Risk Analysis for Occupational Health and Safety and Risk Improvement: A Case Study in an Electric Electronic Company

Hatice Camgöz Akdağ, K. Aybüke Uysal, and Uğur Sezgin

***Abstract*—Occupational Health and Safety has been an important topic both in World and Turkey in recent years. Regulations and preventions are becoming more of an issue from day to day. Turkey is a country which is dealing with occupational health and safety problems a lot. According to Social Security Institution, 1360 death cases deriving from occupational accidents are observed in 2013. In production-based companies, occupational accidents are occurring frequently. As a result of this, companies are trying to decrease the number of the occupational accidents with taking required cautions in order not to experience it.**

The scope of this paper is to investigate the risks in terms of occupational health and safety in one of the biggest electric electronic company located in Turkey and offer a solution to the problem which is found at the end of the study. Furthermore, a detailed research study about occupational health and safety and risk evaluation methods have been included in this study. There are two kind of risk analysis methods which are qualitative methods and quantitative methods. Both of these methods are analyzed in the study in detail. However, in order to obtain a discernable result, the quantitative method which the selected company is using has been examined and another suitable quantitative method has been selected. In light of this information, risk analysis and evaluation method for the company has been appraised and solutions have been presented in this study.

***Index Terms*—OHSAS, risk analysis and evaluation, electric electronic company, qualitative and quantitative methods.**

I. Introduction

Fast industrialization and technologic developments caused significant problems about the safety and health of the workers. Due to this, providing the safety of the workplace has been more important and this need resulted in the development of occupational health and safety.

In recent years, occupational health and safety have been an important topic to focus on by governments and companies. Because of the developing social media and technology the accidents started to create tremendous impression. The importance which is given to human health increased day by day. Therefore, companies and governments have taken occupational health and safety as a prioritized topic. Governments started to design their laws according to this and this generated a constraint on the companies. These obligations made the companies give more importance to occupational health and safety with providing sufficient educations and tools to protect the health and safety of the employees. Aydın, *et al*. [1] stated that, occupational accidents and job diseases are the most important risks which occurs in workplace. Therefore, occupational health and safety is increasing its importance due to the economic, social and technical reasons day by day. Occupational accidents and job diseases have significant negative effects for government, employees and employers. Thus, this negative effects should be analyzed well and concrete solutions should be gathered.

The increasing importance and focus on occupational health and safety conduced to increase the studies about this area. Companies started to educate their workers more properly; audits are increased and so on. In sum, occupational health and safety is a crucial topic to investigate and work on.

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The authors are with the Istanbul Technical University, Management Faculty, Management Engineering Department, Istanbul, 34367 Turkey, (e-mail: camgozakdag@itu.edu.tr, aybuke.uysal@gmail.com, ugurr.sezgin@gmail.com).

II. Literature Review

A. General Information about Occupational Health and Safety

According to International Labour Organization (ILO) and WHO (1950) [2] , occupational health and safety is defined as follows: "The main focus in occupational health is on three different objectives: (i) the maintenance and promotion of workers' health and working capacity; (ii) the improvement of working environment and work to become conducive to safety and health and (iii) development of work organizations and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings. The concept of working culture is intended in this context to mean a reflection of the essential value systems adopted by the undertaking concerned. Such a culture is reflected in practice in the managerial systems, personnel policy, principles for participation, training policies and quality management of the undertaking." As it is indicated in the definition, occupational health and safety focuses on creating more healthy and safe working environments for the workers. The goals of occupational safety and health can be summarized as follows;

- Protection of workers
- Protection of the safety of production
- Providing safety of the corporation
- Not to harm ecological environment

There are some scientific bases of occupational health safety which are medicine, economy, law, psychology and sociology. All of these bases are very critical for the health and safety of employees. It is very normal that occupational

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health and safety touches to law, medicine and psychology since its main focus is the health of the employees. It is also much related to economy for the governments and the companies. If a company adopts occupational health and safety, it will help this company to make cost savings. In terms of sociology, employee rights are very significant, so it can be said that sociology has a strong relationship with occupational health and safety.

A study indicated that, when looking at the history of occupational health and safety, it can be said that this is a recent topic. The need of occupational health and safety arose after Industrial Revolution. After Industrial Revolution, industries started to grow very fast. This situation caused long working hours with unsafe working conditions for the employees. Moreover, child labor was very popular in those years. Also, employees were working for very low amount of fees [3]. The first investigation about occupational health and safety was conducted by the father of occupational health and safety, Bernardino Ramazzini. Ramazzini [3] told that "You should look at the job of a patient firstly." He dealt with job diseases mostly. Although, an Italian laid the foundations of occupational health and safety, its evolution is mostly grew in United Kingdom. It is not hard to guess that the evolution was started in United Kingdom, because United Kingdom is the place which Industrial Revolution occurred potently. First judiciary regulation also took place in United Kingdom. In 1788, a law was published about preventing the child workers to work in chimney cleaning. However, it cannot be taken as the first step for protection of occupational health and safety. The first important judiciary attempt has done in again United Kingdom, in 1802 which is named as Health and Morals of Apprentices Act. This legislation was developed in order to regulate the working conditions in cotton mills. After that, in 1833 with Labour of Children in Factory Act, government inhibited the children who are under the age nine to work. These attempts have not been a permanent solution for the occupational safety and health problems. Finally, an international effort was made in 1919, establishment of International Labour Organization (ILO) [2]. As soon as it is established, ILO made substantial contributions to the working environment. According to ILO, six topics were focused on in the first International Labour Conference which was conducted in Washington, in 1919, which were, working hours, unemployment, ages, maternity protection, night work of young workers and night work of women [2]. The center of ILO is Genova, Switzerland. Now, members of ILO are getting together three times in a year. After the establishment of ILO, governments started to be a member of it and the attempts for occupational health and safety increased. ILO, published some contracts and it has the right to control the countries which approved these contracts. List of the contracts can be found in Appendix 1. Also, European Union has some instructions about occupational health and safety for the member countries. Even if a country did not approve a contract it should obey the instructions of EU as a result of being a member.

B. Occupational Health and Safety in World and Turkey

It can be obviously seen how occupational safety and health is crucial from the statistics of accidents in all over the World. According to ILO [2], in every 15 seconds an employee lose her/his life, about 2,3 million worker die due to occupational accidents and job diseases, over 160 million people have problems about occupational diseases per year and World is losing over 4% of GDP annually because of the accidents in the workplaces. In the table below, the occupational injury numbers of the regions can be seen. According to this data, despite the employment amount is low in Sub-sahara countries, their injury rate is very high. Obviously, in Asian countries the index is invincible, they experience lots of occupational accidents in a year.

According to [4]. European Union has also some instructions about occupational health and safety for the member countries. Even if a country did not approve a contract it should obey the instructions of EU as a result of being a member. There is an association called European Agency for Safety and Health at Work and this association collects and analyses the information about health and safety. Main tasks of EU-OSHA is data collection and analysis, prevention of the accidents and awareness campaigns.

In the table below, the death rates for some EU countries can be found. Most of the countries decreased the rate from 2001 to 2006, which is a good signal. However, Portugal's high numbers are signal.

The need for occupational safety and health was realized with coal mining in Turkey. First judiciary regulations were made in 1865. In 1921, despite the country was in a war, a law was made for the mining workers. Legislations are continued from 1936 to 1974. And, the laws which are made in 1974 maintained its permanence until 2003. In 2003, occupational safety became a law in Turkey and this law brought a new approach to occupational safety and health applications in Turkey. The negotiations with ILO start at 1927 for Turkey. The bases of occupational safety and health in Turkey can be listed as follows:

- The Law no.6331 Occupational Health and Safety Law
- The Law no.506 SGK Law
- Turkish Criminal Law
- Obligations Law
- Turkish Doctors Unity Law
- Environment Legislation
- Law of Trade Unions and Collective Bargaining
- Turkish Commercial Code

According to Social Security Institution (SGK) in 2010 [5], 62963 occupational accidents are occurred in Turkey [6]. 1454 of these accidents have resulted in with deaths. Moreover, 533 occupational diseases are inspected [5]. However, in 2013 191389 occupational accidents happened. There is a sharp increase about occupational accidents in Turkey between these years.

As it is known, Turkey has not a very good report card about occupational accidents. Especially, the accidents which are happened in Turkey have had a broad repercussion in press in 2014 [6].

III. Scope of Occupational Health and Safety Management System (OHSAS)

For all corporations, one of the most encountered problems is not to providing healthy and safe working environment to workers. Companies must perform a planned and systematic occupational health and safety procedure for workers in order

to reach much better condition of competition. Because ISO 9001 and ISO 14001 are most related with quality and environmental management issues, OHSAS (Occupational Health and Safety Management System) 18001 standard is a common necessity for applying successful occupational health and safety practices.

Main approach of OHSAS is to remove or eliminate all threats which have negative impacts on business' current situation [7]. Three main objectives are listed as:

(i)Safety of Workers: providing safe and peaceful working environment for workers.

(ii)Safety of Production: removing or eliminating the losses of workdays or production days by providing increment on working efficiency.

(iii)Safety of Corporation: Preventing the corporate from accidents by making all possible precautions.

Advantages of OHSAS are as follows:

1) Creating awareness about Work Safety on public.
2) Decreasing the level of risks that threaten all personnel's' health and safety inside the corporations.
3) Generating high level motivation for all employees.
4) Having prestige
5) Outmaneuvering on competition with others.
6) Creating proper environment for scientific support and technology transfer.
7) Not to prevent workers' routine operations by preferring practical ways.
8) Saving cost.

IV. Significant Definitions in Occupational Health and Safety Scope

There are many different definitions for occupational accident. According to World Health Organization (WHO), occupational accident is incident that is not planned before and usually causes injuries, damage on machines and equipment or halt of production. According to International Labour Organization, occupational accident is incident that causes a kind of injuries that is not considered before.

Detailed definition for occupational accident is undesirable incidents that people encounter when they are working in corporation or go and return times and causes damages for people and production, deceleration on production process and losses of products [8].

If it is thought as legally, incidents when occur,

- Insured person is located in corporation
- Person is working for the job that is given by employer
- Employer sends worker over to another place
- During breastfeeding activities of insured women workers
- During transportation of workers by a vehicle which is provided by employer are also accepted as occupational accidents.

Cost of accidents are analyzed in three ways:

(i)Direct Cost: treatment expenses, compensations, legal charges, sentences

(ii)Indirect Cost: losses of production, labor and time.

(iii)Other Cost: The impact of accident over the other workers. Deceleration of production process because of doubtful workers.

When reasons of accidents are investigated, it is important not to consider only one hypothesis. All possible hazards should be analyzed in details and necessary precautions must be stated. According to the research of Esin [9], occupational accidents are originated from human factors, environmental factors and technical factors.

V. Risk Management and Risk Evaluation

Risk analysis is one of the basic elements of Occupational Health and Safety procedures. Successful risk evaluation process brings well planned OHSAS 18001 management system. In Turkey, regulations which are related with Labour Law Legislation - the law no. 4857 are prepared for adapting to the European Union.

According to regulation of occupational health and safety, definition of risk prevention and evaluation is stated as:

''Employer must obey the following rules about protection of health and safety.''

- Prevention of risks
- Evaluation of unavoidable risks
- Struggling with risks at their sources

Definitions of risk analysis and evaluation can be described as follows:

Danger/Hazard: It defines the potential damages of different factors like physical, technical or environmental over people and corporations.

Risk: The combined result of probability of dangerous incident occurrence and intensity of incident's hazards.

Risk Evaluation: A systematic approach that aims to arrange all information about materials and situations which have possible dangerous.

Risk Management: Application phase of policies and studies in order to control and evaluate the risks that have negative impacts on people and corporations.

Moraru and Babut [10] stated that, risk evaluation methods are studies that should be made in order to specify possible hazards which are coming from inside and outside, analyze possible factors and determine preventions. Working under negative conditions can causes injuries, loss of organs and death. Therefore, it has to be first decision to determine if danger is important or not. Then, it is also significant that precautions are taken or not.

Main purpose of risk evaluation prevents the occupational accidents. Deeply and systematically analysis supports decreasing of hazards by providing understandable risk knowledge. For this reason, risk evaluation can be defined as assessment that is made in order to apply the basic principles of occupational health and safety in a systematic way [11].

So, risk evaluation process should follow this order:

1) Removal of hazards
2) Change with free of hazard
3) Change with less hazardous one
4) Making precautions/preventions
5) Protection activities

From a larger point of view, risk management includes the control phase of application of this precautions, determination of missing parts and repetition of risk evaluation if it is necessary.

A. Advantages of Risk Analysis and Management

As Ciocoiu and and Dobrea [13] stated that, the purpose of

risk analysis and management is defining procedures and studies that can decrease the impact of possible threats and respond to possible dangers.

Leading advantages of risk analysis and management can be listed as:

- It helps to conduct a written procedures and policies.
- It helps to inform employees and management level of corporation about occupational health and safety.
- Possible hazards and their precautions are stated with the help of risk analysis process.
- It helps to calculate the level of risks and their toleration.
- It helps to arrange corrective actions.
- It helps to measure and record of data and also follow the results.

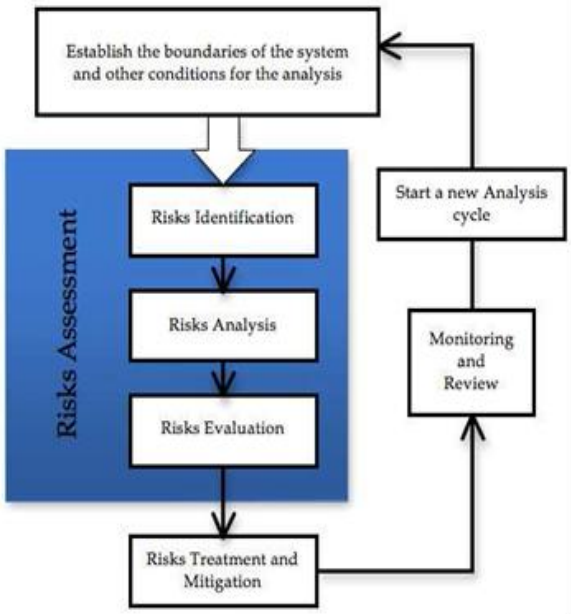

Fig. 1. Risk management overview [12].

B. Five Steps of Risk Evaluation

According to the information gathered from Kinney & Wiruth [14] and Lees [15] five steps of risk evaluation will be analyzed in this section under the headlines below.

1) Specification of Risk Hazard

The phase of specifying possible dangers for employees, products and equipment. It is important to investigate all things not to consider as big or small. Also in this phase, it is necessary to take all employees' opinions when conducting a list of possible hazards. Because they have a critical role to determine of hazards by the reason of close contact with them.

2) Evaluation of hazards

This phase includes evaluation of hazards that was mentioned in previous step and also risk rating for necessary ones.

3) Risk rating

In this step, calculation of weighted ratio of hazards are prepared separately. Thus, risks are listed as order of precedence. Main purpose is determining of damage level of hazards that cannot be removed by single operation. Stating damage level of hazards as low, medium and high provides advantage on planning corrective actions.

4) Application of prevention

For the urgent hazards which is stated in second and third step, preventions are immediately applied. Proper control period is stated in order to remove of possible repeater dangers. In addition that, detailed plans are conducted for preventions that requires complex cost and time extents.

It is almost impossible to remove all hazards in working area. Therefore, the purpose should be keep the dangers in acceptable level.

5) Tracking and review

Examination of current risk management is very important issue for all corporations. Thus, corrective actions or new systems can be applied just in time in case of any deficiency. It is a common requirement to check and refresh the scope of all these studies when there is change in corporation.

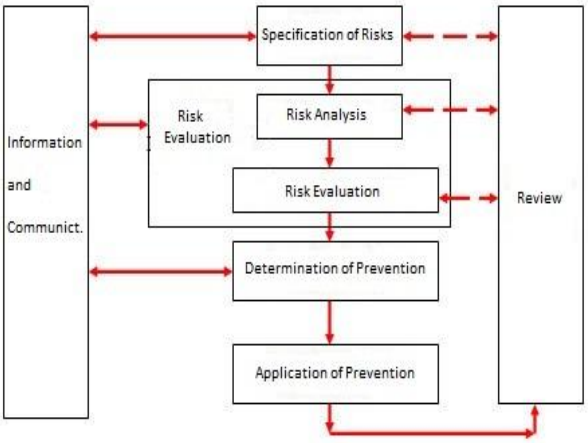

Fig. 2. Five steps of risk evaluation [16].

C. Risk Evaluation Methods

Risk Evaluation Methods are analyzed under the headlines below, according to the information gathered from Caldas *et al.* [17].

Qualitative Risk Evaluation Methods

1) Basic risk analysis

First of all, incidents are defined and then they are solved separately. These solutions can provide basic idea about for which kind of hazards need urgent prevention.

"What if?'' Method

Analysis starts with ''What if?'' question and it depends on the answers of this questions. It can be performed by low experienced risk analysts and it can be applied at any phase of processes.

This method is usually accepted as informal. Because analysts pay attention on just only one point, so they miss major hazard and they cannot obtain efficient results.

2) Hazard and operability study (HAZOP)

According to this method, results of undesirable accidents are examined and study is conducted in result oriented form. Most of the time, this study deals with processes in corporation and it is preferred usually in chemical industry.

3) Failure mode and effects analysis

This method is developed for prevention of poor quality prevention. It deals with possible risks of deficiencies in manufactured products. Main purpose is specify types of

fault and showing its effects. In addition that, this methods care preventions. This type of study is very beneficial for corporation, because it provides information about running of system and its deficiencies.

4) Fault tree analysis

Basic logic of this method is searching the factors that causes hazards. Fault Tree is an illustration that shows the relationship between system failure and components of this system.

Quantitative Risk Evaluation Methods

5) (5x5) L matrix method

L matrix method is the simplest one among the other calculation methods. The equation for this method is as follows

$$Risk\ Score = Likelihood(L) \times Consequences\ (C) \quad (1)$$

Equation includes two different terms namely likelihood and consequence (severity). Consequence describes ''how bad'' level of any risks. It is important to define consequences with objective ways. According to the rules of method, consequence is rated as; 1. Insignificant; 2. Minor; 3. Moderate; 4. Major; 5. Catastrophic

The likelihood of a risk occurring is assigned a number from '1' to '5': the higher the number the more likely it is the consequence will occur:

1. Rare; 2. Unlikely; 3. Possible; 4. Likely; 5. Almost certain

6) Kinney method

Kinney Method includes chance, frequency and severity terms. Chance is the possibility of hazard occurring. Chance factor is evaluated with 0.2-0.5-1-3-6-10. Frequency is repetition number of hazard exposure. Frequency factor is evaluated with 0.5-1-2-3-6-10. The last factor ''severity'' is the impact of hazard on people or environment. Severity is evaluated with 1-3-7-15-40-100. Kinney equation is as follows,

$$Risk\ Score = chance \times frequency \times severity \quad (2)$$

7) Ridley method

Ridley method includes three different terms namely, frequency, probability of occurrence and maximum potential loss.

$$Risk\ Score = frequency \times [\![prob.of\ occurance + max.potential\ loss \quad (3)$$

As it is stated before, there are two types of risk evaluation methods. First one is qualitative methods which depend on verbal comments and suggestions. These techniques are commonly considered by inexperienced risk specialists, but high level risk managers and risk experts usually do not prefer non mathematical calculations. Therefore, as second group of methods, quantitative risk evaluation techniques have strong validity for experts because of their numeric explanations.

Considering the information which is received from Practical Risk Analysis for Safety Management book [11], it can be said that among the quantitative methods, L Matrix technique only deals with possibility of accidents or incidents and its impacts. Because these two factors are scored from 1 to 5 points, it is not totally wrong to say that the method may not include all details about fact. For this reason, Kinney method has some advantages due to its frequency multiplier in equation. With this, Kinney method also contains the influences of previous accidents and represents the further hazards. Frequencies of previous accidents provide easiness for evaluation of every individual incidents in total accidents. In addition that, Kinney risk evaluation method is the most preferred one among the other quantitative methods and currently it is being used in military industry and different kind of production industries all over the world.

VI. Analysis and Results

The data gathered in the years 2013 and 2014 by the company has been started to analyze by us. The first findings were as follows:

- 491 accidents in 2013 and 894 accidents in 2014 were occurred, total number is 1385 accidents. The increase can be seen obviously from 2013 to 2014.
- 400 of the accident resulted in as going back to work. 985 of them included at least one day incapacity to work/disability. At the first glance, it seems to be the number of incapacity due to the occupational accidents, may have a negative effect on the production.
- Primary school graduates faced with 633 accidents. Correspondingly, secondary school graduates faced with 544 accidents.
- 87% of pain accidents and 85% of cut accidents were experienced by primary and secondary school graduates in 2014. It can be said that, there is a positive relation between the education level and experienced number of accidents.

If the accidents are analyzed according to the types of the accidents, there could be found some accident types which are; pain (lifting heavy things), pain, pain (instant movement), sting, sprain, pain (falling), electric shock, cut by curved knife, foreign objects to eyes, animal bite, cut, chemical exposure, fracture, cut by sheet metal, press and smash and burn. The numbers of these types of accidents have been given in the table below. In accordance with the interpreted numbers, pain accidents are the most common accidents in this company. Cut accidents are following the pain accidents in terms of the types of the accidents. When looking at the years, incrementally from 2013 to 2014 it is seen that they are conspicuous. Unfortunately, there is almost 100% increment in the total occupational accidents. Also, there is almost 50% increase in the pain accidents. When the pain data has been analyzed deeper, there is some amount of accidents which can be negligible because they are including the pain that the workers can feel during the work (i.e. headache) independent from the nature of the work. This number is 75 for 2014, 23 for 2013. When looking at the other numbers from the data, it can be seen that there are critical issues from the different approaches in terms of occupational accidents in the analyzed company.

Most of the accidents are observed in High End Factory. High End factory is the place where the televisions are produced. There is a heavy workload in this factory. The

most important accident types in this factory are; pain and cut. Because, in High End workers need to carry the televisions by themselves without any vehicle from the line to the shelves. Thereby, pain accidents are getting increased. On the other hand, there is a metal press line in High End and since the lack of the preventions, there occurs many cut accidents. The number of accidents in Digital Factory has been increased about 300%. This statistic is very invincible. There started to be produced new mobile phones, worker number has been increased, so this can be a reason for the sharp increase. Also, there is about 50% increase in Electronic Production and this number is very important too. This increase is in line with the total accident increase in the accidents, so the main reason cannot be identified specifically.

TABLE III: REASONS FOR ACCIDENTS

	2013	2014
Inattention, inattentiveness, clumsiness	291	488
Unlicensed/high speed vehicle usage	2	0
Work incapability	1	0
Lack of protective equipment	107	169
Improper carrying	1	0
Incorrect method	32	45
Unauthorized process	1	2
other	57	190

Inattention, inattentiveness and clumsiness are very important reasons for the accidents according to the graph and table above. The sharp increase from 2013 to 2014 has been observed in this criteria also. Besides, there is a problem about using personal protective equipment. Workers forget or do not prefer to use protective equipment during the work. Based on the information from the company, sometimes workers do not believe that the personal protective equipment would protect themselves. Furthermore, for some works they need to take off their personal protective equipment and they do not want to put on it every time again. Or, there is a lack of sufficient protective equipment from company's side. With regard to the gloves, there are more new-technology gloves for the company to buy. Moreover, some of the accidents are deriving from using incorrect method and improper carrying.

It is very obvious that primary school and secondary school graduates face with more accidents than others when looking at the figure above. The numbers again increased in line with the increase in 2014. Having big numbers of accidents by primary and secondary school graduates is not surprising but, the surprising one is university graduates that they face more accidents than high school graduates. However, the company is not separating the personnel who faced with the accidents as white or blue collar. Thus, it cannot be known that whether these university graduates are white or blue collar workers.

The types of the operations after the accidents were placed in the data also. When looking at the total numbers of the operations, sending to hospital has the biggest number. Thus, it can be said that there occurs lots of serious accidents in this company as injured people are sent to the hospital very often. The second biggest number is observed in dressing, after sending to work. Dressing also can be seen as a serious operation after going hospital.

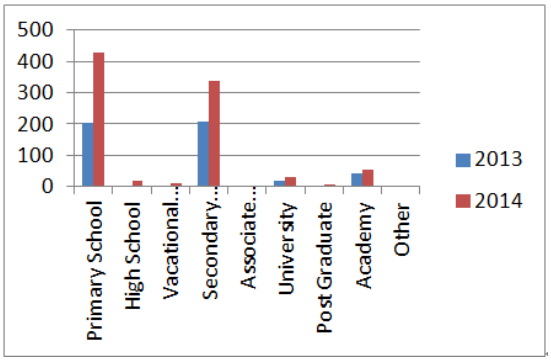

Fig. 4. Accidents by year and education level.

When the data is analyzed in terms of the educational levels, primary and secondary school graduates face with accidents resulting in going to hospital very often. This number can be seen in line with the total number of the accidents which they faced with. The accidents which primary and secondary school graduates face with result in starting work directly rarely.

A. *Kinney Scores Calculation for Accidents*

In this part, Kinney method risk scores for each type of accidents will be calculated according to data of accidents and other reports which are taken from the selected Company. As it is stated before in the literature content, Kinney risk scoring methodology has three different terms. First one is "chance'', it tells the probability of accident's occurrence. But at this point, the word ''probability'' is not related with mathematical meaning. Second factor is frequency. This multiplier is scaled according to the number of specific accidents. With using the number of a specific type of accident, frequency is chosen as 0.5, 1, 2, 3, 6 or 10. These numbers tell occurrence frequency of accident like once in a year, once in a month, once in a week or once a day. As a last factor, severity explains seriousness and importance of that accident type. Scaling numbers 3, 7, 15, 40, 100 tell significance of accident like near accident, minor injury, important injury, serious injury, fatal injury, and deaths.

With the help of data from the Company, Kinney risk scores of each accident types were calculated.

Risk scores are calculated separately for 2013 and 2014. In order to determine frequencies, accident data report for 2013 and 2014 was used. In addition for determining chance and severity scaling, the numbers that are accepted by the company were used. Because calculation includes same types of accidents for 2013 and 2014, chance and severity coefficients are same for both years. But in frequency coefficients, there are some differences because, ratio of number of any specific type of accident to total number of accidents differs.

In the light of results, for both years, pain, cut and cut by metal sheet accidents have high risk scores. Also there is a remarkable results for press and smash accidents in 2013, but this number showed a clear decrease in 2014. When it is evaluated with Kinney risk assessment, firstly ''cut by metal sheet'' accidents have intolerable risk with 420 points risk scores. It is extremely important to take an actions for these type of accidents. Secondly "pain'' accidents are taking place

in substantial risks group with 300 points risk score. Short term improvements are required for these type of risks. Finally, ''cut'' accidents are accepted as important risk group with 180 points risk score. These accidents should be prevented by long term precautions.

As a result, the paper will continue with studies related with these three types of accidents, namely cut, cut by metal sheet and pain.

B. Occupational Accident Cost Analysis

Depending on Kinney Method risk score calculations and occupational accidents data which is received from the company Company, at this stage, cost of three-type accidents will be calculated in terms of labor loss. These accidents are pain, cut and cut by metal sheet.

During cost calculation, there are different parts that should be considered. First one is calculated by impact of labor absence on production process. It explains the cost of workers who keep away from working because of any reason. According to information that is received from the company, if a worker keeps away from working because of any reason, it costs 12 TL per hour for company. So, total amount is calculated as multiplication of cost per hour, average number of days that workers keep away from working for different accident types and number of each accidents. Secondly, there are some transportation cost when workers are taken hospital by ambulance or car.

According to the information which is obtained from authorized personnel in the Company, after having accident the duration of keeping away from work differs between two days and six months. In order to make a calculation in here, for each accident types, average durations are accepted with the help of personnel instructions.

In the light of all these data, labor absence costs and transportation costs for three types of accidents were calculated.

Existing risk evaluation method was L Matrix (5x5) Method. This approach was very limited to find out the risks of possible hazards. Because, it was not evaluating the frequencies of the accidents. Therefore, in consideration of the accident report, Kinney method has been applied as a new risk evaluation method. A reasonable result has been obtained with the help of the accident frequencies based on Kinney Risk Evaluation Method. According to the risk scores, three types of accidents are chosen for the further evaluations which are cut, cut by sheet metal and pain.

In the following step, costs for chosen accident types based on 2013 and 2014 accident data has been calculated. Total costs of chosen accidents have been calculated as follows:

TABLE VII: COSTS IN TERMS OF ACCIDENT TYPE

	Total Cost (2013)(TL)	Total Cost (2014) (TL)
Pain	48361	110400
Cut	20654	40832
Sheet Metal Cut	14368	20416
Total	83383	171648

With regard to the observations in the company, solutions are offered for the improvement which are; personal protective equipment (PPE) [18, 19] usage, additional personnel for metal press line, education and automatic guided vehicles (AGV) [20]. Total costs and improvement rates of these solutions have been investigated and presented with the suggestions. In order to obtain more representative results, 2014 costs according to the accident types has been compared with the costs of the improvements. Additionally, the improvement rates of the solutions are compared with each other. These comparisons are given in the chart below:

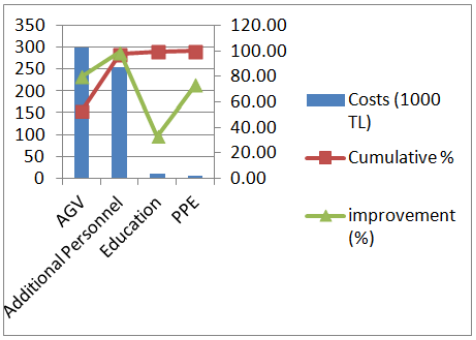

Fig. 5. Cost-Improvement analysis for the improvement types.

As a consequence of all these calculations, personal protective equipment is the first recommendation that is offered because of its low cost and high improvement rate. With this suggestions, the aim is to increase the personal protective equipment usage and protect the employees from the cut accidents. The suggestion includes replacing the existing gloves with the new ones and increasing their usage rate. Secondly, education option can be selected. Although the improvement rate of education is not convincing enough, it can be an option since it has a very low cost when compared to others and it will be a solution for all types of the accidents. As a result, large scaled solution will be suitable for this company. When looking at the other options, despite the improvement rates are remarkable, in terms of costs they are not applicable in business environment. Specifically for AGV, human factor has been eliminated so, the improvement rate is pretty high. Its cost is relatively high but, the payback period time is satisfactory. For additional personnel for metal press line, the improvement rate is almost 100% because it makes that line be reorganized. However, it has a very high cost to be implemented.

In the light of all these analysis, recommended suggestions have been decided as personal protective equipment and education in terms of cost and improvement rate. The other options were too costly for an immediate action. They can be considered for the further executions.

VII. CONCLUSION

In conclusion, in this study literatures related to occupational health and safety have been examined, new risk evaluation method is offered for the company analyzed and cost analysis of the accidents and the recommendations have been conducted in order to give a concrete solution for the accidents.

As a consequence of the literature review, it has been recognized that occupational health and safety issues which are a crucial focus of 21st Century, has gained importance in Turkey as well. In the literature review, global and local numbers of the accidents and information about important institutions from Turkey and World have been given.

Additionally, OHSAS procedures which is validated by all World countries, have been investigated in detail within this study.

In the second part of the paper, risk evaluation methods have been researched. It has been decided that, this company's' risk evaluation method, L Matrix Method, is not sufficient to find out the root causes of the accidents since it is not taking frequencies into consideration. Therefore, in order to obtain more meaningful result, the data has been analyzed according to Kinney Risk Evaluation Method. Under favor of this method, the most important accident types are determined which are; cut, cut by sheet metal and pain.

Lastly, costs of the chosen accidents are calculated according to the information that is given by the analyzed company. After that, suggestions to improve the occupational health and safety procedures of the company, have been explained. Four main suggestions have been offered which are; personal protective equipment (PPE), additional personnel for metal press line, education about occupational health and safety and automatic guided vehicle. Cost-improvement evaluation of these alternative suggestions have been conducted in the previous section. The most suitable alternatives were offered afterwards.

In consideration of all these outcomes, priory recommended suggestions have been personal protective equipment and education. Nevertheless, the company can consider the other options as well according to their budget and priorities.

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Hatice Camgöz Akdağ is a PhD on the field of quality, from Brunel University, UK; a MBA from Eastern Mediterranean University, Turkish Republic of Northern Cyprus; a BA from Bosphorus University, in Turkey. She is a associate professor at Istanbul Technical University, teaching Production Planning and Control, Quality for Engineers, Fundamental Topics of Production Management, Quality Standards and Certification and Total Quality Management courses. She is currently dealing with lean healthcare applications, value-added activities, specially doing projects on how to improve breast cancer departments patient flow. She has a number of publications on the subject of quality, six sigma and benchmarking and two best paper awards from international conferences.

She is also working on a project with a group breast surgeons who are member of senaturk in order to improve the quality and data registry in breast canser centers in Turkey.

K. Aybüke Uysal was graduated from Istanbul Technical University, Management Engineering Department in 2015. She has written her graduation design project under the topic of healthcare quality improvement.

Uğur Sezgin was graduated from Istanbul Technical University, Management Engineering Department in 2015. He has written his graduation design project under the topic of healthcare quality improvement.