk	Possible impact	Likelihood	Frequency	Possible consequence	Risk score	Importance rating	Necessary regulatory and preventive action	Responsible	Time
1	Packaging Area	Fire extinguishers are old type and not checked		Failure to intervene in times of fire and emergency intervention	Injury, explosion, death	6	3	40	720	1	Fire extinguishers should be checked	Warehouse clerk	Immediately
2	Office Department	Inadequacy of the medicine cabinet		Lack of first aid	Injury, death	3	2	40	240	1	Medicine cabinet supplies must be completed	Warehouse clerk	One week
3	Production	The ladder is not fixed		Falling	Injury, fracture, dislocation	6	3	15	270	2	Ladder must be stabilised	Foreman	One week
4	Packaging Area	Lack of anti-slip bands on the stairs		Slipping, falling	Injury, fracture, dislocation	3	3	15	135	3	Anti-slip bands should be added	Foreman	Two weeks

5	Office Department	Drinking water supply		Microbial and infectious diseases	Infectious diseases	6	2	7	84	3	Water dispensers should not be placed in dusty and dirty places	Employer's representative	One month
6	Production	Inadequate lighting		Eye fatigue, visual disturbances, eye disorders	Eye disorders	3	6	15	270	2	Ambient measurements should be made	Employer	One weeks
7	General	Lack of sensor for automatic roller shutter doors		Work Accident	Injury, death	6	6	40	1440	1	Doors must be equipped with stop sensors	Employer	Immediately
8	General	Unsafe work at height		Work accident, fall from height	Injury, fracture, dislocation, death	6	6	40	1440	1	The basket must be connected to the forks with a safety pin	Employer	Immediately
9	General	Emergency exit doors do not open outwards		Panic in emergency situations	Injury, death	6	3	40	720	1	It should be made open to the outside world	Employer	Immediately
10	General	Lack of knowledge about fire		Lack of trained fire extinguishers	Death, serious injury	6	3	40	720	1	Fire team should be formed	Employer	Immediately

11	General	Material stacking on emergency escape routes		Panic in emergency situations	Injury, death	6	6	40	1440	1	Absolutely no material should be stacked on the escape routes	Employer and employee	Immediately
12	Production	Residual current relays		No residual current relay	Electric shock, injury, death, fire	6	10	40	2400	1	Must be maintained	Employer	Immediately
13	Production	No insulating mat in front of the panels		Electric shock due to electric leakage	Injury, loss of limb, death	6	3	40	720	1	Insulating mats should be placed in front of the panels and the front of the panels should be empty	Employee	Immediately
14	Production	Forklift and pedestrian path is not separated		Forklift collision	Injury, loss of limb, death	6	6	40	1440	1	Determine forklift routes inside and outside the facility	Employer	Immediately
15	Production	Inhalation of fabric and cotton dust in the environment		Exposure to fabric dust	Allergic condition, occupational disease	6	6	15	540	1	Aspiration system should be established	Employer	Immediately
16	Chemical storage	Exposure of powder components		Inhalation, skin contact	Poisoning, irritation	3	2	7	42	4	Powder components should be protected by sealing their mouths	Warehouse Supervisor	One month

17	Chemical storage	Storage of flammable, caustic, corrosive substances		Fire, explosion	Injury, death	6	6	40	1440	1	Corrosive substances should not be stored together with flammable, combustible, flammable, reactive and toxic substances	Warehouse Supervisor	Immediately
18	Treatment plant	Handrails on the sides of the pool		No or unstable handrails	Pool falls, injury or death	6	6	40	1440	1	The railings in the walking area should be subjected to physical control at intervals determined by the management	Employer's representative	Immediately
19	Finishing department	Slippery floor		Slip and fall, work accident	Falls and injuries	6	6	15	540	1	Floors must be cleaned and made non-slip immediately	Employer's representative	Immediately
20	Production	Leaving the protective covers on machines and tanks open		Tripping, chemical exposure	Respiratory diseases, occupational accidents, occupational diseases	6	6	7	252	2	Must be kept closed	Foreman	One week

Table 10. Risk analysis after corrective actions

No	Description	Likelihood	Frequency	Possible consequence	Risk Score	Importance Rating
1	A total of 20 fire extinguishers in all departments throughout the facility were renewed after the risk analysis and brought into compliance with the legislation. In addition, it was ensured that the controls were regularly carried out by the supplier company every 6 months.	0.1	3	40	12	5
2	After the risk analysis, medicine cabinets and necessary materials in accordance with the legislation were procured and installed in all departments together with the plates. The materials in the medicine cabinets are regularly checked monthly by the first aid team officer in each department, deficiencies are identified and provided quickly.	0.1	2	40	8	5
3	After the risk analysis, the ladder in the sample fabric warehouse of the quality control department was fixed and railings were added to ensure safety.	0.5	3	15	22.5	4
4	After the risk analysis, anti-slip bands have been added to the stairs and the strength and functionality of the bands are ensured by regular checks.	0.5	3	15	22.5	4
5	After the risk analysis, the cleaning of the water dispensers was made in accordance with the instructions and ensured to be carried out regularly. Cleaning operations were recorded on registration forms by the assigned personnel and traceability was increased.	0.1	2	7	1.4	5
6	After the risk analysis, the lighting system has been rearranged so that the corridors and stairs are at least 50 lux, WC and washbasins are 100 lux, cellar and material storage areas are 200 lux, kitchen and offices are 500 lux and the lighting system has been rearranged and made in accordance with the standards.	0.1	6	15	9	5
7	After the risk analysis, sensors were installed on all automatic shutter doors to increase employee safety and prevent possible accidents.	0.1	6	40	24	4
8	Following the risk analysis, necessary precautions have been taken for working at height in works such as machine maintenance, cleaning, repair and assembly throughout the facility, and the use of appropriate equipment and safety measures have been made mandatory to ensure the safety of employees. Unsafe working conditions have been prevented by regular inspections.	0.1	6	40	24	4
9	Following the risk analysis, necessary precautions have been taken for working at height in works such as machine maintenance, cleaning, repair and assembly throughout the facility, and the use of appropriate equipment and safety precautions have been made mandatory to ensure the safety of employees. Unsafe working conditions have been prevented by regular inspections.	0.1	3	40	12	5

Table 10 (cont). Risk analysis after corrective actions

10	After the risk analysis, a fire extinguishing team was formed and team members were regularly provided with comprehensive training on fire fighting and emergency response.	0.1	3	40	12	5
11	After the risk analysis, the stacks were organised only in the specified areas and complied with the stacking rules to ensure a safe working environment.	0.1	6	40	24	4
12	Following the risk analysis, residual current relays were installed in switchboards and regular maintenance and controls were ensured to prevent electrical accidents.	0.1	10	40	40	4
13	Following the risk analysis, the necessary insulating mats were procured for the panels in the finishing and indigo departments that did not have insulating mats and placed in front of the panels to increase employee safety.	0.5	3	40	60	4
14	After the risk analysis, forklift paths were clearly drawn with permanent paint in accordance with the regulations and traffic arrangement was provided for the safety of employees.	0.1	6	40	24	4
15	After the risk analysis, an aspiration system was installed in the production area and dust masks were regularly provided to the employees. In addition, employees who are allergic to dust were directed to different departments in accordance with their health conditions and possible health problems were prevented.	0.1	6	15	9	5
16	After the risk analysis, the powder components were sealed and protected, thus minimising the chemical exposure of the employees.	0.1	2	7	1.4	5
17	After the risk analysis, paints and chemicals were stored in a cold, dry and well-ventilated area and arrangements were made to prevent exposure to rain, sunlight and other heat sources. In addition, these areas were regularly inspected.	0.1	6	40	24	4
18	After the risk analysis, the railings of all pools were renewed and made in accordance with the regulations in order to ensure the safety of employees.	0.1	6	40	24	4
19	After the risk analysis, the floor was made safe by replacing the slippery tiles. In addition, necessary precautions have been taken to prevent possible accidents by placing warning signs such as "wet and slippery area" during cleaning operations on slippery floors in other parts of the factory and until they dry.	0.1	6	15	9	5
20	After the risk analysis, the lids of the tanks containing caustic, dye and other chemicals in the finishing department were regularly checked to ensure that they were closed, and these checks were linked to a specific plan and safety standards were increased.	0.5	6	7	21	4

In the chemical storage area, significant hazards were identified, including the open storage of powdered substances and the improper placement of flammable and corrosive chemicals. To mitigate these risks, powdered materials were relocated to enclosed containment units, while hazardous chemicals were systematically stored in well-ventilated, dry, and secure environments, thereby substantially reducing the potential for fire outbreaks and toxic exposure incidents.

Similarly, at the wastewater treatment facility, the absence of protective railings around the perimeters of open pools was found to pose a substantial risk of falls and related injuries. In response, appropriate safety railings were installed, and routine inspections were initiated to ensure ongoing compliance with occupational safety regulations.

As a result of these targeted interventions, a substantial proportion of identified risks was effectively minimized to acceptable thresholds, contributing to a marked improvement in workplace health and safety conditions. The implementation of these corrective actions following the risk assessment played a critical role proved instrumental in safeguarding employee well-being and enhancing overall operational reliability.

IV. CONCLUSION AND EVALUATION

This study endeavors to advance occupational health and safety standards through a rigorous and methodical risk assessment conducted at a leading denim manufacturing facility located in Bartın, Turkey. In the preliminary phase, in-depth data acquired from the company's senior management were utilized to analyze the factory's overarching operational framework, production workflows, and standard practices. These insights were further enriched by sector-specific literature reviews and comprehensive on-site evaluations, enabling the systematic identification of potential hazards that may pose risks to employees, machinery, or product integrity. Each operational unit within the facility was meticulously examined, allowing for a thorough assessment of activity-specific risks across various sections of the production environment.

During the hazard identification process, systems, work equipment, and the working environment were evaluated as potential sources of hazards. The analysis revealed that a single source could lead to multiple hazards, which in turn could create multiple risks. This evaluation aligns with other studies applying the Fine-Kinney method. For instance, studies in the apparel sector have shown significant improvements in worker health and operational efficiency through ergonomic risk assessments [9]. Similarly, research in the textile sector has demonstrated the method's effectiveness in identifying high-risk practices and developing measures to mitigate these risks [10].

The comprehensive risk assessment process identified 20 discrete hazards spanning eight functional areas within the facility, each accompanied by detailed and context-specific mitigation strategies. Following the implementation of the recommended corrective actions, a secondary assessment was carried out, confirming that all previously recorded hazards had been reduced to levels deemed acceptable by occupational safety standards. The distribution of risk categories revealed that 47.80% originated from human-related factors, 26.21% from mechanical sources, and 9.69% from general operational deficiencies. Importantly, a significant share of human-related hazards was attributed to insufficient awareness and inadequate adherence to established safety procedures. These findings highlight the urgent necessity of institutionalizing comprehensive, ongoing safety training programs that are both contextually relevant and behaviorally focused, in order to foster a proactive safety culture and ensure sustained compliance.

In 2023, the facility employed an average of 400 workers, with 42 workplace accidents resulting in 8528.48 lost workdays. By 2024, the workforce increased to 429, the number of accidents decreased to 24, and lost workdays dropped to 6695.92. Consequently, the accident frequency rate (AFR) decreased from 52.76 in 2023 to 28.26 in 2024. The implemented measures improved workplace safety standards and significantly reduced risk levels, consistent with findings from other studies highlighting the impact of effective safety measures on organizational performance [17].

The risk analysis revealed that the facility's emergency preparedness was hindered by inadequate fire-fighting infrastructure, including an insufficient number of fire suppression devices and the obstruction of existing equipment due to improper storage practices. To address these deficiencies, the assessment

recommended the installation of advanced fire detection systems and fire protection relays, as well as the establishment of systematic maintenance and inspection protocols to ensure ongoing operational reliability and regulatory compliance.

Chemical-related risks were particularly prominent in areas like dye houses. Improvements ensured the classification and storage of chemicals in appropriate facilities and measures against spills and leaks. Material Safety Data Sheets (MSDS) were recommended to be translated into Turkish to ensure clarity for workers. Storing strong oxidants like hydrogen peroxide near acids and bases was found to increase fire risks, and these chemicals were relocated to suitable storage areas.

Ventilation systems were also identified as a significant hazard source. Cold air during winter and high temperatures in summer negatively affected workers. Solutions included implementing exhaust systems near sources of emissions and designing fresh air supplies to avoid direct exposure to workers.

In conclusion, the comprehensive efforts undertaken effectively prevented workplace accidents and occupational diseases, contributing to a stronger occupational health and safety culture. Enhancing the safe use of chemicals, optimizing ventilation systems, implementing fire prevention measures, and maintaining continuous training programs significantly improved the overall safety level of the facility. This study reaffirms the effectiveness of the Fine-Kinney method in enhancing safety standards and preventing workplace accidents in the sector.

The Fine-Kinney method, while an effective tool for evaluating risk factors, may not comprehensively address all hazards and risks. In particular, it may fall short in assessing psychosocial risk factors. Since the study was conducted solely in a denim factory in Bartın, the findings have limited generalizability to other enterprises in the sector or similar organizations operating in different geographical regions. Additionally, the absence of modern risk assessment techniques such as fuzzy logic, Bayesian analysis, and clustering algorithms in this study may have narrowed the scope of the analysis process. The lack of these advanced methods may have hindered a broader perspective in the risk assessment process and the derivation of more detailed results.

Article Information

Acknowledgments: The authors extend their sincere gratitude to the editor and the anonymous reviewers for their insightful comments and constructive feedback, which significantly contributed to the improvement of this manuscript.

Author's Contributions: Conceptualization and original draft preparation: M.O. and Z.O.B.; review, analysis, and editing: M.O. Z.O.B. and Both authors have read and approved the final version of the manuscript.

Artificial Intelligence Statement: No artificial intelligence tools were employed in the preparation or writing of this manuscript.

Conflict of Interest Disclosure: The authors declare that there are no conflicts of interest related to the content of this article.

Plagiarism Statement: This manuscript has been screened for plagiarism using standard plagiarism detection software and found to be free of any academic misconduct.

V. REFERENCES

- [1] “TİM İhracat Raporu 2023,” Accessed: Dec. 26, 2024. [Online]. Available: https://tim.org.tr/files/downloads/Strateji_Raporlari/TIM%20%C4%B0HRACAT%20RAPOR%202023%20D%C4%B0J%C4%B0TAL.pdf
- [2] T.C. Kalkınma Bakanlığı, “On Birinci kalkınma planı (2019-2023), tekstil-deri-hazır giyim çalışma grubu raporu,” Accessed: Dec. 26, 2024. [Online]. Available: <https://www.sbb.gov.tr/wp-content/uploads/2022/08/Tekstil-Deri-Hazir-Giyim-Calisma-Grubu-Raporu.pdf>
- [3] EVÇED Planlama ve Denetim Daire Başkanlığı, “Tekstil Sektörü 2023 Yılı Kıyaslama Raporu 1.” Accessed: Dec. 26, 2024. [Online]. Available: <https://enerji.gov.tr/evced>
- [4] İstanbul Sanayi Odası Tekstil İmalatı Sanayi, “Avrupa Birliği’ne tam üyelik sürecinde İstanbul Sanayi Odası meslek komiteleri sektör stratejileri geliştirilmesi projesi: Tekstil imalatı sanayi”. Accessed: Dec. 26, 2024. [Online]. Available: www.iso.org.tr
- [5] M. Gul and E. Celik, “Fuzzy rule-based Fine–Kinney risk assessment approach for rail transportation systems,” *Human and Ecological Risk Assessment: an International Journal*, vol. 24, no. 7, pp. 1786–1812, 2018.
- [6] Türkiye İstatistik Kurumu Haber Bülteni, “Yıllık sanayi ve hizmet istatistikleri,” Accessed: Dec. 26, 2024. [Online]. Available: <https://data.tuik.gov.tr/Bulten/Index?p=Annual-Industry-and-Service-Statistics-2022-49569>
- [7] Sosyal Güvenlik Kurumu (SGK), “İş kazası istatistikleri,” Accessed: Dec. 26, 2024. [Online]. Available: <https://www.sgk.gov.tr/Istatistik/Yillik/fcd5e59b-6af9-4d90-a451-ee7500eb1cb4/>
- [8] Eurostat, “NACE Rev. 2 – Statistical classification of economic activities in the European Community,” Accessed: Dec. 26, 2024. [Online]. Available: <https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF>
- [9] S. Gülerer and E. C. Sabır, “Bir konfeksiyon işletmesinde seçilmiş ergonomik risklerin iş sağlığı ve güvenliği kapsamında analizi ve risk değerlendirmesi,” *Çukurova Üniversitesi Mühendislik Fakültesi Dergisi*, vol. 37, no. 1, pp. 237–248, 2022.
- [10] M. Güner, E. Acar and M. Küçük, “Konfeksiyon sektöründe Fine Kinney metodu kullanılarak risk analizi yapılması,” in *2nd ERASMUS International Academic Research Symposium*, İ. Serbestoğlu, Ed., Paris, France: ASOS Yayınevi, 2019, pp. 123–134.
- [11] M. Çoban, *Genel Tekstil Terbiyesi ve Üretim Süreçleri*, vol. 1. İzmir: Tekstil ve Konfeksiyon Araştırma Merkezi, 1999.
- [12] İ. Seyfioğlu and F. D. Kadem, “Bir ayakkabı işletmesinin Fine-Kinney yöntemi ile risk değerlendirmesi,” *Çukurova Üniversitesi Mühendislik Fakültesi Dergisi*, vol. 37, no. 4, pp. 925–936, 2022.
- [13] N. Baç and I. Ekmekçi, “Psychosocial risk assessment using COPSOQ II questionnaire - A case study with maintenance workers in a metal plant in Istanbul Turkey,” *Heliyon*, vol. 7, no. 4, 2021, Art. no. e06777.
- [14] M. Oturakçı and C. Dağsuyu, “Fuzzy Fine-Kinney approach in risk assessment and an application,” *Karaelmas Journal of Occupational Health and Safety*, vol. 1, no. 1, pp. 17–25, 2017.

- [15] U. Ergün and F. Kahraman, “Elektrik yapım işi sektöründe bulanık Fine-Kinney metodu ile risklerin önceliklendirilmesi,” *Çukurova Üniversitesi Mühendislik Fakültesi Dergisi*, vol. 38, no. 1, pp. 281–292, 2023.
- [16] M. Güngör and A. Çoban, “Entegre bir tekstil işletmesinde iş sağlığı ve güvenliği açısından risk analizi çalışması,” in *ISITES2015, 3rd International Symposium on Intelligent Technologies in Engineering and Science*, Valencia, Spain, 2015, pp. 2627–2636.
- [17] M. Altuğ and M. İnce, “Tekstil kimyasallarının depolanmasında Fine-Kinney metodu ile risk değerlendirme.” Accessed: Dec. 26, 2024. [Online]. Available: http://www.isguvenligivecalisansagligikongresi.org/bildiriayrinti/tekstil-kimyasallarinin-depolanmasinda-fine-kinney-metodu-ile-risk-degerlendirme_459
- [18] Z. Değirmenci and M. İ. Bozkurt, “Tekstil sektöründe iş sağlığı ve güvenliği uygulamaları,” *Kilis 7 Aralık Üniversitesi Fen ve Mühendislik Dergisi*, vol. 2, no. 1, pp. 1–16, 2018.
- [19] “Hazır Giyim ve Konfeksiyon Sektörü Güncel Durum”. Accessed: Dec. 26, 2024. [Online]. Available: <https://www.ihkib.org.tr/content/files/uploads/4170/hazir-giyim-ve-konfeksiyon-sektoru-2024-mart-ihracat-bilgi-notu.pdf>
- [20] Çalışma ve Sosyal Güvenlik Bakanlığı, “Tekstil sektörü iş sağlığı ve güvenliği yönetim sistemi rehberi,” Accessed: Dec. 26, 2024. [Online]. Available: <https://www.csgb.gov.tr/media/96226/tekstil-sektoeru-isgys-rehberi-by-25-09-2024.pdf>
- [21] İ. Cündübeyoğlu and R. Kayabaşı, “Seramik fabrikasında Fine-Kinney yöntemi ile risk değerlendirmesi,” *European Journal of Science and Technology*, no. 35, pp. 633–642, 2022.
- [22] A. E. Acar Filizci and B. Erdebilli, “Akaryakıt istasyonuna ait klasik fine kinney risk analizinin bulanık Fine Kinney yöntemi karşılaştırılması,” *Sürdürülebilir Mühendislik Uygulamaları ve Teknolojik Gelişmeler Dergisi*, vol. 5, no. 2, pp. 188–198, 2022.
- [23] A. Grassi, R. Gamberini, C. Mora and B. Rimini, “A fuzzy multi-attribute model for risk evaluation in workplaces,” *Safety Science*, vol. 47, no. 5, pp. 707–716, 2009.
- [24] P. A. Erickson, *Practical Guide to Occupational Health and Safety*. San Diego: Academic Press, Elsevier, 1996.
- [25] M. R. Yazgan, *İş Sağlığı ve Güvenliği Risk Değerlendirmesi Rehberi*, vol. 1. İstanbul: Yazgan Medya, 2015.
- [26] G. F. Kinney and A. D. Wiruth, “Practical risk analysis for safety management,” 1976, Accessed: Dec. 26, 2024. [Online]. Available: https://www.researchgate.net/profile/Guibert-Crevecœur/post/What-is-the-unification-theory-of-safety-science/attachment/59d6252c79197b80779837dc/AS%3A316678640996352%401452513479333/download/Basic_Kinney_article.pdf
- [27] S. E. Hacıbektaşoğlu, B. Mertoğlu and H. Tozan, “Bulanık çok kriterli karar verme yöntemleriyle bir risk analizi uygulaması,” *International Journal of Advances in Engineering and Pure Sciences*, vol. 34, no. 3, pp. 403–414, 2022.
- [28] G. Tümay Ateş, “Risk analizi ve yönetim yaklaşımları: teorik temeller ve uygulamalar,” *İş Sağlığı ve Güvenliği Dergisi*, pp. 45–60, 2023.
- [29] B. Dogan, M. Oturakci and C. Dagsuyu, “Action selection in risk assessment with fuzzy Fine–Kinney-based AHP-TOPSIS approach: a case study in gas plant,” *Environmental Science and Pollution Research*, vol. 29, no. 44, pp. 66222–66234, 2022.

- [30] M. C. Bağdatlı and A. M. Kılıç, "Occupational safety risk analysis of organized industrial enterprises in Nevşehir province of Turkey by Fine-Kinney method," *International Journal of Engineering Technologies and Management Research*, vol. 7, no. 7, pp. 33–41, 2020.
- [31] S. H. Gökler, D. Yılmaz, Z. F. Ürük and S. Boran, "A new hybrid risk assessment method based on Fine-Kinney and ANFIS methods for evaluation spatial risks in nursing homes," *Heliyon*, vol. 8, no. 10, 2022, Art. no. e11028.
- [32] S. R. Satıcı and S. Mete, "Fine-Kinney-based occupational risk assessment using pythagorean fuzzy AHP-COPRAS for the lifting equipment in the energy distribution and investment sector," *Gazi University Journal of Science*, vol. 37, no. 2, pp. 854–873, 2024.