

Analysis of Shipyard Accidents in Turkey

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Authors' contributions

This work was carried out in collaboration between all authors. Author AIY designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors FY and UBC managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Shipbuilding industry is one of the oldest and the heaviest production industries all over the world. There are several unsafe production processes which result accidents. Occupational accidents cause to death or injuries for workers, and financial loss for employers. For this reason, this study has been done for analyzing occupational accidents at Tuzla Shipyard Region-Istanbul-Turkey.

Methodology and Duration of Study: Research data has been obtained between 2011-2013 statistics of occupational accidents with "Retrospective Cohort" method in "Shipyard S" in Tuzla, Istanbul. Within this study, occupational accidents that occurred in the shipyard between those years are investigated.

Results: According to study results, victims' education level, ages, injured parts of the body, type and severity of injuries, reasons, effects and ratio of accidents due to seasons and months have been obtained. During the study, 13 major accidents, and 87 minor accidents happened. Primary

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school graduates or illiterate workers were exposed 39% of occupational accidents. Young workers under the age of 30 were exposed 59% of accidents. Eye (23%), hands (22%) and the finger (17%) injuries the most common injuries occurred in shipyard.

Conclusion: Both employees and employers should fulfill their responsibilities for occupational health and safety. All major and minor accidents in shipyards should be recorded, their causes should be investigated, and all necessary measures should be taken. Both shipyard enterprises in shipyard regions should perform within the framework of a management system for health and safety, and 'shipyard passport' application should be brought on the system in shipyard region. In this study, for analyzing shipyard accidents efficiently, Shipyard Accidents Analysis and Management System (SAAMS) modulus was prepared and various results were obtained.

Keywords: Safety; shipyard; accident analysis; shipbuilding.

1. INTRODUCTION

Shipyards and shipbuilding industry holds an important role for trading. Shipbuilding industry is referred as heavy industry due to the equipment used and the complexity of the total production processes. The shipbuilding and repairing industry uses and produces a wide variety of manufactured components in addition to basic construction materials. There are several production processes which cause accidents for occupational safety and health. There is a major manpower requirement to maintain production in shipyard industry under hard working conditions with hazardous materials. Shipbuilding is an extremely complex business, which means quite complicated tasks have to be performed parallelly. In addition, sufficient space must be provided for the storage of massive amounts of materials and equipment [1,2,3,4,5,6].

Though steel dominates in ships, aluminum and other materials are used for some superstructures like the deck-houses of ships and other specific areas within the ship. The industrial use of welding is highly labor intensive. The workers are exposed to fumes and gases which may be hazardous to their health. Mainly respiratory irritation and related effects, few chronic, long term effects have been directly attributed to welding fumes and gases [7,8,9].

Shipbuilding workers are also exposed to a variety of genotoxic compounds including polycyclic aromatic hydrocarbons (PAHs). Painters are exposed to a wide variety of hazardous substances including aromatic hydrocarbons, aliphatic hydrocarbons, ketones, alcohols, and esters in paints, thinners, hardeners, and other painting materials. The health risks of inhalation exposure to volatile organic solvents may not only depend on the total external dose, but also on the pattern of

exposure. It has been suggested that exposure to regularly occurring peak concentrations may have a stronger impact on the brain than constant exposure at the same average level [10,11,12].

Shipbuilding industry production process contains variety of occupational accident risks such as, falling, exposure to electric shock, explosion, being hit by equipment, construction machinery and crane accidents, fire, and hundreds of people die by means of these accidents all over the world. Furthermore, exposure to burrs, toxic fumes and dusts occurred by welding works cause injuries or occupational accidents that result loss working days. Major reasons of these accidents are; inadequacy of trainings and personal protection equipment that provided to employees, not implementing "working at height" methods, not carrying out periodic maintenance and systematic environment measurements, working with subcontractors and inadequacy of inspections. Additionally, as reasons of accidents analyzed, managerial faults come to the forefront. It has been seen that records of all major and minor occupational accidents haven't been kept, reasons of these accidents haven't been analysed, risk assessments haven't been done well enough and precautions haven't been managed within a management system and accidents occurred due to these reasons [2,13,14,15,16,17].

Purpose of this study is, with knowledge of previous researches, statistics and results of this study, investigating risk factors of work related accidents at shipyards in Turkey, determining necessary measures, establishing documentation and management system for tracking and filling work related accidents, and recommending Shipyard Accidents Analysis and

Management System (SAAMS) for filling and tracking work-related accidents.

Analyzing occupational accidents occurred in shipyards is important for identifying risks correctly, preparing occupational safety plans in workplaces, conducting occupational safety works systematically and avoiding from accidents that might occur in the future [18,19,20]. The research aims analyzing occupational accidents, investigating their reasons and building a management system with the aim of helping planning preventive actions by revealing factors that might create risks at the shipyards.

2. MATERIALS AND METHODS

Research data has been obtained between 2011-2013 statistics of occupational accidents with "Retrospective Cohort" method in "Shipyard S" in Tuzla, Istanbul. Within this study, occupational accidents that occurred in the shipyard between those years are investigated. Data are collected from the occupational physicians and safety experts' accident reports for registered occupational accidents.

Retrospective Cohort Method is widely used in medical research and monitoring. In this type studies, cohort is created in a previous time. Exposure and diseases are observed based on records collected during this time. At the planning stage of studies, how to create cohort and how long to be monitored is determined by researchers. In the next step, the exposure conditions of patients in the cohort and the results are analyzed. How to define criteria for exposure is determined at the planning stage. At the end of monitoring time, cause-effect relationships are investigated between accident and exposed risk factors. Retrospective cohort studies are based on records collected. Thus, the records must be accurate and reliable. Retrospective cohort method is widely used in the investigation of workplace accidents. This method has also been used in accidents analysis in shipyards [14,21,22,23,24,25,26].

Data collection was carried out with the permission of the shipyard. Before the start of the study, the shipyard is informed about the research objectives, scope and methodology. Research have been conducted with the support of the "Chamber of Turkish Naval Architects & Marine Engineers". Firstly, the software is designed to facilitate data collection and occupational health and safety staff (shipyard

safety experts, occupational physician and occupational health nurse) were informed about the use of the program. Data collection process was followed by weekly periods and shipyard occupational accidents and exposure information were recorded in detail in 16-month period.

A Visual Basic based software (Accidents Analysis and Management System) has been developed for analyzing detailed occupational accidents easier and faster. This software offers securing large amount of data about occupational accidents in the chosen shipyard. Additionally, the most important advantages of the software are ability of obtaining charts about accidents, making analysis based on the types of accidents, divisions where accidents happen etc. One can easily realize the lack of safety requirement related with the job by analyzing these charts.

In the light of the collected data by means of the computational software, 100 major and minor occupational accidents in shipyards were presented and classified by types and the causes, and demographic characteristics of exposed workers by analyzing of all the factors to cause occupational accidents. The victim's age, gender, education level, department, cause of accident, accident date, type of injury, type of accident, workday losses and related information were collected. Accidents that cause less than 3 days incapacity were classified as "minor", accidents that cause incapacity between 4-9 days were classified as "major". If workday loss is more than 10 days, it is called "major-serious" accidents. When determining the causes of occupational accidents, the findings were taken into account included in the accident investigation reports.

3. RESULTS AND DISCUSSION

3.1 Current Status in Turkish Shipbuilding Industry

Between 2002-2009, employment in Turkish Shipbuilding Industry has increased as required, especially due to the constantly increasing demand for shipbuilding sector. As a result of increasing in number of employees, number of accidents at workplaces increased too and occupational health and safety requirements became more evident.

Building new ships, repairing and maintaining has been processing in Turkish Shipbuilding

Industry. The demands of new ship buildings dramatically increased from 2002 to the end of 2008. After 2009 Global Crisis, the new ship demands were greatly reduced and replaced by repair and maintenance. In fact, laboring in repair and maintenance and shipbuilding is the almost same process. These are “handling, storage, lifting, grinding, scraping, painting, cutting, bending, welding, assembly and electrical works” which has same potential hazard for occupational accidents.

In Turkey, 80% of the workers are subcontracted from third party companies in shipyards. High amount of subcontractors limit the possibility of necessary organization and precautions for the workers’ health and safety issues. Working in open areas under cold and hot weather, rain, wind and similar bad weather conditions can cause dangerous working conditions (physical reasons) for accidents and loss of work motivation results with hazardous behaviors (personal reasons). Due to the increase in the amount of accidents with loss of life in Tuzla area in Istanbul, studies on workers’ health and safety are accelerated. But the missing systematical and scientific structure of these studies in Tuzla shipyard zone shows missing organizational share, necessary cooperation of the industry, preventive actions to solve known problems, the continuation problem of work health and safety studies, industrial and shipyard based studies with partial breakups causing loss of time and the loss of importance knowledge which can be summarized as the prevention of safety understanding to become a life style. Table 1

shows the risks of occupational safety in Shipbuilding Industry in Turkey [27].

Shipyards occupational accidents were classified by several statistical agencies under the construction or manufacturing topics. Shipyards occupational accidents are similar to those occur in construction industry, generally with the modification created by the characteristic requirement to work in restrained spaces [28]. In recent years, studies based on importance of occupational health and safety is not inadequate both in national and international wide. There are a limited number of studies about occupational health and safety issues in Turkey which are as Turkey Grand National Assembly [29], Turkish Presidency State Supervisory Board [30], Ministry of Labor and Social Security [31] as formal institution besides Chamber of Naval Architects [32] and Shipbuilders’ Association of Ship Industrialists [33]. Some researchers have investigated statistical studies for occupational accidents in shipyards and compared the situation of shipyards between Turkey and the World [34,35].

As a result of researches, reasons of the accidents occur at shipyards are shown in Table 2 in percentage basis. 30% of victims of fatal accidents occurred at Turkish shipyards are in 25-29 age group. According to the same research, 37.1% of fatal accident victims are welders. In Table 3, one can see more details for age range and occupation in fatal accidents [2].

Table 1. Risks of occupational safety in shipbuilding industry in Turkey (Akanlar et al. 2009 [3])

| Process | Occupational risk |
|--------------------------------------|--|
| Transportation, lifting, warehousing | Fall or crash due to not completing periodical maintenance of transport equipment. |
| Grinding | Eye injuries due to metal burrs from grinding, high noise effect on worker, risk of fire due to grinding sparks, fragmentation risk of grinding stone. |
| Blasting | Not wearing necessary protection for blasting, breathing dust and gas created by the blasting |
| Bending | Bending material can harm workers, reckless of worker during bending process, manual material movement risks. |
| Assembly | Holding material on crane during assembly and risk of crane malfunction, not using correct material for scaffold during assembly, falling from high assembly areas, exposing to welding fumes in segregated areas. |

Table 2. Classification of fatal occupational accidents in Turkish shipyards (Barlas, 2012b [2])

| Cause of the accident | % |
|-----------------------------------|------|
| Falling from a height | 39,1 |
| Exposure to electric shock | 15,7 |
| Fire and/or explosion | 15,7 |
| Being struck by or struck against | 12,1 |
| Caught in between (squeeze) | 7,8 |
| Others | 9.6 |

Table 3. Characteristics of fatal occupational accidents in Turkish shipyards (Barlas, 2012a [2])

| Factor (age) | Number of death | % |
|---------------------|-----------------|------|
| <20 | 7 | 7.8 |
| 20–24 | 13 | 14.5 |
| 25–29 | 27 | 30.0 |
| 30–34 | 16 | 17.8 |
| 35–39 | 9 | 10.0 |
| 40–44 | 11 | 12.2 |
| 45–49 | 4 | 4.4 |
| 50< | 3 | 3.3 |
| Work area | Number of death | % |
| Welder | 23 | 37.1 |
| Scraper and painter | 14 | 22.6 |
| Block Production | 9 | 14.5 |
| Electrician | 5 | 8.1 |
| Unskilled worker | 3 | 8.1 |
| Engineer | 2 | 3.2 |
| Plumber | 2 | 3.2 |
| Crane operator | 1 | 1.6 |
| Shipowner | 1 | 1.6 |

According to situation of shipyards, the main causes of accidents are as follows: Being unprepared for the rapidly increasing demand; the subcontractor system cannot work regularly; the lack of qualified intermediate staff; the lack of education of employees in the shipyards; the lack of audit; the insufficiency of penalties [36].

The shipbuilding and repair industry processes include surface preparation, painting and coating, metal plating, solvent cleaning and degreasing, machining and metal working, welding, vessel cleaning, and fiberglass operations etc. [37]. The organization of factories and workshops are very important in shipyards, because it directly effects production. Thus some shipyards are organized to specialization for rapid construction of certain types of ships. This kind of shipyard are capable of shipbuilding with lower costs in the shorter construction time [38]. The internal organization

of shipyard should be ergonomically arranged, departments and machines in the departments in accordance with work-flow. Otherwise, work accidents are inevitable.

Based on the evaluation of past accidents, the risk of possible accidents in shipyards depend on five different basis, which are falling from a height, electric shock, explosion, falling or collision of materials. When evaluating the accident, potential hazards and risks need to be introduced according to the nature of work to be done. Since hazardous factors like electricity, toxic gas and dyes are present at shipyards, the potential risks of them must be identified and some precautions must be taken to prevent relevant accidents [4,35,36,39,40].

Risks of falling from a height can be divided into two main factors; worker related and worker unrelated. During welding process, workers sweat and this increases conductivity. In such case, it is likely to get electrical shock when contacting with any electrical current. When setting up electric motors, workers may be exposed to sudden shocks. High-current electrical accidents are virtually fatal. Work environments are generally disorganized and messy. The cables ports' location is not very obvious. The material falls, shock or originated from work machines accidents occur [2,41].

In works related to electric machines, workers exposed to electric shock quite likely because of without taking safety measures and not using personal protective equipment. Shipyards frequently encounter fires caused by flammable and explosive gases. LPG, LNG, oxygen, hydrogen, acetylene and other gases can cause these types of fires. Explosion occurs due to buildup of gas when there is lack of proper ventilation in closed areas. Many flammable solids, liquids and gas substances are used in shipyard environment. These substances are potentially susceptible to explosion. Workers are exposed to risks of being struck by falling materials from scaffolds, and decks; most fundamental reason for those types of accidents are not using helmets and other personal protective equipment while welding processes [2].

3.2 Analysis of Occupational Accidents in “Shipyard S”

In Table 4, importance of the education levels of victims is being shown considering the rates of

accidents according to the education. Due to the low number of public education center graduate and literate workers, accidents experienced by these workers may not be considered.

However, the percentage of primary school graduates' accidents noteworthy. Because of this excess in number of accidents of primary school graduates can be interpreted as related with their low education levels. Percentage of vocational high school and high school graduate's accident is due to the multitude of workers at this level. In addition, workers who had accidents can be defined as the young people. Assuming that 90% of workers exposed to work-related accidents are under 40 years of age.

In a national study (Dizdar, Toprak) Turkey's shipyards' accident analysis was performed according to the age of the workers. Considering the study according to this criterion, the vast majority of young workers (19-24 age group) are exposed to 32.6% of accidents, while the 25-29 years age group is 19.8% and 30-34 years age group is 16.3% [42]. Data in studies related to S Shipyard are parallel with these values. 19-34 age range young age in the S Shipyard reveal with a range of 73%.

Table 5 indicates that hands, arms, and fingers effected especially in significant accidents. In this situation, it can be considered that Personal Protective Equipment (PPE) is not used in the work. A similar situation exists for the eyes. Disusing of PPE in welding works and in the works to result in material splashing can cause eye injuries. Distribution of ratio of accidents which workers expose to whole human body states that almost 85% of accidents harm the upper part of the body.

Analysis of causes of accident graph illustrates that majority of accidents occur due to falls and collision or splashing of objects. The reasons of this accidents extremely simple such as

unsecured scaffold and disusing or depriving of PPE.

Analysis of factors causing accidents state that nearly % 80 of accidents happen due to unsafe conditions such as unsafe design, inadequate protection, insufficient tools and machines. In Table 6 percentage of factors of accidents are given. Position of the Personal Protection Equipment in this table shows the importance of PPEs as a factor.

Employee's sick leave, which cause workday loss after the accident is also an extremely important issue. Accidents resulted in disability more than 3 days are defined as 'major accidents'; accidents resulted in disability less than 3 days are defined as 'minor accidents'. If workday loss is more than 10 days, it is called major and serious accidents. It is known that minor occupational accidents, which are not considered sufficiently and even not registered, cause great financial loss in workplaces. Since 87 of 100 accidents are minor accidents, but 13 of 100 accidents are major accidents. Table 7 gives an idea about seriousness level of accidents.

Importance levels of accidents are significant because they are examples of gaining experience for other accidents. Priority is given to high importance level issues in forming risk analysis. %50 of employees are outpatient and go back to business on the same day. %32 of employees have sick leave between 1-3 days. Due to medical conditions of %17 employees are serious, their treatment are done in medical center. During this period in a very big accident exposed by a worker, the worker started maintenance of the machine without shutting it down and taking security precautions and he had a spinal cord injury due to being jammed in the machine.

Table 4. Educational status and the number of victims by age for “Shipyard S” between 2011 and 2013

| Educational status\age (%) | 19-24 | 25-29 | 30-34 | 35-39 | 40 + | Total |
|-----------------------------------|--------------|--------------|--------------|--------------|-------------|--------------|
| Public training certified | 1 | 0 | 0 | 0 | 0 | 1 |
| Literate | 0 | 0 | 0 | 2 | 0 | 2 |
| Primary school | 6 | 7 | 9 | 9 | 5 | 36 |
| High school | 9 | 3 | 3 | 2 | 4 | 21 |
| Vocational school | 19 | 3 | 2 | 2 | 1 | 27 |
| Junior college | 3 | 4 | 0 | 1 | 0 | 8 |
| University | 4 | 0 | 0 | 0 | 1 | 5 |
| Total | 42 | 17 | 14 | 16 | 11 | 100 |

For the better assessment of Fig. 1 containing all accidents in 2012 and accidents in the first 6 months of 2013, merely evaluation of accidents in 2012 is carried out. According to this, there is a remarkable increase in number of accidents in summer season when weather warms up and workload intensifies. Since this evaluation consists of only 1 year's accident values, it cannot be possible to understand valid value for overall sector.

Table 5. Injured body parts after the occupational accident for “Shipyard S” between 2011-2013

| Injured body parts | % |
|--------------------|----|
| Eyes | 23 |
| Hands | 22 |
| Fingers | 17 |
| Arms | 7 |
| Toes | 7 |
| Body | 5 |
| Internal organs | 4 |
| Feet | 4 |
| Head (Eyes down) | 4 |
| Head (Eyes up) | 3 |
| Spinal Cord | 3 |
| Legs | 1 |

Table 6. Percentage distribution of the factors of accidents for “Shipyards S” between 2011 and 2013

| Factors of accidents | % |
|---|----|
| Inadequate PPE | 23 |
| Unsafe design | 18 |
| Unsafe arrangement | 17 |
| Defective or deficient equipment | 13 |
| Unprotected machine | 7 |
| Slippery, weak and uneven ground | 4 |
| Poor cleanliness and tidiness | 3 |
| Disorder of equipment, machinery and system | 3 |
| Incorrect/Inadaquate instruments/equipment | 2 |
| Inadequate alert system | 2 |
| Others | 8 |

Table 7. After the occupational accidents, loss of workforce by rate of accidents

| Classification of the loss of workforce | % |
|---|----|
| Without lost work days (Minor) | 65 |
| 1-3 days (Minor) | 22 |
| 4-9 days (Major) | 3 |
| 10 days and over (Serious, Major) | 10 |

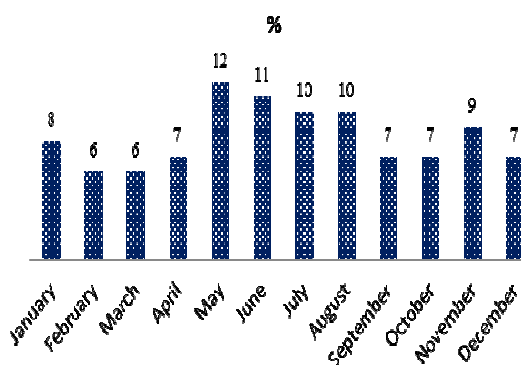


Fig. 1. Number of accidents by month for the year 2012

4. CONCLUSION

In this study, 100 pieces of shipyard accidents registered into the software for examination. The result of this study shows the facts about the ages and education level of the victims, injured parts of the body, degree of injury. There has been no fatal accidents in the chosen shipyard during the research period. Only 1 severe injuries occurred. It is known that minor occupational accidents, which are not considered sufficiently and even not registered, cause great financial loss in workplaces. Since 87 of 100 accidents are minor accidents, but 13 of 100 accidents are major accidents.

According to the survey results, primary school graduates or illiterate workers were exposed 39% of occupational accidents. On the other hand, young workers under the age of 30 were exposed 59% of accidents. As a result of accidents, eye (23%), hands (22%) and the finger (17%) injuries the most common injuries occurred in shipyard. Hand tools, welding, grinding, metal cutting, bending, assembly works are cause such accidents in shipyards. “Falling from height” is the primary cause of death in shipyards. However, through effective measures taken, there has been no “falling from height” in shipyard “S”.

According to the causes of occupational accidents; “inadequate or non-use of PPE” has been found as the most important factors of accidents. Besides, “unsafe design”, “unsafe arrangement” and “defective or deficient equipment” were determined as other important causes of the accidents. Shipyard production and employment is increasing during the summer.

Thus, shipyard accidents are increased in summer seasons. Since 87 of 100 accidents are minor accidents, but 13 of 100 accidents are major accidents. During the study, minor accidents have resulted 44 workday loss while major accidents have resulted 138 workday loss. Workday losses were caused great financial loss for employer.

Carelessness of employees is the main reason of accidents. All employees have to pay attention to usage of PPE. It should be given educational, instructional and informative occupational safety seminars covering all topics and risks. Necessary steps should be taken to get rid of mistakes after examination of occupational safety reports prepared by both company and whole sector. Till the obligation of using personal protection equipment becomes workers' own decision, trainings have to be given and this process should be followed continuously.

Jobs should not be given to a person who doesn't have expertise in business. Alerts and guiding signs should be placed according to the work done and attention should be given to them. Work areas should be ventilated regularly. In all electricity areas necessary controls should be done permanently.

Permanent environment measurements should be taken for work to be done in closed areas. Attention should be given to the air temperature in the work environment and work environment's temperature should be adjusted properly. Personal Protective Equipment (PPE) should be defined and classified according to the work and material.

It is understood here, occupational safety related studies in shipyards should be carried out within the framework of a management system and detailed report of occupational accidents occurring in the shipyards should be kept. Risk assessment studies should be done and revised in the light of examining causes and results of accidents in detail. In Tuzla-Istanbul region where most of the shipyards have been existed, the safety and health should be addressed in a systematic way as well. To minimize the hazardous waste materials, to protect the workers' health in a long term, these traditional production methods should be replaced with alternative new production technologies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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