ANALYSIS OF RISKS IN NIGERIA SHIPBUILDING INDUSTRY

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CERTIFICATION

This is to certify that this thesis **"Analysis of Risks in Nigeria Shipbuilding Industry"** was carried out by **Anyanwu Nnamdi (Reg. No: 20194193468)** in the Department of Maritime Management Technology, School of Management Technology Federal University Of Technology Owerri, for the award of Master of Science (M.Sc.) Degree in Maritime Management Technology.

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DEDICATION

This thesis is dedicated to my dear wife, Mrs. Christiana Anyanwu for the special love, moral support and understanding throughout the period of this work. It is also dedicated to our children, Victoria, Christiana Anyanwu.

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All thanks to God for granting me strength cum divine grace to embark on this work and for its glorious conclusion. May all glory and honour be unto Him.

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ABSTRACT

The aim of the study was to determine the determinant risks of occupational injury and illness associated with exposure to hazards in the shipbuilding and repair sector in Nigeria. The study used Starzs shipyard Onne, Rivers shipbuilding and repair clusters and Niger Dock shipbuilding facility in Lagos clusters and adopted a mixed research design approach in which both secondary data from the Environmental Health and Safety Department of the Shipyard and the primary data from survey were used. The method of principal component analysis , Risks analysis methods, and descriptive statistics cum inferential statistics were used to analyze the data obtained. It was found that, welding and cutting hazards, chemical fumes and dust inhalation hazards, and noise hazards with Eigen value for each exceeding 1 (Eigen value>1), constitute the determinant hazards of Starzs shipbuilding and repair facility in Rivers clusters in Nigeria while in Niger Dock Shipbuilding facility Lagos clusters, risk of hazards associated with welding fabrication and cutting, noise hazards, chemical fumes and metallic particles inhalation, hazards linked to vibration of equipment and hazards linked to fire and explosion each have Eigen value greater than 1(Eigen value>1), as a result formed the determinant hazards in the Niger Dock Shipbuilding and repair facility to which worker are exposed. The workers in Niger Dock are further significantly exposed to fire and explosion hazards and hazards linked to vibration of equipment in addition to the three hazard types (welding and fabrication hazards, noise hazards and chemical fumes and dust particles inhalation risks) to which workers in Starzs Marine Shipyard are significantly exposed. The implication is that dock workers in Niger Dock are exposed significantly to greater number of occupational hazard types than those in Starzs Marine Shipyard, implying that workers in the shipbuilding and repair sector in Nigeria are exposed to similar hazard types, but significance or proportion of exposure to each hazard type is a function of the shipyard. The findings of the study also indicate that burns injury, rhinorrhea illness, cuts injury and tinnitus illness pose the greatest levels of risk of occurrence in Niger Dock. The result also indicates that about 42.1% of the dockworkers identified the existence of fall hazards (slips and trips hazards) in the shipbuilding sector in Nigeria while 77.3% of the respondents identified that dockworkers are exposed to electrical hazards in the shipbuilding and repair sector in Nigeria. About 62.5%, 83%, 26.1%, 99.8%, 52.3%, and 84.1% of the respondents identified that dockworkers in the shipbuilding and repair sector are exposed to vibration hazards, noise hazards, biological hazards, welding & cutting hazards, fire & explosion hazards, chemical fumes and dust hazards respectively. The implication of this is that the shipyard and the shipbuilding and repair sector in Nigeria should prioritize the control reduction and elimination of the occupational injury and illness types that pose the greatest risk of occurrence and consequences in Nigeria.

Keywords: workplace-Hazards, risks-analysis, occupational-safety, shipbuilding-and-repair-industry, accidents, incidents, diseases.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The concept of shipbuilding is viewed as the process of construction on new ships in a shipyard and the remodeling, conversion and recycling of older ships into new ship types. Every newly built ship has a life span of between one and 25 years. Ships are usually made of various metal types, making it obvious that, the processing of the metals, the painting, and sandblasting processes, will constitute various dangers of health cum environmental hazards to the society.

Given that a vessel is usually made of systems composed of various kinds of metals such as Iron, Aluminum, Steel, alloys, etc.; these are radioactive elements, oxidants, toxic paints pigments and electrically charged components which when exposed to humans in an environment, constitute risks of serious health hazards. It is viewed that, shipbuilding and conversion has potentials for causing serious health and environmental hazards to workers in the marine ecosystem.

Health and environmental hazards in this concept are conditions that are viewed as having the capability to cause health injuries and marine environmental degradation. This is the major reason for the constitution of health and environmental risk assessment before the location of shipbuilding and conversion facilities around or within environments inhabited by people (Osha, 2013).

Nigeria is a maritime nation, blessed with a coastline of about 870km and about 3000 kilometers of inland waterways. The country's natural resources include petroleum, natural gas, tin, columbite, ironore, coal, zinc, limestone, lead, and in reserve, the country holds 37,070,000,000 barrels of proven oil reserve, 202 trillion cubic feet of gas and 42.74 billion metric tons of Bitumen. The economic value of these resources to the nation in terms of foreign earnings is directly related to the maritime component of the respective industries. Oil and Gas (O&G) sector is the predominant sector in Nigeria's short-sea trade and is estimated to constitute about 95% of coastal and inland shipping while fishing trawlers and break-bulk carriers make up the remain 5%. This presents enormous coastal trade opportunities for shipping companies in Nigeria. The Government, mindful of the need to develop indigenous merchant marine fleet has at various times initiated policies and projects to boost indigenous vessels acquisition. Notable in this respect was the acquisition of 24 vessels by the now defunct Nigeria National Shipping Line (NNSL) in the 1970s and the establishment of the Ship Acquisition and Shipbuilding Fund under National shipping policy Act 1987 Cap 44 of 1990. Unfortunately the laudable initiatives aforementioned failed to achieve their objectives. Nigeria has taken significant strides to protect its indigenous shipping industry. In 2003, the country's government passed the coastal and Inland shipping (cabotage) Act, which put into law several conditions relating to participation in shipping activities, chiefly that vessels must be built and registered in Nigeria, and owned and manned by Nigerian citizens.

The requirement that vessels must be built in Nigeria presents a huge opportunity for shipbuilding activities in Nigeria which is presently at a low. A country like Nigeria should not be talking about shipbuilding, when the market for new building is low and the basic raw material is lacking. However, there are about 10 ship repair yards in the country, including Starzs shipyard which stands as the oldest privately-owned indigenous ship repair yard, and has so far carried out more than 950 dry docking and refits for clients within and outside the country. The company commenced full operation on 28th October 2000,when she docked successfully one of seacor marines service boat called MV Blair m'ccall. Starzs shipyard is located at Federal Ocean Terminal, FOT in Onne, operating on an International Ship and Port facility Security (ISPS) Code level 1. The name of the floating dock is Chrisbar Bridgetown, which has nine ballast tanks and three pumps, with a 2 ton revolving crane and two winches on each vertical side. The length of the dock is 30 meter while the width is 11 meter. A reasonable workforce is required in production areas under difficult conditions while handling hazardous materials. Most of these production areas include welding, painting, blasting, and fiberglass production have a direct effect on workers' health. For example, exposure to volatile organic compounds (VOCs) and fumes generated from burning base metal, as well as a substantial generation of Nitrogen oxides (NOx) gases during the welding and cutting processes can cause severe and chronic health problems (Celebi and Alarein,2010). In recent years, research pertaining to health and safety issues of shipyard workers has flourished. While some studies were conducted on how process outcomes (fumes, spark, asbestos) adversely impact on the health of the shipyard workers, others focused on the consequences of environmental factors (dust, noise, vibration, VOCs) on the shipyard workforce (Coggon & Palmer 2016; Selikoff & Hammond, 1978; Kilburn,Warshaw & Thorton, 1985; Cherniack Brammer, Lundstrom, Meyer, Morse, Nealy & Fu 2004; Gillibrand,Ntani & Coggon,2016; Malharbe & Mandin,2007). The shipyard environment demands constant caution to control or mitigate the hazards inherent in the production processes.

It is necessary to identify and manage any potential hazards, hazardous situations using risk analysis tools and techniques such as Failure Mode Effects and Criticality Analysis (FMECA), Fault Tree Analysis (FTA), Hazard and Operability studies (HAZOP) or Preliminary Hazard Analysis (PHA), which are safety analysis methods applied to the design for safety processes. It is strongly suggested that PHA be carried out in the initial stages of the marine and offshore system design process. Using PHA, a checklist of conceivable hazards, and hazardous situations, related to Starzs shipyard were identified. The data collected for analysis was generated through interviews and a survey. PHA is a semi-quantitative analysis that is widely used to detect all potential hazards that may lead to an accident and prioritize them based on their severity and recommend the supplementary initiatives in order to alleviate the hazards (Rausand, 2004). PHA helps to generate a hazard log which assists the incessant observation of a hazard to ensure that it is under control or eliminated (Pinto, Magpili & Jaradat, 2015).

1.2 Statement of the Problem

Most ship production areas such as welding, painting, blasting and fiberglass production have a direct effect on workers' health. For example, exposure to fumes generated from burning base metals, as well as a substantial generation of Nox gases during the welding and cutting processes can cause severe and chronic health problems. The shipyard environment demands constant caution to control or mitigate the hazards inherent in the production process. Available empirical literatures have been able to establish that ship building and conversion is associated with health injury and environmental hazards, particularly to the workers exposed to the shipyards. However, there is a seeming knowledge gap backed with empirical evidence of what constitute the determinant health and environmental hazards associated with the professional shipbuilding industry in Nigeria. Thus, no empirical information is available to provide evidence of the level of impacts of shipbuilding and the determinant health hazards and risks of injury and death associated with shipbuilding in Nigeria. Therefore, there is a problem of seeming lack of information and knowledge of what constitute the determinant shipbuilding health and environmental hazards, evidencing the impacts of shipbuilding industry on maritime workers and environment.

The existence of the above identified challenges constitutes the major problem which the study identified. Closing the identified knowledge gap will thus ensure that actions are strategically taken to curtail the impacts of ship demolition on workers' health and environment by concentrating mitigation attempts on the determinant hazards of ship demolition to workers and the environment

1.3 Aim and Objectives of the Study

The aim of the study is to identify and evaluate the determinant workplace hazards in the shipbuilding/repair industry in Nigeria with a view to developing procedures, strategies and practices that limits the occurrences of occupational accidents and work-related injuries in Nigerian shipyards.

The specific objectives of the study are:

(i) To identify the determinant workplace health hazards in the shipbuilding industry in Nigeria.

(ii) To evaluate the risk of injury to health of dockworkers associated with workplace hazards in the shipbuilding sector in Nigeria.

(iii) To evaluate the risk of illness to dockworkers associated with workplace hazards in the shipbuilding industry in Nigeria

(iv) To determine the dominant health risks posed by hazardous conditions in the shipbuilding in Nigeria

1.4 Research Questions

Research questions on this study are:

(i) What are the determinant workplace health hazards in the shipbuilding industry in Nigeria?

(ii) How can the risk of injury to health of dockworkers associated with workplace hazards in the shipbuilding sector in Nigeria be evaluated?

(iii) How can the risk of death to dockworkers associated with workplace hazards in the shipbuilding industry in Nigeria be evaluated?

(iv) What is the dominant health risk posed by hazardous conditions in the shipbuilding in Nigeria?

1.5 Hypothesis

The following proposed hypothesis will be tested for their validity in the course of this research

H_{01}: There are no determinant health hazards in the shipbuilding industry in Nigeria.

H_{02}: The risk of injury to health of dockworkers associated with hazards in shipyards in Nigeria is undefined.

H_{03}: The risk of death to dockworkers due to exposure to hazards in the shipbuilding and repair sector in Nigeria is indeterminate.

H_{04}: There are no determinant health risks faced by dockworkers in the shipbuilding industry in Nigeria.

1.6 Significance of the Study

To improve the decision making process relevant to risk control and mitigation, a (PHA), will be used to develop an initial listing of potential hazards and hazardous events that affect workers' health and safety. Following the initial listing of the hazards, the study presents a hazard evaluation worksheet (PHA worksheet), based on a systematic approach, which is designed to help the shipyard take corrective actions.

1.7 Scope of the Study

Theoretical Scope: Theoretically, the study is limited to the determination of the determinant health hazards of shipbuilding, the determinant environmental hazards of shipbuilding, the determination of the significant hazards mitigation measures in the shipbuilding industry in Nigeria and the identification of the major health risks of shipbuilding in Nigeria.

Geographical Scope: The study used a case study approach, using Starz marine shipyard in Onne, in the Rivers state shipbuilding clusters as a case study to study the Nigerian ship building industry in general.

Time Scope: The secondary data used for the study covered the period between 2014 and 2017.

1.8 Definition of Terms

Accident: An undesirable event that results in damage to humans, assets and/or the environment.

Hazards: Possible events and conditions that may result in severity, i.e cause significant harm.

Incident: An undesirable events that are detected, brought under control or neutralized before they result in accidental outcomes.

ILO: International Labour Organization.

IMO: International Maritime Organization.

Process: A set of interrelated resources and activities which transforms input into output.

Risk: An evaluation of hazards in terms of severity and probability.

Shipyard: A place where ships are built and repaired.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Concept of Occupational Hazards in Shipbuilding

Occupational hazards in the shipbuilding industry represent underlying condition and practices with inherent capacity to cause the occurrence of accidents in a shipyard (Agusionu, 2018). Occupational hazards are unsafe conditions (physical and nonphysical), unsafe work practices, that form the root causes of accidents in shipyards, thus, threatening the safety and health of dockworkers since accidents induce injury, death and/or damages to properties exposed to it. For example, in the shipyards, fall hazards, hazards associated with inhalation of chemical fumes and particulate matter, radioactive hazards, collision hazards, chemical-explosion hazards, etc are preponderance with each of these categories of hazards having the inherent capacity to cause the occurrence of accidents with the consequent injury and death effects. Thus, occupational safety and health studies particularly in the shipbuilding industry dwell much on the study of the hazards associated with shipbuilding as a root cause approach towards eliminated the occurrence of accident induced injury and death of dockworkers (Agusionu, 2018). The identification and assessment of the occupational hazards associated with shipbuilding is therefore a positive approach that provides proactive insights into the prevention of occupational accidents in shipbuilding and the associated loss prevention which can be transferred through the company`s safety management system.

In the context of this study therefore, we define the concept of occupational hazards in shipbuilding as the unsafe practices, unsafe physical conditions, and unsafe non-physical conditions such as inappropriate work procedure and practice that form the root causes of occupational accidents in shipyards, with the attendant injury and death of dockworkers in the shipbuilding sector in Nigeria. Hazard identification in the concept of the study is thus viewed as the determination and bringing to fore, all the unsafe practices and unsafe conditions that form hazards of shipbuilding and the root causes of all occupational accidents and the associated injury and death of workers in the shipbuilding sector in Nigeria. Hazard identification is viewed by Agusionu (2018) as the first step towards hazard assessment, while hazard assessment is the determination of the level of risk and impact the occurrence of occupation accidents induced by a particular hazard as a root cause can have on the organization. The purpose of hazard assessment being to employ hazard control tools to limit as much as possible the manifestation of a hazard into an accident and the impact such an accident may have on the organization (Rayner, 2000).

2.1.2 Concept of Workplace Hazard Assessment

Agusionu (2018) note that hazard identification is the first step towards hazard assessment, while hazard assessment is the determination of the level of risk and impact the occurrence of occupation accidents induced by a particular hazard as a root cause can have on the organization. Thus, part of the purpose that hazard assessment must first fulfill is hazard identification, which aims at identifying and bringing to the fore all hazardous substances, unsafe conditions and unsafe practices that constitute hazard in a given workplace. Workplace hazard assessment is thus employed as hazard control tool to limit as much as possible the manifestation of a hazard into an accident and the impact such an accident may have on the workplace (Rayner, 2000).

One way of ensuring that action is taken before a hazard result into an accident/disaster particularly in the shipbuilding sector, is the use of hazard assessment. This has been described as "a rational and systematic process for assessing the risks associated with shipbuilding and shipping activity and for determining whether unsafe work conditions and unsafe practices and substances exist in a workplace, that can cause the disaster of injury and death to dockworkers once exposed to the source of hazards, (IMO, 2009).

ILO (2001) views that based on the inventory of hazardous substances, the workplace should regularly be inspected and information obtained on:

(a) hazardous substances that are present or likely to occur, along with other hazardous ambient factors; and

(b) hazardous activities and processes.

ILO (2001) notes that in the case of identified chemicals, the employer should obtain information on the intrinsic hazards of the substances or products according to the physical state (for example solid, liquid, gas) in which they are provided by suppliers and the inventory of hazardous materials, if available. Where this is not practicable, employers should obtain information provided by other bodies such as the International Agency for Research on Cancer (IARC), the World Health Organization (WHO), the International Programme on Chemical Safety (IPCS), the European Union and other competent international and national institutions (ILO, 2001, IMO, 2009).

Furthermore, where the expected risk is from exposure to mineral or synthetic fibres, mineral dusts and vegetable dusts, employers should consider, in particular, the provisions in the Asbestos Convention, 1986 (No. 162), and the Asbestos Recommendation, 1986 (No. 172), the ILO codes of practice on occupational exposure to airborne substances harmful to health (1980), safety in the use of asbestos (1984), and safety in the use of synthetic vitreous fibre insulation wools (glass wool, rock wool, slag wool); and the ILO(2001) guide on Dust control in the working environment (silicosis) (ILO, 2001; IMO, 2009). Employers seeking information for assessment should take account of specific work situations where workers are likely to be exposed, for example, to:

(a) Hazardous fumes as by-products (for example welding);

(b) Hazardous substances and oxygen deficiency in confined spaces;

(c) Prolonged periods (such as during overtime) with the risk of accumulation of higher doses;

(d) Higher concentrations due to fluctuations in ambient conditions (for example hot environments where vapour pressures of hazardous substances may be elevated);

(e) Absorption through multiple routes (inhalation, ingestion, absorption through the skin); and

(f) Hazardous substances that may be present even in concentrations below exposure limits while performing arduous tasks.

IMO, (2009) observed that as listed above, the exposure limits specified by the competent authority for normal work situations would in some cases not reflect the workers' exposures. Employers should therefore accordingly obtain practical information from the competent authority, international organizations and institutions (ILO, WHO, IPCS) or other bodies.

ILO (2001) notes that the second stage of the hazard assessment in a workplace involves the use of the information obtained to assess the risk to health resulting from exposure, especially from the effects of chemical mixtures, and should also take account of:

(a) Routes of entry (skin, inhalation, ingestion);

(b) The risk of penetration through damaged skin or seepage through PPE;

(c) The risk of ingestion;

(d) Levels of airborne concentrations of hazardous substances;

(e) The rate at which work is performed (for example arduous tasks);

(f) The length of exposure (for example higher exposures resulting from prolonged overtime); and

(g) The influence of other ambient factors (for example heat) in enhancing the risk of exposure.

At the third stage of the assessment, the need for a programme for the measurement of airborne contaminants (monitoring) should be determined. According to ILO (2001), such a programme is required to:

(a) Determine the extent of exposure of workers; and

(b) Check the effectiveness of engineering control measures.

Categories of Hazards of Shipbuilding and Repair Sector

(A) Slips and Trips Hazards

Aage,(2001) notes that Slips and trips are one of the most common types of hazards in shipbuilding and repair industry**.** They are mostly categorized as fall hazards in shipbuilding and repair sector.

Injuries such as strains, sprains, bruises to joints and muscles, ligaments, tendons and bones are often the consequences of slips and trips which represent fall hazards in the shipbuilding and repair sector (Aage, 2001). Common examples of trips and slips hazards include missing walkways, materials left in walking aisles, deterioration of steps and stairs, unprotected openings, poorly maintained ladders and walking surfaces rendered slippery by:

a wet or oily surfaces;

b occasional spills;

c weather hazards;

d loose covers of decks or floors; or

e low friction of wet or steel decks.

Other causes of trips and slips hazards representing unsafe workplace conditions are Inadequate lighting, poor visibility, waste, uncovered electrical cables or air and gas hoses, and uneven walking surfaces can also be significant factors. The risk of accidents is increased when workers carry objects that block their view or are too heavy or awkward.

To prevent and or eliminate trips and slips hazards in the workplace, the following basic conditions are necessary:

(i) Employers should assess the risk of slips and trips, especially during maintenance, when the risk can be higher.

(ii) Slipping should be prevented, for example by placing rubber mats on decks and on travel lines for pedestrians in front of ships, particularly in wet or icy conditions.

(iii) Tripping should be prevented through the use of hand- rails and of battery-operated power tools to minimize the need for electric cables. Walkways and floors should be kept clean and free from tools, including:

a additional tools, material and equipment that are not necessary to perform the job in progress;

b debris, including solid and liquid wastes at the end of each work shift or job; and

c all cables and hoses crossing walkway (Aage, 2001)

(B) Noise Hazards

According to ILO (2001), noise hazards constitute one of the identified hazard categories in shipbuilding and repair operations. Noise hazards have capacity to cause injuries in the form of hearing impairment and hearing loss. ILO (2001) and IMO (2009) agree that a competent authority should set standards for the maximum noise dose considered acceptable to prevent hearing impairment in the working environment on a daily basis and for the maximum peak noise level. IMO (2009) views that when monitoring areas of high noise exposure, the employer should, as appropriate, consider the:

(a) Risk of hearing impairment;

(b) Degree of interference to communication essential for safety purposes

(c) Risk of fatigue, with due consideration of the mental and physical workload and other non-auditory hazards or effects.

In order to prevent adverse effects of noise on workers, employers should:

(a) Identify the sources of noise and the tasks that give rise to exposure to noise;

(b) seek the advice of the competent authority and/or the occupational health service about exposure limit standards and other nationally and internationally recognized instruments to be applied;

(c) seek the advice of the suppliers of processes and equipment used in shipbuilding and ship repair facilities about expected noise emission

(d) If this advice is incomplete or in doubt, arrange for measurements by competent professionals in accordance with current nationally and internationally recognized instruments (ILO, 2001; IMO, 2009).

Studies by Aage (2001) note that noise measurements should be used to:

(a) Quantify the level and duration of the exposure of workers and compare it with exposure limits, as established by the competent authority or internationally recognized instruments;

(b) Identify and characterize the sources of noise and exposed workers;

(c) Create a noise map for the determination of risk areas;

(d) Assess the need both for engineering noise prevention and control and for other appropriate measures and their effective implementation

(e) Evaluate the effectiveness of existing noise prevention and control measures (Aage, 2001).

Based on the assessment of the exposure to noise in the working environment, the employer should establish a noise prevention programme with the aim of eliminating the hazard or risk, or reducing it to the lowest practicable level by all appropriate means (Aage, 2001). The employer should review the effectiveness of any engineering and administrative controls to identify and correct any deficiencies. If a worker's noise exposure exceeds the permissible level, the employer should use all feasible engineering and administrative controls to reduce the worker's noise exposure to the permissible exposure level, and enroll the worker in a hearing conservation programme that would include:

(a) Audiometric testing;

(b) Training and education on hearing loss;

(c) Provision of effective hearing protection;

(d) Additional noise measurements to determine continued exposure; and

(e) Continued examination of methods and controls to lower noise levels causing the over exposure.

(C) Vibration Hazards

Aage (2001) views those vibrations hazards constitute one of the hazards in shipbuilding and repair sector to which employees are exposed with the associated risk of physical and internal injuries. According to Aage (2001), the exposure of workers to hazardous vibration main comprises of and occurs mainly:

(a) whole-body vibration, when the body is supported on a surface that is vibrating, such as in vehicles or when working near vibrating industrial machinery; or

(b) hand-transmitted vibration, which enters the body through the hands and is caused by various processes in which vibrating tools or work pieces are grasped or pushed by the hands or fingers.

ILO (2001) observes that employers should comply with exposure limit standards and other nationally and internationally recognized instruments, as required by the competent authority. If workers are frequently exposed to hand-transmitted or whole-body vibration, and obvious steps do not eliminate the exposure, the employer should assess the hazard and risk to safety and health resulting from the conditions, and:

(a) Identify the sources of vibration and the tasks that give rise to exposure;

(b) Seek the advice of the supplier of vehicles, machinery and equipment about their vibration emissions; or

(c) If this advice is incomplete or in doubt, arrange for measurements by a competent person, in accordance with nationally and internationally recognized instruments and currently available knowledge.

ILO (2001) standards notes that vibration measurements should be used to:

(a) quantify the level and duration of exposure of workers, and compare it with exposure limits as established by the competent authority or other nationally and internationally recognized instruments to be applied;

(b) Identify and characterize the sources of vibration and the exposed workers;

(c) Assess the need both for engineering vibration control and for other appropriate measures, and for their effective implementation;

(d) Evaluate the effectiveness of particular vibration prevention and control measures; and

(e) If possible, determine the resonance frequencies.

(D) Electrical Hazards (Electricity)

Electrical hazards are unsafe conditions and unsafe practices associated with electrical equipment, electrical devices, tools and related electrical faults (OSHA, 2013). Thus in a shipyard, to limit the prevalence of electrical hazards, electrical equipment should only be installed in a manner consistent with national laws and regulations or other nationally and internationally recognized instruments (OSHA, 2013). Sufficient numbers of suitably certified and competent persons should be assigned to develop, implement and maintain all electrical equipment in conformity with those requirements (OSHA, 2013). According to

OSHA (2013), to limit the preponderance of electrical hazards and the associated risks, the following basic work processes and safety procedures should be noted:

(i) An electrical control plan respecting all the electrical equipment at the shipbuilding and ship repair facility and the ship under construction should be prepared and implemented. The electrical control plan should cover:

(ii) The examination and testing of all electrical equipment before use, after installation, reinstallation or repair;

(iii) the systematic examination and testing of all electrical equipment at the shipbuilding and ship repair facility and the ship under construction to ensure its proper maintenance, including ensuring that accumulation of dust is not permitted;

(iv) The intervals, which may differ for different equipment and parts of equipment, within which all electrical equipment should be examined and tested;

(v) The nature of the examination and testing to be carried out; and

(vi) The manner in which the results of every examination and test made pursuant to the control plan are to be durably recorded (OSHA, 2013).

OSHA (2013) also observes that to ensure safety with regards to the use of electrical devices, no one, except a competent person or persons working directly under their close personal supervision, should undertake any electrical work where technical knowledge or experience is required. It also requires that notices be posted at prominent positions at the shipbuilding and ship repair facility and the ship under construction:

(a) Prohibiting any unauthorized person from handling or interfering with electrical equipment; and

(b) Setting out directions as to the rescue and first aid of persons suffering from electric shocks or burns (OSHA, 2013).

(E) Biological Hazards

OSHA (2013) identified that biological hazards in shipbuilding and repair industry are hazards caused by biological agents leading to risks of infection, allergy or poisoning due to biological agents. According to OSHA (2013), biological hazards are prevented or kept to a minimum when the work activities comply with relevant nationally and internationally recognized Occupational Safety and Health (OSH) instruments.

OSHA (2013), notes that in areas where biological agents pose a hazard (sludge evacuation, bilge- and sediment-clearing operations, etc.), preventive measures should be taken which consider the mode of transmission, in particular:

(a) Detection, where possible – for example, by testing drinking water;

(b) The provision of sanitation and sanitary hygiene information to workers, both women and men;

(c) Action against vectors, such as rats and insects;

(d) Chemical prophylaxis and immunization;

(e) the provision of first aid, antidotes and other emergency procedures in case of contact with poisonous animals, insects or plants, and suitable preventive and curative medicine; and

(f) The supply of adequate protective equipment and clothing that is adaptable for use by both women and men, and other appropriate precautions (OSHA, 2013).

2.1.3 Concept of Formal safety Assessment (FSA) in Shipyard Operations

One way of ensuring that action is taken before a disaster occurs particularly in the shipbuilding sector, is the use of a process known as formal safety assessment. This has been described as "a rational and systematic process for assessing the risks associated with shipbuilding and shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks" (IMO, 2011). Since the prevalence of hazardous conditions predisposes the shipyards to risks of accidents of various kinds, formal safety assessment can be used as a tool to help evaluate new regulations or to compare proposed changes with existing standards. It enables a balance to be drawn between the various technical and operational issues, including the human element and between safety and costs. FSA - which was originally developed partly at least as a response to the **Piper Alpha** disaster of 1988, when an offshore platform exploded in the North Sea and 167 people lost their lives - is now being applied to the IMO rule making process (IMO, 2011).

The Guidelines for FSA for use in the IMO rule-making process were approved in 2002 Maritime safety Committee (MSC) circular (Circ.) 1023 and Maritime Environmental Protection Committee (MEPC) circular 392 (MSC/Circ.1023/MEPC/Circ.392). The Guidelines have since been amended by MSC/Circ.1180-MEPC/Circ.474 and MSC-MEPC.2/Circ.5. The amendments include revisions to section 3 Methodology, including the addition of a paragraph outlining the need for data on incident reports, near misses and operational failures to be reviewed objectively and their reliability, uncertainty and validity to be assessed and reported. The assumptions made and limitations of these data must also be reported.

The MSC agreed to establish a Correspondence Group to further consider unresolved issues in particular concerning inconsistent results of different FSAs on the same subject and clarifications of the technology used for particular FSAs. The MSC also agreed on the establishment, when necessary, of an FSA Group of Experts for the purpose of reviewing an FSA study if the Committee plans to use the study for making a decision on a particular issue. A flow-chart for the FSA review process was agreed. The MSC agreed in principle that the proposed expert group would undertake to review FSA studies on specific subjects submitted to the Organization, as directed by the Committee(s) and prepare relevant reports for submission to the Committee(s). The structure of the group of experts was left open for future discussion, though the Committee agreed, in principle, that members participating in the expert group should have risk assessment experience; a maritime background; and knowledge/training in the application of the FSA Guidelines (IMO, 2011; Iqbal, Zakaria, & Hossain, 2011).

Sung (2010) writes that FSA is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and shipbuilding, by using risk analysis and cost benefit assessment. FSA can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of the marine environment or in making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and between maritime safety or protection of the marine environment and costs.

Sung (2010) states that according to the IMO, FSA consists of five steps:

1. identification of hazards (a list of all relevant accident scenarios with potential causes and outcomes);
2. assessment of risks (evaluation of risk factors);
3. risk control options (devising regulatory measures to control and reduce the identified risks);

4. cost benefit assessment (determining cost effectiveness of each risk control option); and;
5. Recommendations for decision-making (information about the hazards, their associated risks and the cost effectiveness of alternative risk control options is provided).

In simple terms, these steps can be reduced to:

1. What might go wrong? = identification of hazards (a list of all relevant accident scenarios with potential causes and outcomes)
2. How bad and how likely? = assessment of risks (evaluation of risk factors);
3. Can matters be improved? = risk control options (devising regulatory measures to control and reduce the identified risks)
4. What would it cost and how much better would it be? = cost benefit assessment (determining cost effectiveness of each risk control option);
5. What actions should be taken? = recommendations for decision-making (information about the hazards, their associated risks and the cost effectiveness of alternative risk control options is provided).

Application of FSA may be particularly relevant to proposals for regulatory measures that have far reaching implications in terms of costs to the shipbuilding industry or the administrative or legislative burdens that may result. This is achieved by providing a clear justification for proposed regulatory measures and allowing comparison of different options of such measures to be made. This is in line with the basic philosophy of FSA in that it can be used as a tool to facilitate a transparent decision-making process. In addition, it provides a means of being proactive, enabling potential hazards to be considered before a serious accident occurs (Sung, 2010). FSA represents a fundamental change from what was previously a largely piecemeal and reactive regulatory approach to one which is proactive, integrated, and above all based on risk evaluation and management in a transparent and justifiable manner thereby encouraging greater compliance with the maritime regulatory framework, in turn leading to improved safety and environmental protection. One area where FSA is already being applied is bulk carrier safety. In December 1998, the Maritime Safety Committee, IMO's senior technical body, agreed to a framework setting out project objectives, scope and application, namely:

- to inform IMO's future decision-making regarding measures to improve the safety of bulk carriers;
- to apply FSA methodology to the safety of dry bulk shipping; and
- to secure international collaboration and agreement.

FSA is highly technical and complex and does offer a way forward and a means of escaping from the dilemma of the past in which action was too often put off until something went wrong - with the result that the actions taken often owed more to public opinion and political considerations than they did to technical merit (Sung, 2010).

2.1.5 Hazardous Substances Identified In Line With International Labour Organization's General Provisions

The International Labour Organization (ILO, 2001) provides the basis for eliminating or controlling exposure to hazardous substances (including dusts, fumes and gases, etc), the provisions of the ILO code of practice on ambient factors in the workplace (2001)) form the basis for identification and elimination of hazardous substances in the workplace and the enthronement of health and safety environment. Where workers are exposed to hazardous chemicals, the provisions of the ILO (1974) code of practice on safety in the use of chemicals at work (1993), the Occupational Cancer Convention, 1974, and Occupational

Cancer Recommendation, 1974, also applies. This is not limited to the shipbuilding sector, but generic for the production oriented and process industries (ILO, 2001).

The provision of the ILO (2001) code for elimination of hazardous substances in the workplace determined that it is the responsibility of a competent authority set-up by the organization to ensure that criteria are established governing the measures to be adopted for safety and health, in particular in respect of:

(a) The handling, storage and transport of hazardous substances;

(b) The disposal and treatment of hazardous chemicals and hazardous waste products, consistent with national laws and regulations, or other nationally and internationally recognized instruments.

Furthermore, ILO (2001) notes that responsibility of the employer to prepare, if not already available, an inventory of hazardous substances involved in shipbuilding or ship repair for example, and require from contractors and subcontractors an inventory of hazardous substances used in their project. This list should highlight those substances which are mutagens, carcinogens and reproductive toxins. In the case of ship repair, the employer should ensure that each ship for repair is in a safe condition, has the necessary safety certifications and licenses, and meets the conditions for repair in accordance with nationally and internationally recognized instruments, and particularly that:

(a) Hazardous substances have been removed and recycled in an environmentally sustainable manner;

(b) the ship and its tanks are gas free; and

(c) the ship has an asbestos register to ensure that the ship repair facility can take preventative measures.

More responsibilities of ensuring a hazard free workplace fall on the organization in the case of ship repair; the shipyard is further required to make available an inventory of hazardous substances on the ship, and categorized according to the inherent health and injury risk it portends. The inventory should be used especially for identifying hazardous substances present that are listed in Appendices 1 of the IMO (2011) Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009, on board ships and their locations and quantities, if applicable (Puntoni, Merlo, Borsa, Reggiado, Garrone, & Ceppi, 2001).

It is also important to identify that national laws also have provisions for protection of workers and employees against certain levels of exposure to hazardous substances and conditions in the work environment. Thus, national laws also provide basic information on how and the processes of hazards identification and control in the work environment. As prescribed by national laws and regulations, employers should ensure that workers are not exposed to hazardous substances to an extent that exceeds exposure limits or other exposure criteria for the evaluation and control of the working environment (IMO, 2009). Both national laws and the provisions of the ILO (2001) and IMO (2009) empower the employers to ensure that all chemicals handled, stored and transported or otherwise used are marked, giving their relevant characteristics and instructions on their use, in accordance with the provisions of:

(a) The ILO code of practice on safety in the use of chemicals at work (1993); and

(b) The chemical safety data sheets provided by the supplier.

Chemicals which have not been marked or are not provided with chemical safety data sheets should not be handled and stored until similar relevant information has been obtained by the employer and has been made available to workers and their representatives (ILO, 2001). Where necessary in order to minimize the risk to workers, written instructions should be prepared specifying the correct procedure to be observed in these circumstances. The necessary steps should also be taken to inform all workers of possible hazards and the precautions to be taken when hazardous substances are likely to be encountered at the workplace, including evacuation procedures (ILO, 2001).

2.2.5 General Principles for Monitoring Chemical Hazards in the Workplace

In order to mitigate the risk of occurrence of occupational accidents induced by the preponderance of hazardous conditions in shipyards and process industries, the ILO (2001) and IMO (2009) regulations provided for the Measurement and monitoring of airborne contaminants in the workplace to provide a valid estimate of the risk of exposure and to assess the existing control measures. These provisions require the deployment of procedures identified in accordance with Chapter 12 of the ILO (2001) and ILO (1993) code of practice on safety in the use of chemicals at work. Under the identified codes, the techniques for the assessment of risk of exposure to airborne contaminants in the shipbuilding and process industries include the following:

(i) Provision of information on the intrinsic health and physical hazards, obtained from the ship's inventory of hazardous substances and chemical safety data sheets which correspond to the requirements established in Chapter 5 of the ILO code of practice on safety in the use of chemicals at work (1993), in particular the International Chemical Safety Cards provided by the IPCS.

(ii) estimation of exposure levels based on the method of work and work pattern

(iii) workers experience of exposure in the workplace or that of other users; and

(iv) Simple qualitative tests, such as the use of smoke tubes or pellets to determine ventilation characteristics, and dust lamps for illuminating dust emissions (ILO, 2001; ILO, 1993).

According to Agusionu (2018), the measurement techniques and methods include the following:

(a) The use of sampling equipment and analytical methods validated over a suitable range of concentrations above and below the standard exposure limits determined in accordance with nationally and internationally recognized instruments.

(b) Use of static monitoring to determine the distribution of an airborne chemical throughout the general atmosphere of the workplace and to identify problems and priorities (Agusionu, 2018).

(c) Personal monitoring and area monitoring should be used to evaluate the risk of exposure to the individual worker. Air samples for personal monitoring should be collected in the worker's breathing zone by means of personal samplers. Sampling should be carried out while the work activity is being undertaken.

(d) ILO (2001) notes that where concentrations vary from one work operation or phase to another, personal sampling should be done in such a manner that the average, and in any case the maximum level of exposure of each individual worker can be determined.

(e) Personal sampling should measure exposure, or allow assessment of exposure, throughout the work shift. The expo- sure should be compared to occupational exposure limit values, which are usually quoted for an eight-hour period or, for short-term limits, 15 minutes. The measurement may be continuous over the whole shift or intermittent, so long as this allows a valid calculation of the average exposure and, where necessary, is supplemented by short-term sampling during periods of peak emission (Agusionu, 2018; ILO, 2001; IMO, 2009).

6. Exposure profiles of particular jobs or occupational categories (such as gas cutters, removers of asbestos, polychlorinated biphenyl, paint, etc.) should be constructed from the air sampling data for different operations and from the workers' exposure time in these jobs.

According to Singapore Workplace Safety and Health Regulations (SWPSHR, 2008), proactive strategies must be developed by organizations for identification and control of workplace hazards in order to limit employees exposure to such hazards in the workplace

SWPSHR (2008) notes that a systematic measurement programme is to be deployed to evaluate whether the exposure of workers to certain hazardous chemicals prescribed by the competent authority or determined by the initial assessment is being kept under control.

According to (SWPSHR, 2008) the aim of this strategic programme towards proactive control of workers exposures to hazards in the workplace are as follows:

(i) ensure that the health of the workers is efficiently protected

(ii) ensure that the preventive actions which have been taken are still effective

(iii) ensure that the levels, as measured previously, remain unchanged or fall;

(iv) Ensure that any changes made in recycling processes or work practices will not lead to excessive exposure to hazardous chemicals; and promote the implementation of more efficient preventive measures.

2.2 Health and Safety Requirements for the Most Common Hazardous Operations and Tasks in the Construction and Repair of Ships

IMO (2009) identified basic safety requirements needed to navigate through most common hazardous operations and tasks in the shipbuilding and repair industry. For example, for dock and docking operations, IMO (2009) and ILO (2001) identified that:

(i) All docks are to be provided at approximate places with life-saving equipment such as life-saving buoys.

(ii) When a vessel is entering or leaving a dock, only the persons required for the docking or undocking operation are to be on board. During the docking or undocking operation, the workers are to remain on the open deck. The only exceptions to this rule are the persons required to operate the vessel.

(iii) During docking and undocking operations, the dock need to be securely closed so that persons not engaged in the operation are not exposed to danger. Cranes in floating docks should always be secured against any inadvertent movement during docking or undocking operations. In an emergency docking of a vessel at Starzs shipyard during my time, the portside crane of the floating dock rolled into the river. The effort of a diving contractor salvaged the equipment at a cost.

(iv) Before docking and undocking of the ship, the stability of the operation must be checked by the dock manager in cooperation with the competent ship officer.

(v) Before floating the dock, an inspection of the valves and draining openings in the bottom and side of the ship are to be carried out to ensure that the openings are closed and properly secured.

(vi) Tankers that are carrying or have carried volatile liquids as cargo are not to enter a dock unless their cargo tanks, spaces and piping have been emptied, cleaned, ventilated, and tested for gas, and the master has obtained a certificate from the competent authority, or its authorized representative, that there is no fire or explosion hazard connected with the vessel.

(vii) Before work begins on a vessel in dock, it is to be cleared of silt, dirt or ice, and be cleaned, the hull should be earthed; the propellers and the rudder should be blocked; and the fire-extinguishing system should be connected to the dock water mains.

(viii) Temporary piping, hose or electric cables laid from the shore to the vessel are to be supported on ladders, gangways or the like. Piping, hose and cables are to be kept clear of the passage way on gangways (IMO, 2009; ILO, 2001).

According to ILO (2001), surface preparation and preservation operations also represent another activity area in shipbuilding and repair sector that exposes dockworkers to the hazard of exposure to inhalation of toxic fumes with the attendant health risks. As a result, most safe practices and methods adopted in surface preparation and preservation according IMO (2009) and ILO (2001) include:

a. Toxic cleaning solvents
b. Chemical paint and preservative removers
c. Power tools
d. Flame removal
e. Abrasive blasting
f. High-pressure water

Each of these operations involves hazards, including work with acid and heat sources, toxic vapours, fumes and dust, noise and vibration, electricity and machinery, as well as the risk of eye injury. Abrasive blasting operations cause high levels of noise and dust. This dust can be flammable or contain toxic materials. Thus, protective shields and safe work procedures and practices must be adopted. For example, in abrasive blasting, the following constitute safe work practices and procedures:

- No sand or other substance containing free silica should be used for abrasive blasting on board ships. Used abrasive should not be used again except in closed systems.
- When this type of work is being conducted, no other workers should enter the exclusive zone.
- Abrasive blasting should If possible, be carried out in a blasting enclosure, such as a chamber or cabinet, which should be kept completely closed while blasting is in progress.
- Blasting enclosures should be equipped with exhaust ventilation adequate to remove and safely discharge the dust produced during blasting.
- Hoses and all fittings used for abrasive blasting should be inspected frequently to ensure timely replacement before an unsafe amount of wear has occurred.
- Workers engaged in abrasive blasting should be provided with suitable PPE, including filter type respirators used in conjunction with appropriate eye, face, hearing and head protection, coverall and gloves. When abrasive blasting is carried out in confined spaces, operators should be protected by hoods and airline respirators, or by air helmets of a positive pressure type.
- Persons engaged in abrasive blasting should undergo periodical medical examinations, including a chest radiographic examination (IMO, 2009).

In painting operations, the most common prevalent hazards involved in painting include:

(i) toxic fumes or vapours inhalation,

(ii) the risk of eye injury **(iii)** irritation of lungs and skin. (iv) Repeated exposure to solvents can have long-term effect on health, including dermatitis.

(V) Painting in confined spaces where vapours cannot escape is particularly hazardous, as solvents can display air and may be poisonous, flammable or explosive.

Thus safe work practices and procedures in painting operation include the following:

(a) Approaches to work areas where hazards from toxic or irritant fumes may exist should be provided with notices or signs indicating the hazards involved and the prevention measures to be taken.

(b) The preparation and mixing of hazardous substances for paint should be carried out in special preparation premises, separated from other workplaces and well ventilated. All operations involving any handling of hazardous substances, whether liquid or solid, such as transfer from one container to another, should only be carried out in premises equipped with exhaust ventilation and using tools and appliances that prevent the spillage of such substance (IMO, 2009).

It is important to also note that spray painting is usually carried out by the use of toxic materials, such as lead, carbon bisulphide, carbon tetrachloride, mercury, antimony, arsenic, arsenic compound or method or a mixture containing more than 1percent of benzene, and require that the workers must wear adequate airline breathing apparatus to protect themselves against these toxic materials (IMO, 2009).

2.2.1 Hazards Associated With Welding, Flame-Cutting and Hot Works and the Associated Safe Practices

Studies by Aage (2001) views that the common hazards associated with welding, cutting and heating in shipbuilding and repair operations include:

(i) Electric shocks,

(ii) radiation, fumes (Particularly when working in confined spaces)

(iii) fire,

(iv) noise, and;

(v) vibration (Aage, 2001).

The study provided that to overcome the hazards associated with welding and cutting jobs in ship building and construction and work safely without the occurrences of accidents, the basic safe work conditions and practices as stipulated below should be adopted:

(a) No welding or steel cutting should be carried out on board a vessel except on the orders of a competent supervisor.

(b) Before any local heating, welding or flame cutting or other hot work is begun, it should be ascertained that the place and the surfaces inside and outside to be treated are free from flammable substances, including gases, coatings and materials.

(c) A suitable fire extinguisher should be kept ready for immediate use at a reasonable distance from any place where hot work is being undertaken.

(d) Floors of places at which welding is being carried out are to be kept free from pools of water.

(e) Welders should wear suitable Personal Protective Equipment (PPE), such as fire-resistant gauntlets and aprons, helmets and goggles with suitable filter lenses. Welders should wear clothing that is free from grease, oil and other flammable materials.

(f) Workers engaged in the removal of excess metal or slag or in other similar operations, should:

a. Wear gloves and goggles or a face screen

b. Chip away from the body

c. Ensure that other persons are not struck by chips

Furthermore, Aage (2001) notes that when welding in workplaces where fire hazards are eminent, workers must ensure that:

(i) As far as practicable, objects to be welded, cut by flame or heated should be taken to a place free from fire risks.

(ii) If objects cannot be taken to a safe place, all combustible waste and other combustible material should be at a safe distance from welding, flame or heating.

(iii) If these measures cannot be adopted, precautions should be taken to prevent the dispersion of slag, sparks and heat and to protect combustible material in the vicinity by effective means. The work should in all instances be authorized by a competent person.

(iv) Before any welding, cutting or heating is undertaken on any surface covered with a preservative coating of unknown flammability, the flammability should be tested by a competent person.

(v) While surface that have been covered by highly flammable preservative coatings are being heated, suitable fire-extinguishing equipment, such as a hose, should be kept ready for use at the workplace (Aage, 2001).

ILO (2001) and IMO (2009) agree that when heating operations are to be carried out in confined spaces, the below identified safe work methods and practices are to be used:

(i) When sufficient ventilation cannot be obtained without blocking the means of access, workers in the confined space should be protected by airline respirators, and a person on the outside of the confined space should be assigned to maintain communication with those working within the space and to aid them in an emergency.

(ii) Immediately after welding, cutting or heating is commenced in enclosed spaces on metal covered by soft and greasy preservatives, and at frequent intervals thereafter, it is necessary for a competent person to make tests to ensure that no flammable vapours are being produced by the coatings. If the presence of such vapours is determined, the operation must be stopped immediately and not be resumed until the necessary additional precautions have been taken to ensure that the operation can be resumed safely (ILO, 2001; IMO, 2009).

Aage (2001) observes that gas welding and cutting possess a varied degree of hazards, particularly fire and explosion hazards. Thus, workers involved in gas welding and cutting operations must imbibe basic safe work methods and practices which include:

(i) The oxygen pressure for welding should always be high enough to prevent acetylene from flowing back into the oxygen line (Aage, 2001; Ruxton & Wang, 1992)).

(ii) Acetylene should not be used for welding at a pressure exceeding I atm gauge.

(iii) At the close of work for the day and before any lengthier interruption of work, Supply valves of cylinders, acetylene generators and gas mains should be safely closed.

(iv) Blowpipes and movable pipes or hoses for flammable or oxidizing gas should be taken to the topmost completed deck or to another safe place that is adequately ventilated and supervised to prevent any dangerous concentration of gas or fumes, unless adequate testing for explosive concentrations of gas or oxygen is made by a competent person before torches are delighted (Aage, 2001).

Aage (2001) notes that the risk of exposure to hazards in the shipyards should be assessed on the basis of the numerical results obtained, supported and interpreted in the light of other information, such as length of exposure, work procedures and patterns, measurements of air circulation and other particular circumstances of work during measurement. According to Aage (2001), in the event that monitoring discloses levels that are in excess of the exposure limits, employers should inform the workers and their representatives, in a manner which is easily understood by the workers, of the risk and of the action to be taken to reduce this as part of the prevention and control action programme (Aage, 2001). The purpose of the assessment is basically to control the risk of exposure of workers to the hazards and the sources. The control measures according Aage (2001), ILO (2001) and IMO (2009) may include but not limited to the following:

(i) For any situation or operation involving a risk of occupational exposure to airborne asbestos dust in the repair or removal of structures containing asbestos materials and in the handling, transportation and storage of asbestos or asbestos-containing materials, the provisions of the ILO code of practice on Safety in the use of asbestos (1984), the WHO– ILO joint publication Outline for the Development of National Programmes for Elimination of Asbestos-Related Diseases and the ILO resolution concerning asbestos should apply. No new asbestos product that is not recommended in the regulations should be used in shipbuilding, ship conversion or ship repair.

(ii) Appropriate preventive and protective measures should be taken in relation to the following most common hazardous activities involving chemical substances:

a asbestos removal and disposal;

b disposal of polychlorinated biphenyl;

c bilge and ballast water removal;

d oil and fuel removal;

e paint removal and disposal;

f metal cutting and metal disposal; and

g removal and disposal of miscellaneous ship machinery.

(iii) In accordance with the provisions of sections 6.5–6.9 of the ILO code of practice on safety in the use of chemicals at work, specific control measures should be carried out for:

a chemicals hazardous to health;

b flammable, dangerously reactive or explosive chemicals;

c the storage of hazardous chemicals;

d the transport of chemicals; and

e the disposal and treatment of chemicals;

(iv) The employer should:

a inform each worker who could be exposed to dangerous substances about the hazards related to the chemicals, and other on-site employers whose workers could be exposed, about chemical hazards and appropriate protective measures;

b ensure workers and/or trained first-aid personnel are aware of emergency procedures related to exposure to hazardous chemicals; and

c provide workers with the necessary training and protection to prevent exposure to hazards, including protective clothing that is adaptable for both women and men.

(v) Each employer should:

a develop and implement a written hazard communication programme;

b maintain it for as long as a hazardous chemical is known to be at the shipbuilding and ship repair facility; and

c share relevant information with other on-site employers whose workers could be affected.

(vi) The employer should ensure:

a proper storage of chemicals by:

(1) Storing separately chemicals which react with one another;

(2) Minimizing volumes of stored chemicals;

(3) Providing for containment of spills; and

(4) Ventilating storage areas;

b that, where hazardous chemicals are used, handled or stored, measures are in place to minimize workers' exposure (for example, ventilated fume hoods, remote handling), with reasonable accommodation for pregnant workers.

c that, where necessary, appropriate PPE that is adaptable for use by both women and men is provided and workers are trained in its correct use, and it is used properly;

d that emergency showers and eyewash stations are available where hazardous chemicals are used and/or stored;

e the cleaning of work clothes that have been polluted by chemicals (if reusable) or their disposal; and

f the provision of appropriate hygienic conditions and facilities (for washing) in places where food or tobacco are consumed.

2.2.2 Concept in Risk of Exposure to Hazards in Shipbuilding Industry

A familiar practical situation has been selected here to explain the meaning of the term risk. Moller (2012) notes that with regards to an injury suffered by a pedestrian involved in a car accident on the road for example, risk basically is the seriousness of the accident in relation to its frequency of occurrence (Moller, 2012). While the injury is a consequence of the accident denoted as “C”, the frequency refers to the probability of occurrence of the accident denoted as “P”. But the occurrence probability of the accident and the frequency of the occurrence (P) is a consequence of the availability of a hazard (H) or hazardous condition (unsafe condition, practice, or faulty procedure) to which the injured is exposed. Moller (2012) notes that, it is useful to plot consequence against probability of occurrence in order to have a clearer view of the level of injury risk posed to the workers in the organization.

Thus, the greater the number of pedestrians exposed to hazardous conditions causing accident, the greater the number or risk of injuries, even though the amount of injury to individual pedestrians may be minimal and not too serious. In other words, consequence (C) is low, but probability of occurrence (P) is high. The position of this scenario on the C-P diagram is shown by Point l (Moller, 2012).

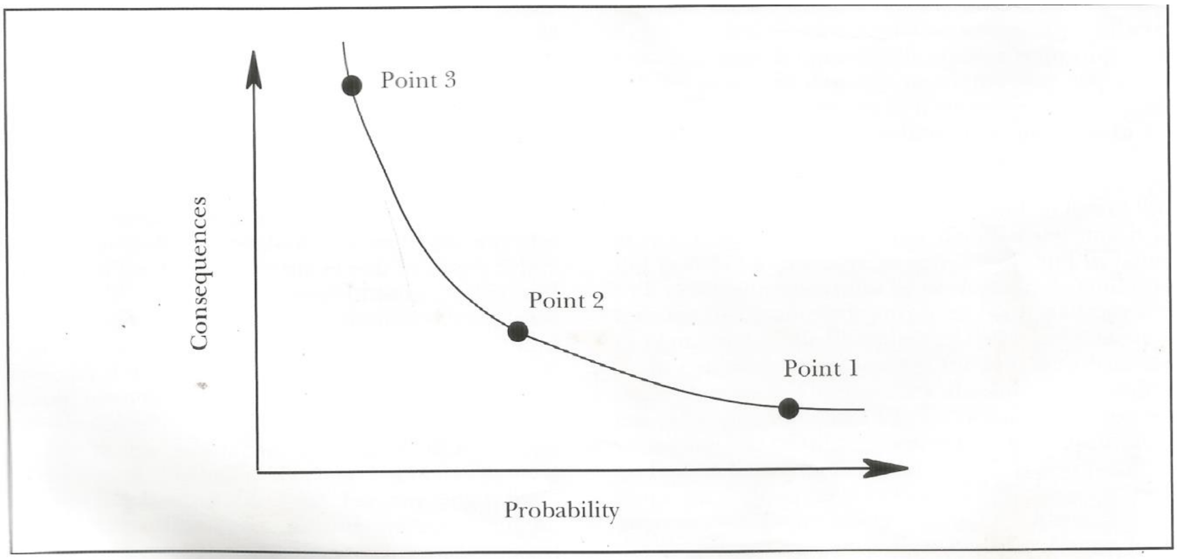


Figure 2.1: Consequences and probability plot illustration of risk of injury

According to Moller (2012), the relationship between C and P is approximated as follows:

$$C\ \alpha \frac{1}{P} \qquad (2.1)$$

This implies that, the consequence (c) is inversely proportional to probability of occurrence (P)

Thus the mathematical relationship is such that:

$$C = \frac{Constant}{P} \qquad (2.2)$$

Where R = constant: risk of injury to pedestrians as a result of exposure to hazardous conditions causing accidents to occur.

Therefore: $R = C \times P$ (2.3)

We therefore define risks as the product of the consequence of the occurrence of accidents following exposure to hazardous conditions and the frequency or probability of occurrence of the accident.

Firstly, it seems fairly straight forward to determine risk (R) by deriving numerical values for C and P but these are both complex parameters involving up to five factors, i.e., management decisions, engineering features, operational procedures, human factors and time (Nautical Institute, 1999). Secondly, accident statistics are regularly used to provide acceptable standards of safety but these are not at all a trustworthy guide to the future. The main reason for this is that risk estimates are altered by those involved once an accident has occurred or its probability of occurrence is recognized (moller, 2012).

In the shipbuilding industry, the hazardous conditions under which employee work as aforementioned represent root causes of accidents in the shipyards which lead to occupational injuries and death. By implications, the consequences of exposure to hazards in the shipbuilding sector offers a sample space of injury (J) and death (D) while the frequency and/or probability of occurrence (P) per annum is determined by the numbers of dockworkers who suffered injury and death each year following exposures to the hazardous conditions in the shipyards. Thus, we define risk of exposure to hazardous condition in the shipyard (R) as the product of the probability/frequency of occurrence and the consequence (injuries and death) over a given period of time, e.g per annum. Risk ® can thus be defined as the product of the probability/frequency (P) of accident occurrence following exposure to hazards and the consequences (C) of the accident. The consequences may range from fatal (death) to non-fatal (injury). The probability of occurrence represents the frequency of accident occurrence involving shipbuilding human capital.

Thus, a common definition of risk is that risk is the combination of probability and consequences, where the consequences relate to various aspects of health, environment and safety, for example loss of life and injuries. This definition is in line with that used by International Standard Organization (ISO, 2002; ILO, 1993). However, it is also common to refer to risk as probability multiplied by consequences (losses) i.e., what is called the expected value in probability calculus. There are different interpretations of probability. Here are the two main alternatives:

(a) A probability is interpreted in the classical statistical sense as the relative fraction of times the events occur if the situation analyzed were hypothetically "repeated" an infinite number of times. The underlying probability is unknown, and is estimated in the risk analysis.

(b) Probability is a measure of expressing uncertainty as to the possible outcomes (consequences), seen through the eyes of the assessor and based on some background information and knowledge.

Following definition (a) we produce estimates of the underlying true risk. This estimate is uncertain, as there could be large differences between the estimate and the correct risk value. As these correct values are unknown it is difficult to know how accurate the estimates are.

Following interpretation (b), we assign a probability by performing uncertainty assessments, and there is no reference to a correct probability. There are no uncertainties related to the assigned probabilities, as they are expressions of uncertainties.

The implications of the different perspectives are important. If the starting point is (a), there is a risk level that expresses the truth about risk, for example for an offshore installation at a given point in time. This risk level is unknown, true, but in many cases it is difficult to see whether people are talking about the estimates of risk or the real risk.

If the starting point is (b), the experts' position may be weakened, as it is acknowledged that the risk description is a judgment, and others may arrive at a different judgment. Risk estimates also represent judgments, but the mixture of estimates and real risk can often give the experts a stronger position in this case. Depending on the risk perspective, there may be different approaches to risk analysis and assessments, risk acceptance etc. We will discuss this in more detail below; see the following sections.

Seeing risk as the combination of probability and consequence means a quantitative approach to risk. A probability is a number. Of course, a probability may also be interpreted in a qualitative way, using an interpretation such as the level of danger. We may for example refer to the danger of an accident occurring without reference to a specific interpretation of a probability, either (a) or (b). However, as soon as we address the meaning of such a statement and the issue of uncertainty, we must clarify whether we are adopting interpretation (a) or (b). If there is a real risk level, it is relevant to consider and discuss the uncertainties of the risk estimates compared to the real risk. If probability is a measure of the analyst's uncertainty, a risk assignment is a judgment and there is no reference to a correct and objective risk level. In the context of this study, we define risk of exposure to hazardous condition in the shipyard (R) as the product of the probability/frequency of occurrence and the consequence (injuries and death) over a given period of time, e.g per annum. Risk ® can thus be defined as the product of the probability/frequency (P) of accident occurrence following exposure to hazards and the consequences (C) of the accident. The consequences may range from fatal (death) to non-fatal (injury).

2.3 Theoretical Review

Under the theoretical framework, the various theories that explain the concept of risk and its application in the safety management of maritime operations are discussed. The various theories are as explained below:

2.3.1 The Human Factor SafetyTheory (HFT)

The human factor theory (HFT) postulates that three factors lead to human error, and human error causes unsafe conditions and accidents while accidents causes injuries, death and damages. The three factors that cause human error and unsafe conditions as identified in HFT are overload, inappropriate response and inappropriate activities. Overload is an indication of imbalance between a person's capacity and the load that person is carrying at a particular point in time (Ludwig, 2012). Ludwig (2012) observes that a load consist of burdens resulting from situational factors, internal factors or environmental factors so that workers bears them in addition to their usual task and job responsibilities. The human factor theory notes that overworking impairs worker's thinking ability to act rationally when faced with a hazardous condition (Ludwig, 2012).

The HFT asserts that the way a worker responds when under an overload situation can prevent or cause an accident when a worker detects a hazardous condition and could or does not correct it, then they have responded to inappropriately and the inappropriate response may cause an accident. It may also be a decision of the worker to err by responding inappropriately, in an attempt to overcome overload. Typical example of an overload condition is increased demand in production without proportionate increase in manpower, which may strain workers into sloppiness, overworking and irritability which are accident causing conditions. Ludwig (2012) notes that the adjustment stress theory is as a result of factors in human factor theory and states that any negative stress or pressure placed on a worker internally (e.g. fatigue), or externally (e.g. noise) will increase the probability of accidents stress, impairs worker judgment and is a source of unsafe behavior as a result of which a worker may deliberately choose to ignore a hazard or fail to detect it, causing accident to occur (Ludwig 2012, ISO, 2002).

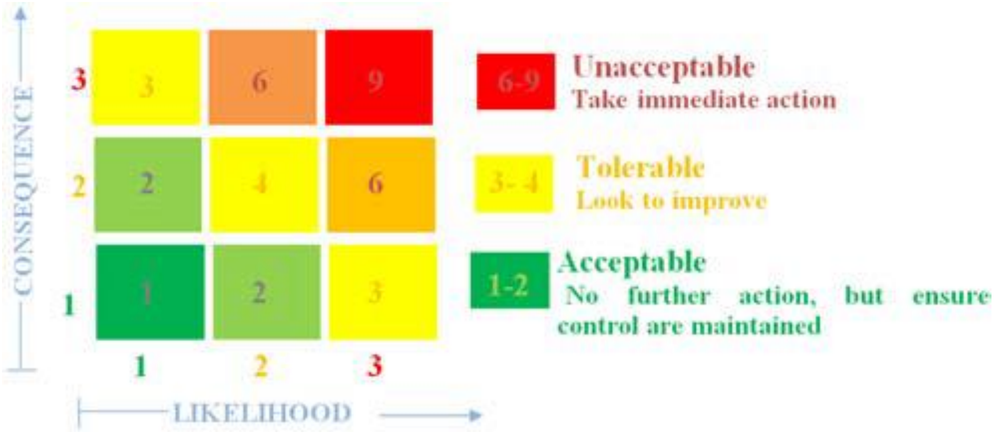
It is observed that an inappropriate activity involves the performance of a task by a worker without appropriate prior training and knowledge of the risk involved. The distraction theory which has correlation to the HFT can be explained to be the consequence of an overload or inappropriate activity. The theory states that workers suffer once they are distracted by Jobsite (occupational) hazard stress or pressure (Ludwig, 2012). The theory insists that pressure in particular could induce workers to ignore hazardous condition so as to meet employer's expectations such as deadline, stress and mental worries could distract workers from detecting a hazard in time to avoid them. Taylor (2001) while explaining the human behavior theory of accident causation notes that inappropriate activities may also be caused by overconfident risk takers who may misjudge the degree of risk involved in a task. The IMO seems to have observed the role of human in accident causation when it issued the Standards of Training, Certification and Watch-keeping (STCW "93 as amended) instrument and made it a compulsory requirement to work on-board. Similar instruments like the STCW "95 as amended that recognizes the importance of training to limit the occurrence of human error related marine accidents have over the years been made compulsory for work of ocean going vessels and offshore drilling vessels. Example is the Basic Offshore Safety Induction and Emergency Training (BOSIET). In the shipbuilding sector, the lack of information on the existence of hazardous substances in the workplace and available unsafe conditions and wrong work procedures constitute examples of conditions that can lead to human error and occurrence of occupational accidents in the shipyards (Haltiwanger, Landaeta, Pinto, &Tolk, 2010). Thus, in the view of the HFT, these conditions should be identified, assessed and controlled in order to limit the occurrence of occupational accidents in the shipbuilding and repair sector in Nigeria.

2.3.2 The Safety Incident Theory

The theory claims that unsafe act by workers is a resultant effect of an overload, ergonomic traps or a decision to err. It postulates that pressure such as deadlines and peer pressure could cause a worker to succumb to pressure to work faster than his natural pace and endowment and therefore raise his probability of being involved in an accident. Petersons accident / incident theory sets managements role in accident prevention by establishing that it is the role of management to take necessary safety procedures and defining responsibility regarding safety, ensuring that employees receive safety training and comply with safety procedures such as inspecting, correction and in the use of PPE. OSHA (2013) further notes that, it is the duty of the company to ensure a clean and healthy work environment that eliminate environmental factors that could impair health.

2.3.3 The Theory and Principles of Hazard Identification Risk Management

Risk is defined as the effect of uncertainty on objectives. OSHA (2013) opines that risk is the likelihood or probability that an event (incident) will occur and adversely affect the achievement of an objective function. In hazard and risk assessment, the first step is to clearly state the objective (goal) to be achieved which also helps to derive exactly what is exposed to hazards and the associated risk of accident occurrence. This is followed by hazard identification which identifies the events (conditions) that form the hazards/threats to the objectives. The result of the hazard identification process is a register, (list) containing internal and external hazards that possess the risks of injury, death or damages that form threat to the dockworkers, maritime property and other group of persons. This is followed by the third (3) steps which is assessment of the likelihood of occurrence and impact of each identified hazard. The assessment can be done with either qualitative or quantitative way (OSHA, 2013; ILO, 1974). It is expected that the impact be expressed in quantities or magnitude of economic loss (damages) and injuries. Both hazard and risk identification objective setting and assessment are done using tools and methods which were earlier discuss under FSA. The fourth process of hazard and risk prioritization is done by comparing individual hazards and risk, frequently used methods here include the expected value method, which ranks hazards and their associated risks according to the product of a risk probability and impact (consequence) and plotting risks on a risk matrix which offers a visual aid to compare risks. See figure 2.2, in risk matrix.



Source: Authors drawing

Figure 2.2. Ranking and comparing of Hazards/risk.

When risks have been prioritized an appropriate risk response or management method is applied to mitigate, manage or deal with risk. This include risk avoidance, risk reduction, risk retention and risk transfer (OSHA, 2013; Cherniack, Brammer, Lundstrom, Meyer, Morse, Nealy, & Fu, 2004; Moller 2012). The last process in the risk management process is monitoring to ensure that the risk does not constitute threat anymore. Reassessment can often or periodically be done depending on residual risk severity. This monitory step is the final step in the risk assessment process and serves as a feedback Mechanisms that close as well as continuously sustain the risk management process. OSHA (2013) and Ruxton and Wang (1992) are in agree that the risk management theory identifies four strategic principles of risk management for industrial risk management to include risk avoidance/risk prevention, risk reduction, risk retention and risk transfer (insurance).The adoption of either of the above risk management strategies/principle or a combination of strategies by organizations will however depend on the expected utility to be derived from such. Decision theory is required for choice making so that the risk management and control principle that maximizes utility is preferred. OSHA, (2013) upheld the choice of risk management tool based on optimal utility criteria as best.

2.3.4 Domino Theory

According to W.H. Heinrich (1931), who developed the domino theory, 88% of all accidents are caused by unsafe acts of people, 10% by unsafe actions and 2% by “acts of God”. He proposed a “five-factor accident sequence” in which each factor would actuate the next step in the manner of toppling dominoes lined up in a row. The sequence of accident factors is as follows:

1. Ancestry and social environment

2. Worker fault

3. Unsafe act together with mechanical and physical hazard

4. Accident

5. Damage or injury.

In the same way that the removal of a single domino in the row would interrupt the sequence of toppling, Heinrich suggested that removal of one of the factors would prevent the accident and resultant injury; with the key domino to be removed from the sequence being number 3. Although Heinrich provided no data for his theory, it nonetheless represents a useful point to start discussion and a foundation for future research (Puntoni, Merlo, Borsa, Reggiado, Garrone & Ceppi 2001; Iqbal et al, 2011).

2.4 Empirical Review

Muhammad (2013) carried out a study on the Health hazards and risks vulnerability of ship breaking workers: A case study on Sitakunda ship breaking industrial area of Bangladesh.

The study notes that Ship breaking activities are facing both challenges and opportunities for coastal zone management in a holistic manner with increase of its demand of raw materials for re-rolling mills and other house hold purposes inspite of various negative impacts on coastal environments in Chittagong region of Bangladesh. The aim of the study was to find out the socioeconomic condition and health hazard risks of workers due to ship breaking activities at the Sitakunda ship breaking industrial area in Chittagong region of Bangladesh. The study used a mixed method, employing both primary and secondary sources of data during the period of September 2012 to August 2013. It found that the socio economic condition of the ship breaking workers indicated that most of the workers are working at the ship yards with low facilities, risky and vulnerable by health and diseases. It was observed from the survey that most of the workers came from poverty stricken regions of Bangladesh, where opportunity of employment is very poor or less. The survey revealed that 59.59% of workers migrated from different districts and 40.40% workers permanently living in the study area or the Chittagong. It was found that the most prevalent common hazards and risks of ship breaking activities are in five categories namely; serious accident related hazard, Physical hazards, Mechanical hazard, Biological hazard and Ergonomic and Psychological hazard on workers as well as residences nearest the breaking yards in the study area (Muhammad, 2013; Haltiwanger, Landaeta, Pinto, & Tolk, 2010)).

Ahamad, et al , (2021) carried out a study in title- Livelihood Assessment and Occupational Health Hazard of the Ship-Breaking Industry Workers at Chattogram, Bangladesh. The paper investigated the livelihood index and health hazards of workers engaged in ship-breaking activities at the Bhatiari coast of Chattogram, Bangladesh. It employed both qualitative and quantitative data collected through participatory rural assessment (PRA) tools that included 128 individual interviews (II), ten focus group discussions (FGDs), and 15 key informant interviews (KIIs). The workers' livelihoods revealed that workers lack basic facilities and are exposed to occupational health hazards due to working in a risky environment. Workers of different origins claimed to have 1 to 6 years of work experience and worked 11 to 12 h a day. More than 60% of workers reported being injured or suffering from various physical problems such as blurred vision, abdominal pain, and skin problems, Labor-intensive and unstable occupations, limited access to medical services, poor housing and sanitation, and lack of basic safety requirements increase workers' plight. The study recommended the use of advanced protective equipment, better medical facilities, and a safe workplace to improve the workers' livelihoods (Ahamad, et al , 2021).

Kutub, Nishat, Shahreen and Yasin (2017) did a research on 'Ship Breaking Industries and their Impacts on the Local People and Environment of Coastal Areas of Bangladesh'. The study notes that the coastal area of Bangladesh is one of the most ecologically productive and it contains a rich biodiversity which includes several species that are endemic to this region. It observed that much attention has been focused on ship breaking industries in the coastal areas because of the threat they pose to this thriving biological communities along with their other environmental impacts and the perilous working environment of the workers. The study adopted an exploratory survey design method. It was found that the coastal environment of Sitakunda is severely contaminated by various processes related to ship breaking i.e. the disposal of different toxic wastes into the sea water, deforestation by expanding ship breaking yard, changing land-use pattern and release of toxic substance into the soil. Moreover, the workers of this industry are exposed to an extremely risky and toxic working environment which makes them vulnerable to both physical and psychological disorder as well as to accidental deaths and injury. Still, workers embrace these risks for very poor wages and most of the profits go to the already rich businessmen. Despite various negativities, this industry has gained importance due to the increasing demand of raw material for re-rolling industries and employment opportunities for the people of the coastal areas (Kutub, et al, 2017).

Moller, N., (2012), carried out a study on "The Concepts of Risk and Safety"; contained in S. Roeser, Hillerbrand and Peterson (2012) (eds.) Handbook of Risk Theory. They opined that risk management has developed an enormous usability and popularity by the scientific world but also by organizations and practitioners. Therefore, although risk management has been always part of human kind and their organizations, it had to pass some decades before the integrated approach was finally understood and the benefits of its method came to the view for managers and decision makers. The study observed that the evolution of risk Management has led to a comprehensive approach hazards affecting workers in the global shipping sector. It recommended risk management approaches particularly risk transfer to the process industries and all industrial entities which have capital intensiveness as a major characteristic as well as operations that have fatal accident historical records. It is important to state at this point that the offshore oil and gas sector encompassing exploration and drilling operations remain one of such capital intensive industries with high risk of fatal and damage accident severity. According to Moller, N., (2012), under this perspective, organizations is supposed to proactively manage risk, monitoring in a continuous and conscious way the risks associated with their strategic objectives. The latter would indicate then, permanent measurement of the severity and evolution of risks within the organization, with the objective of maintaining an overall risk profile aligned with the strategic objectives of the organizations.

Aage (2001) carried out a study on 'Worker safety in the ship-breaking industries'. The study note that a ship consists mostly of steel and other metals. Consequently, at the building and end of its useful life, it becomes a source metallic-related hazardous substances especially ferrous fumes which impact workers health negatively when assimilated into the body system in significant quantities. Thus, the geographical migration of shipbuilding yards and scrapping locations mirrors global industrial economic development while also representing sources of hazards and exposure to hazardous metallic fumes (Aage, 2001).

Unfortunately, it is found that shipbuilding and scrapping operations are not so user-friendly when the means adopted are considered and the consequences it generates are compared with respect to:

(i) occupational safety;

(ii) health; and

(iii) the environment

The study notes that though there are little or no available data or reports on workers' health, workers are known to be exposed to situations which are potentially negative for their health due to the working procedures adopted such as:

(i) torch cutting without protection (eye injuries)

(ii) heavy lifting (wear and tear, back injuries)

(iii) noise (hearing defects)

and; from the exposure of hazardous substances such as:

(i) chemicals (PCB, PCV, PAH, tin-organic compounds (TBT), oils and gas)

(ii) asbestos

(iii) heavy metals;

(iv) Fumes (dust, fume/gas components: dioxins, isocyanides, sulphurs, etc.) (Aage, 2001).

2.5 Literature Gap

As aforementioned in the empirical review, many empirical study have been able establish the existence of categories of environmental and health hazards such as biological hazards, electrical hazards, fire and explosion hazards, chemical hazards, slips and trips (fall hazards), etc in the shipbuilding sector in the global maritime industry. However, for purposes of proactively mitigating the effects of hazards associated with the shipbuilding and repair sectors, available empirical studies have not been able to determine the significant hazards of shipbuilding workplace and the associated risk profiles to enable prioritization of mitigation measures and resources.

The study therefore identified the following literature gaps in line with the objectives of the study:

(i) The determinant hazards faced by dockworkers in the shipbuilding industry in Nigeria have not been determined by any available empirical study.

(ii) The risk profile of injury to health and death of dockworkers associated with hazards in shipyards in Nigeria is yet to be determined by any empirical study.

(iii) The determinant health risks faced by dockworkers in the shipbuilding industry in Nigeria are yet to be empirically determined. These are the gaps which the current study is determined to bridge.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

The study area of the research is the Nigeria shipbuilding and repair sector with specific emphasis on the shipbuilding and repair yards having capacity to handle 500 tonnage vessels and above in floating dry-docks (FD) technology. This exclude naval yards and shipyards dedicated to specific clients and companies. Rivers state, Lagos state and Warri Delta state host majority of the shipbuilding and repair clusters in Nigeria. The shipyards, their locations, capacities and status as at the time of this study are summarized in the table below:

Table 3.1 Ship Repair Yards in Nigeria

SHIP REPAIR YARDS IN NIGERIA					
s/n	**Name**	**Location**	**Dock Type**	**Lifting capacity**	**Status/comment**
1	Starzs Marine and Engineering Limited (StarzsShipyard)	Onne	FD	500T	Fully operational with a development plan to expand to 8000T
2	Niger Dock	Lagos	DD	25000T	Operational
			FD	3500T	Not in-good operational condition
3	West Atlantic Shipyard	Onne	FD	7000T	Operational,dedicated to a specific client only.
			FD	4800T	Not operational
4	Naval Dockyard	Lagos	DD	10000T	Mainly used to service military vessels and a few commercial ships.It has structural defects.
			DD	500T	
			DD	500T	
5	Continental Shipyard	Lagos	FD	6000T	Not operational
	Naval Shipyard	Port	Slipway	200T	Not operational

6		Harcourt	Slipway	50T	Not operational
7	Technitrade	Warri	FD	250T	Not operational
8	West African Dockyard (WAV)	Onne	FD	2500T	Operational
9	Shipside Drydock (Nestoil)	PHC	FD	5000T	Operational, dedicated to specific clients category
10	Niger Benue Transport Company Limited	Warri	Derrick Crane	250T	Operational

Source: Nwokedi etal (2019)

Of the operational shipyards, Starz shipyard Onne, Niger dock Lagos and West African Ventures Dockyard (WAV) have 5000T capacity above, floating dry-dock technology (FD) and are open for general use and not dedicated to specific clients. The study thus adopted Starz shipyard in Rivers industrial cluster and Niger dock in Lagos industrial cluster as case study. Both represent about 66.67% of operational high capacity general use shipyards in Nigeria, which is significant for use in the study.

3.2 Research Design

The study employed a mixed design method in which both primary data from survey and secondary data from the company records were used. The primary data were sourced using a check list as a survey instrument to obtain data on the level of slips and trips hazards, electrical hazards, vibration hazards, welding and cutting hazards, noise hazards and biological hazards to which the employees working in both Starzs and Niger dock shipyards were exposed over time. The idea is to enable the study determine which hazard categories form the significant hazards in shipbuilding and repair sector in Nigeria over the years.

Similarly, the secondary data was sourced from the occupational safety and health records of each shipyards, showing the number of occupational illnesses, injuries and deaths associated with each hazard category that dockworkers (employees) suffered over a period of four years from 2014-2017. This data will be used to determine the risks of injury and death to which employees in the shipyard are exposed to over the period covered in the study.

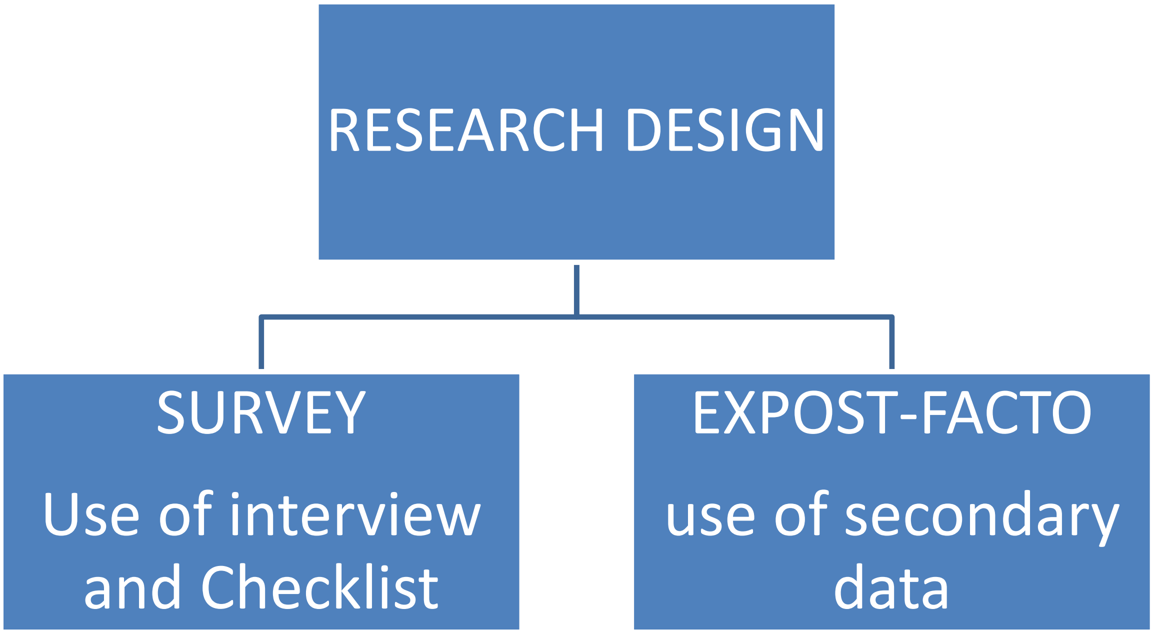


Figure3.1; Research Design

Source: prepared by the author.

3.3 Sources of Data

The major sources of data used in the research were secondary and primary sources .The researcher obtained secondary data from the occupational safety and health records/department of Starzs and Niger dock shipyards respectively. It also obtained primary data through survey from the employees/dockworkers in the shipyards by the use of interview and checklist as survey instruments.

3.4 Population of the Study and Sampling Technique

The population of the study consists of about 115 dockworkers and operational staff who work in the dock (operations department) section of the companies. From this population, samples were randomly selected and the hazard identification checklist delivered to each respondent for responses. For the purpose of conducting the survey, the study adopted a purposive random sampling technique in which the responses of workers in the dock section of the shipyards were purposively sampled randomly. The reason for the purposive random sampling was because these employees in the dock section of the shipyards were the ones that are directly exposed to the occupational hazards of shipbuilding and repairs in greater form than other categories of workers who work in the offices.

3.5 Sample Size

The sample size was determined by the use of Taro Yammane formula for determination of sample for known population that:

$$n = \frac{N}{1+N(e)^2)} \qquad (3.1)$$

Where :

n= sample size required

N = number of people in the population

e = allowable error (%) = 0.05

n = 88

The sample size consists of 88 employees in operational section of each of the shipyards randomly sampled.

3.6 Method of Data Analysis

3.6.1 Principal Component Factor Analysis (PCFA)

The study was designed to analyze the occupational hazards and risks of the shipbuilding and repair sector to workers in Nigeria. The study used a mixed design approach comprised of survey and ex-post facto. A questionnaire and hazard identification checklist was used as survey instruments to gather primary data from dockworkers in Starzs marine and Niger dock shipyards concerning the identification of the hazards to which they are exposed in the shipyards and prevalence of each identified hazard category in the shipyard. The (PCFA) statistical method was used to analyze the data obtained from field survey in order to determine which among the categories of hazards of shipbuilding extracted from available empirical literature and identified by the respondents as a relevant hazards faced by dockworkers in the shipyards are the determinant/significant hazards of shipbuilding and repair industry in Nigeria. The hazard categories as earlier mentioned are:

(i) Biological hazards

(ii) Electrical hazards

(iii) Vibration hazards

(iv) Welding and cutting hazards

(v) Noise hazards

(vi) Slips and trips hazards (fall hazards)

(vii) Fire and explosion hazards

The hazards identification checklist was used to identify the hazards associated with shipbuilding and repair in the shipyards while the questionnaire was calibrated to elicit the respondents (dockworkers) rating/score of the prevalence of each hazard category for purposes of conducting the principal component analysis to determine the determinant hazards of the shipbuilding industry in Nigeria. The reliability of the instrument was tested by using the split-half reliability measure which gave a correlation coefficient of 0.76, indicating that the dataset was reliable. The analysis was implemented using SPSS version21 analytical software.

3.6.2 Risk Score Analysis (RSA)

We used the risk score analysis method to analyze the secondary data obtained in order to generate a risk score for each of the occupational illness and injury types associated with shipbuilding and repair sector in Nigeria over the period covered in the study. While the number of workers affected by each occupational illness, injury and death represent the consequences (C) of the exposure to the hazards of shipbuilding and repair faced by the dockworkers over the period, the probability of occurrence of each consequent type (injury and illness types) denoted as ‘P’ is obtained as the ratio of number of dock workers affected by each type of illness of injury to the total number of workers affected by occupational injury and illnesses over the period covered in the study. The probability of occurrence can equally be estimated as the ratio of number of specific occurrences with the period to the sum of the total occurrences over the period. The occurrence probability of injury or death (consequence of exposure to hazards/accident) and the frequency of the occurrence (P) is a consequence of the availability of a hazard (H) or hazardous condition (unsafe condition, practice, or faulty procedure) to which the injured is exposed.

According to Moller (2012), the relationship between C and P is approximated as follows:

$$C \alpha \frac{1}{P} \tag{2.1}$$

This implies that, the consequence (c) is inversely proportional to probability of occurrence (P)

Thus the mathematical relationship is such that:

$$C = \frac{Constant}{P} \tag{2.2}$$

Where R = constant: risk of injury or death to dockworkers as a result of exposure to hazardous conditions causing accidents to occur.

Therefore: $R = C \times P$ (2.3)

In the shipbuilding industry, the hazardous conditions under which employee work as aforementioned represent root causes of accidents in the shipyards which lead to occupational injuries and death. By implications, the consequences of exposure to hazards in the shipbuilding sector offers a sample space of injury (J) and types or illness types and death (D) while the frequency and/or probability of occurrence (P) per annum is determined by the numbers of dockworkers who suffered injury and death each year following exposures to the hazardous conditions in the shipyards. Thus, we define risk of exposure to hazardous condition in the shipyard (R) as the product of the probability of occurrence and the consequence (number of workers affected by specific illness and injury types and death) over a given period. Risk ® in the context of this study is thus defined as the product of the probability (P) of accident occurrence following exposure to hazards and the consequences (C).

Using the above method, we analyzed the secondary data obtained, in order to obtain the risk score for occupational illness types, injury types, and death of dockworkers exposed to hazardous conditions in each shipyard.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Data Presentation

Table 4.1: Data on Respondents' Identification of Hazards Categories to which Dock workers are exposed in Starzs Shipyard, Nigeria

hazards	Slips & trips	Electrical hazard	Vibration hazards	Noise hazard	Biological hazards	Welding and cuttings	Fire & explosion	Chemical fumes & dust	Others:	total
frequency	37	68	55	73	23	87	46	74	-	463

Source: Field survey

Table4.1 is the data generated from the field survey using the hazard identification checklist. It shows data of dockworkers identification of the various types and groups of occupational hazards in the shipbuilding and repair sector to which they are exposed in Starzs shipyard, Nigeria. The survey indicates that dockworkers are exposed to about eight (8) different categories/types of occupational hazards in the shipyard which include: slips & trips (fall hazards), electrical hazards, vibration hazards, noise hazards, biological hazards, welding and cutting hazards, fire and explosion hazards, and chemical fumes and dust inhalation hazards. Out the aggregate of 88 dockworkers in sampled size, 37 identified the existence of fall hazards (slips and trips) in the shipbuilding sector in Nigeria, 68 respondents identified the presence and exposure of dockworkers in the shipyard to electrical hazards, 55 indicated the exposure of dockworkers to vibration hazards induced by the use of heavy machine and equipment while 73 workers identified that they are also exposed to noise hazards. 23, 87, 46, and 74 dockworkers identified that they are equally exposed to biological hazards, welding &cuttings hazards, fire & explosion hazards and chemical fumes& dust inhalation hazards respectively.

Table 4.2 Respondents prevalence rating/score for each hazard category in Starzs shipyard Nigeria

hazards	Slips & trips	Electrical hazard	Vibration hazards	Noise hazard	Biological hazards	Welding and cuttings	Fire & explosion	Chemical fumes &dust	Number of respondents
aggregate prevalence score/rating	137	407	319	496	102	678	228	586	88
Mean prevalence score/rating	1.56	4.62	3.63	5.64	1.16	7.7	2.59	6.66	88

Source: field survey.

Table4.2 shows the aggregate and mean scores/rating of the prevalence of the identified occupational hazard types in the shipbuilding and repair sector in Nigeria. On a scale of between 1 and 9 hazard prevalence score, the 88 dockworkers in the sample size were able to assign a score/rating to each occupation hazard types to indicate the prevalence and/or extent to which they are routinely exposed to each occupational hazard types in their daily operations in the dockyard. With 1 representing the least prevalent hazard type, 9 represent the most prevalent occupational hazard type. The table indicates aggregate prevalence scores/ratings of 137, 407, 319, 496, 102, 678, 228, and 586 for fall hazards (slips &trips), electrical hazards, vibration hazards, noise hazards, biological hazards, welding & cuttings hazards, fire & explosion hazards, and chemical fumes& dust inhalation hazards respectively.

It indicates mean prevalence scores of 1.56, 4.62, 3.63, 5.64, 1.16, 7.7, 2.59 and 6.66 respectively for fall hazards (slips &trips), electrical hazards, vibration hazards, noise hazards, biological hazards, welding & cuttings hazards, fire & explosion hazards, and chemical fumes& dust inhalation hazards. The table4.2 above form the basis for further analysis to determine the determinant occupational hazards types in the shipbuilding and repair sector in Nigeria.

Table 4.3: Physical Injuries, illnesses and death to dockworkers associated with exposure to workplace hazards in Starzs shipyard in Nigeria

Year	Physical injury	Illness related to occupational hazards	Death associated with exposure to hazards
2014	4	2	0
2015	3	1	0
2016	3	1	0
2017	2	0	0
Sum	12	4	0

Source: Health and Safety Department Records (2017)

Table4.3 shows the secondary data obtained from the occupational safety and health Department of Starzs shipyard showing the annual workplace hazard related to physical injury, illness and deaths that occurred to dockworkers between 2014 and 2017. The table shows that an aggregate of 12 dockworkers suffered physical injury between 2014 and 2017 as a result of exposure to occupational hazards in the shipyard while an aggregate of 4 dockworkers suffered workplace hazard induced illnesses over the same period. The table also indicates that no worker died over the period as a result of exposure to occupational hazards in the shipyard.

Table 4.4: Number of Dockworkers who suffered various Illnesses and Injuries associated with exposure to occupational hazards in the Shipyard between 2014 and 2017.

Welding &cuttings hazard		**Vibration**		**Chemical fumes& dust inhalation hazards**		**Noise hazards**	
Laceration injury	2	Headache	2	Rhino rhea illness – due exposure to dust from sandblasting operation	3	Tinnitus illness – due to exposure to noise from heavy equipment	2
bruise	3	-	-	Eye irritation	2	-	-
cuts	3	-	-	-		-	-
Strain & sprain	2	-	-	-		-	-
Burns injury	5	-	-	-		-	-
fracture	2	-	-	-		-	-
Musculoskeletal injury	2	-	-	-		-	-
Arc eye	3	-	-	-		-	-

Source: Health and Safety Department Records (2017)

Table4.4 indicates that welding & cutting hazards, vibration hazards, exposure to chemical fumes & dust hazards and noise hazards constitute the occupational hazard types that caused dockworkers physical injury and illness in the shipyard between 2014 and 2017. Of these three occupational hazard groups, welding & cutting hazards caused the most physical injuries to dockworkers which include 2 laceration injuries, 3 bruises, 3 cuts, 2 strain &sprain injury, 5 burns injury, 2 fractures, 2 musculoskeletal injuries and 3 arc eye injuries. Exposure to chemical fumes & dust inhalation hazard caused the second most prevalent illnesses in the dockyard with about 3 dockworkers suffered Rhinorhea illness and 2 suffering eye irritation illness as a result of exposure to chemical fumes and dusts from sandblasting and painting operations. Exposure to noise hazards caused 2 dockworkers develop Tinnitus illness while exposure to vibration hazards caused 2 dockworkers to have headache over the period.

Table 4.5: Table Showing Data on Respondents' Identification of Hazards Categories to which they are exposed in Niger Dock Shipyard, Lagos, Nigeria

hazards	Slips & trips	Electrical hazard	Vibration hazards	Noise hazard	Biological hazards	Welding and cuttings	Fire & explosion	Chemical fumes &dust	total
frequency	41	59	60	63	28	77	51	84	463

Source: Field survey

Table4.5 shows the result of field survey carried out at the Niger Dock facility in which dock workers in the ship yard identified the various hazard categories to which they are exposed in the course of the work, by the use of a hazard checklist administered to the sample population. Similar to the outcome of the survey in Starzs shipyard, the workers in the Niger Dock facility also identified about 8 major hazard sources of groups to which they are disproportionately exposed to in the course their work in the facility. According to the survey implemented with the help of a checklist, inhalation of chemical fumes and dust particles, injuries from welding fabrication cuttings and hazards from vibration of equipment and tools were respectively identified by 84, 77 and 60 respondents as prevalent in the facility. Similarly, electrical hazards, noise hazards and fire explosion risks were also identified to be faced by the workers in the facility as a component of the risks of hazards associated with shipbuilding and repair operations in Niger Dock. Lastly, slips & trips and biological hazards were also identified in the checklist as part of the hazard components to which dock workers in the shipbuilding and repair facility are routinely exposed in the course of their daily work.

Table 4.6 prevalence rating/score of each hazard category in Niger Dock shipyard, Lagos Nigeria

hazards	Slips & trips	Electrical hazard	Vibration hazards	Noise hazard	Biological hazards	Welding and cuttings	Fire & explosion	Chemical fumes &dust	Number of respondents
aggregate prevalence score/rating	123	202	422	597	157	731	233	483	88
Mean prevalence score/rating	1.40	2.30	4.80	6.80	1.80	8.31	2.65	5.50	88

Source: field survey.

Table 4.6 shows the mean prevalence rating/score of each category of occupational hazards types to which the dock workers in Niger Dock are exposed in the course of the work in the facility. The prevalence scores were determined on a scale between 0 and 9 prevalent rating in the checklist to which the 88 workers which constitute the sample size in the facility were made to rate or score the prevalence rate of each hazard category based on the experience in the facility. With 0 representing the least prevalent hazard type, 9 represent the most prevalent occupational hazard type. The table indicates that the mean prevalence scores for the identified hazard categories are: 1.40, 2.30, 4.80 and 6.80 for slips & fall hazards, electrical hazards, vibration hazards and noise hazards respectively. Biological hazards, welding fabrication & cutting hazards, fire & explosion risks and hazards associated with inhalation of chemical fumes & dust have respective prevalence ratings/scores of 1.80, 8.31, 2.65 and 5.50

Table 4.7: Number of Dockworkers that suffered various Illnesses and Injuries associated with exposure to occupational hazards in Niger Dock between 2014 and 2017.

Welding &cuttings hazard		**Vibration**		**Chemical fumes& dust inhalation hazards**		**Noise hazards**	
Laceration injury	2	Headache	5	Rhino rhea illness – due exposure to dust from sandblasting operation	8	Tinnitus illness – due to exposure to noise from heavy equipment	9
Bruise	6	-	-	Eye irritation	4	-	-
Cuts	8	-	-	-		-	-
Strain & sprain	4	-	-	-		-	-
Burns injury	11	-	-	-		-	-
Fracture	3	-	-	-		-	-
Musculoskeletal injury	6	-	-	-		-	-
Arc eye	7	-	-	-		-	-

Source: Health and Safety Department Records (2017)

Table 4.7 shows the secondary data collected from the HSE Department of Niger Dock shipyard, Lagos. The data shows the various categories of occupational injuries and illnesses suffered by workers in the shipyard between 2014 and 2017 as a result of the exposure to various categories of occupational hazards in the facility. It indicates that hazards associated with welding fabrication & cutting, vibration, chemical fumes & dust inhalation and noise caused the most injuries and illnesses in the shipyard between 2014 and 2017. The identified injuries and illnesses include: Laceration injury, bruise, cuts, Strain & sprain, Burns injury, fracture, Musculoskeletal injury, Arc eye, Headache, Rhino rhea illness – due exposure to dust from sandblasting operation, Eye irritation, and Tinnitus illness – due to exposure to noise from heavy equipment. The table was used for further analysis in subsequent sections and the discussion of findings.

4.2 Results and Discussion of Findings

Table 4.8: Categories of Occupational Hazards identified in the Starzs Shipbuilding and Repair Facility in Nigeria

hazards	formula	% of respondents that identified each hazard group as occupation hazards they are exposed to in the shipyard
Slip &trips (fall hazards)	$\frac{37}{88} * \frac{100}{1}$	42.1
Electrical hazards	$\frac{68}{88} * \frac{100}{1}$	77.3
Vibration hazards	$\frac{55}{88} * \frac{100}{1}$	62.5
Noise hazards	$\frac{73}{88} * \frac{100}{1}$	83
Biological hazards	$\frac{23}{88} * \frac{100}{1}$	26.1
Welding & cutting hazards	$\frac{87}{88} * \frac{100}{1}$	98.9
Fire & explosion hazards	$\frac{46}{88} * \frac{100}{1}$	52.3
Chemical fumes & dust inhalation	$\frac{74}{88} * \frac{100}{1}$	84.1
Others:	-	-

Source: Authors calculation.

We employed the use of the simple percentage measure to analyze the hazard identification data on table 4.8 in the Starzs Ship building and Repair yard. This is in order to determine the percentage of exposure to each identified hazard category identified by the dockworkers in the sample size. The result indicates that about 42.1% of the dockworkers identified the existence of fall hazards (slips and trips hazards) in the shipbuilding sector in Nigeria while 77.3% of the respondents identified that dockworkers are exposed to electrical hazards in the shipbuilding and repair sector in Nigeria. About 62.5%, 83%, 26.1%, 99.8%, 52.3%, and 84.1% of the respondents identified that dockworkers in the shipbuilding and repair sector are exposed to vibration hazards, noise hazards, biological hazards, welding & cutting hazards, fire & explosion hazards, chemical fumes and dust hazards respectively.

The figure 4.1 is the pie-chart showing sectorial representation of the various occupational hazard groups to which dockworkers are exposed in the shipbuilding and repair sector in Nigeria.

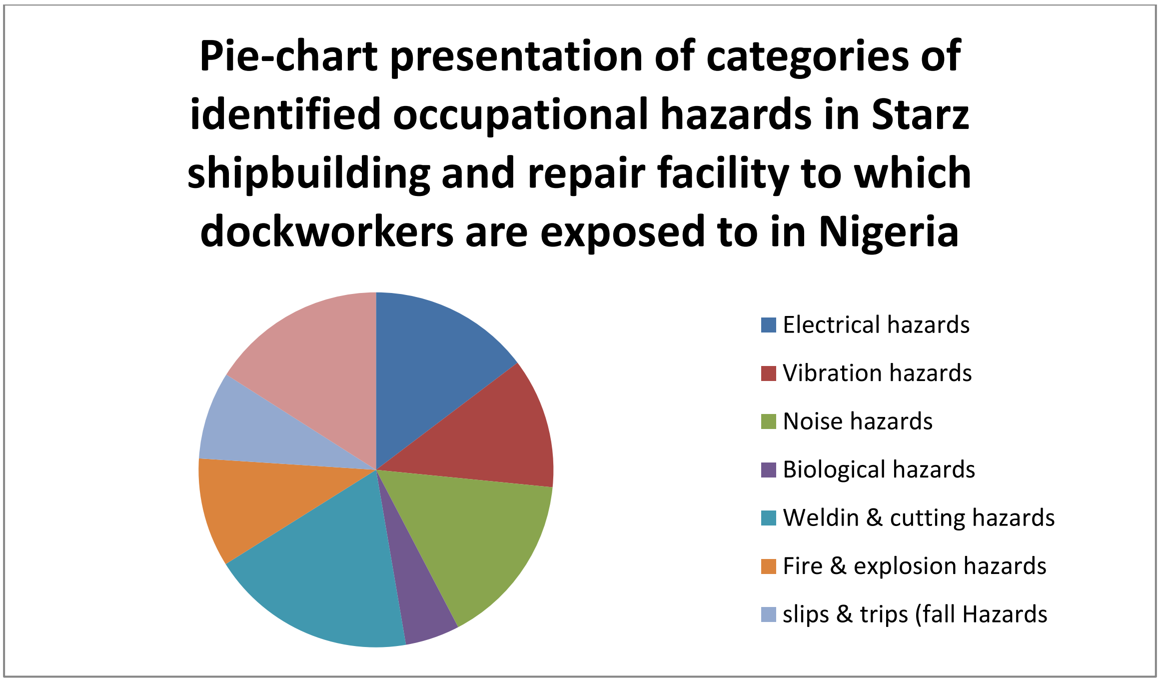


Figure 4.1: Pie-chart presentation of categories of identified occupational hazards in Starz shipbuilding and repair facility to which dockworkers are exposed to in Nigeria

Source: Prepared by the author

Table 4.9: Determinant Occupational Hazards of the Starz Shipbuilding and Repair Facility in Nigeria

	Mean	Std. Deviation	Analysis N
Electricalhaz	4.6250	.53202	88
vibrationhazards	3.6477	.54751	88
Noisehazards	5.6932	.59419	88
Biologicalhaz	1.4659	.50170	88
Weldingcuthaz	7.7045	.81873	88
Fireexplosion	2.5909	.81136	88
Falhazards	1.5341	.50170	88
chemfumesdusthaz	6.6364	.83297	88

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.813	35.163	35.163	2.813	35.163	35.163
2	2.062	25.776	60.938	2.062	25.776	60.938
3	1.284	16.046	76.984	1.284	16.046	76.984
4	.785	9.816	86.800			
5	.549	6.860	93.660			
6	.353	4.407	98.067			
7	.155	1.933	100.000			
8	-9.546E-017	-1.193E-015	100.000			

Source: Author's calculation

Table4.9 shows the mean scores of the various hazards associated with shipyard operations in Nigeria. The result indicates that the welding and cutting hazards have the highest mean occurrence score of 7.7045. This is followed by hazard of inhalation of chemical fumes and dust and noise hazards which have respective mean occurrence scores of 6.63 and 7.7045.

The Eigen values showing the significances of the influences of each factor are shown in table4.10 below.

Table 4.10: Extraction Method: Principal Component Analysis.
Component Matrix[a]

	Component		
	1	2	3
Electricalhaz	.915	-.103	-.003
vibrationhazards	.920	-.058	-.011
Noisehazards	.720	-.213	-.239
Biologicalhaz	.124	.968	-.210
weldingcuthaz	.105	.308	.635
fireexplosion	.745	.066	.356
Falhazards	-.124	-.968	.210
chemfumesdusthaz	-.121	.174	.780

Extraction Method: Principal Component Analysis.[a]
3 components extracted.

The result of the Principal Component Analysis (PCA) implemented using SPSS analytical software is shown in Table 4.10 above. The result shows the decisive occupational hazard types in the shipbuilding and repair sector in Nigeria. It indicates that electrical hazards, vibration hazard and noise hazard, have respective eigen values of 0.785, 0.549 and 1.284, while fire & explosion hazards, slips & trips (fall) hazards, and biological hazards have eigen values of 0.353, 0.155, and -9.016E-017 respectively. Similarly, welding and cutting hazards and chemical fumes & dust inhalation hazards have respective Eigen values of 2.813 and 2.063.

The results indicate that only three (3) occupational hazard groups which include welding & cutting hazards, chemical fumes and dust inhalation hazards and noise hazards with eigen values greater than one (Eigen>1) constitute the determinant occupational hazards to which the dock workers in the shipbuilding and repair industry are exposed. They represent the significant and major occupational hazards prevalent in the shipbuilding and repair sector in Nigeria.

It is also found that electrical hazard with Eigen value of 0.785 constitute a more prevalent hazard in shipbuilding and repair industry than vibration hazards with Eigen value of 0.549 (0.785>0.549). Though, the remaining 6 hazard types with Eigen values less than one are to significant and as such are not determinant shipbuilding and repair hazards, it is important to rank the identified occupational hazards in shipbuilding and repair industry in order of decreasing significance as shown in figure 4.2.

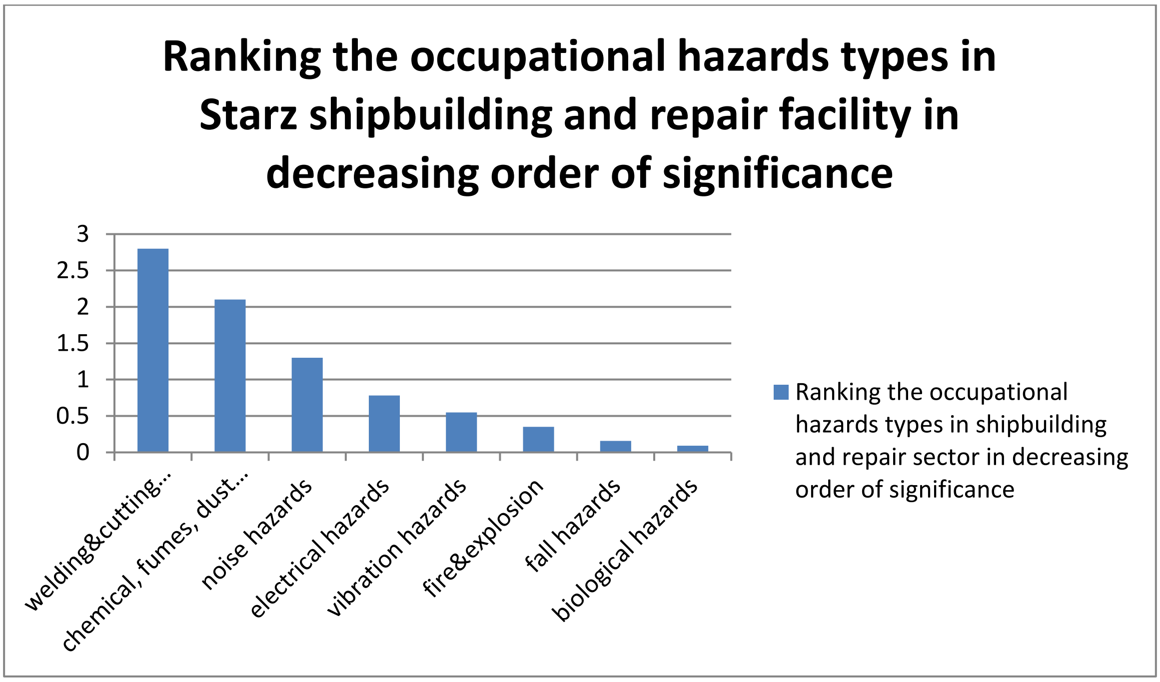


Figure 4.2: Bar chart showing Ranking the occupational hazards types in Starz shipbuilding and repair facility in decreasing order of significance

Source: prepared by authors

Table4 11: the level of Risk of Physical Injuries, illnesses and death to dockworkers associated with exposure to workplace hazards in the Starzs shipyard in Nigeria between 2014 and 2017

Type of occupational health risk	Consequence (C)	Probability (p)	Level of Risk/Risk Score
Risk of Death	0	0	0
Risk of Physical injury	12	0.75	9
Risk of Illness	4	0.25	1
Aggregate	16	1	10

Source: Authors calculation

The result of table 4.11 indicates that dockworkers in the Starzs shipbuilding and repair facility in Rivers shipbuilding clusters faced higher level of risk of physical injuries (fractures, bruises, burns, musculoskeletal injuries, arc eye, laceration, etc.) than illness and death between 2014 and 2017 as a result of exposure to hazards of shipbuilding and repairs. Physical injury has a risk score of 9 when compared with occupational illnesses with risk score of 1. This indicates that dock workers in the Starzs shipyard are 9 times more prone to suffer physical injury than other illness types as a result of exposure to occupational hazards in the facility. The risk score for death is zero, indicating that over the period between 2014 and 2017, there was no occupational accidents related death in the Starzs marine shipbuilding and repair facility. Thus the risk of death associated with exposure to hazards in the facility is zero. Other illness types such as laceration, headache, tinnitus illness etc., have risk score of 1.

The probability of occurrence of physical injury to dock workers in the Starzs shipyard is 0.75 while it is 0.25 for occupational illnesses other than physical injury. The policy implication is that in Starzs dockyard, in order to protect workers against the effects of exposure to occupational accidents, the facility should prioritize implementing programmmes and policies that will aim at reducing the occurrence of physical injuries to dock workers since physical injuries have the highest probability of occurrence and risk level.

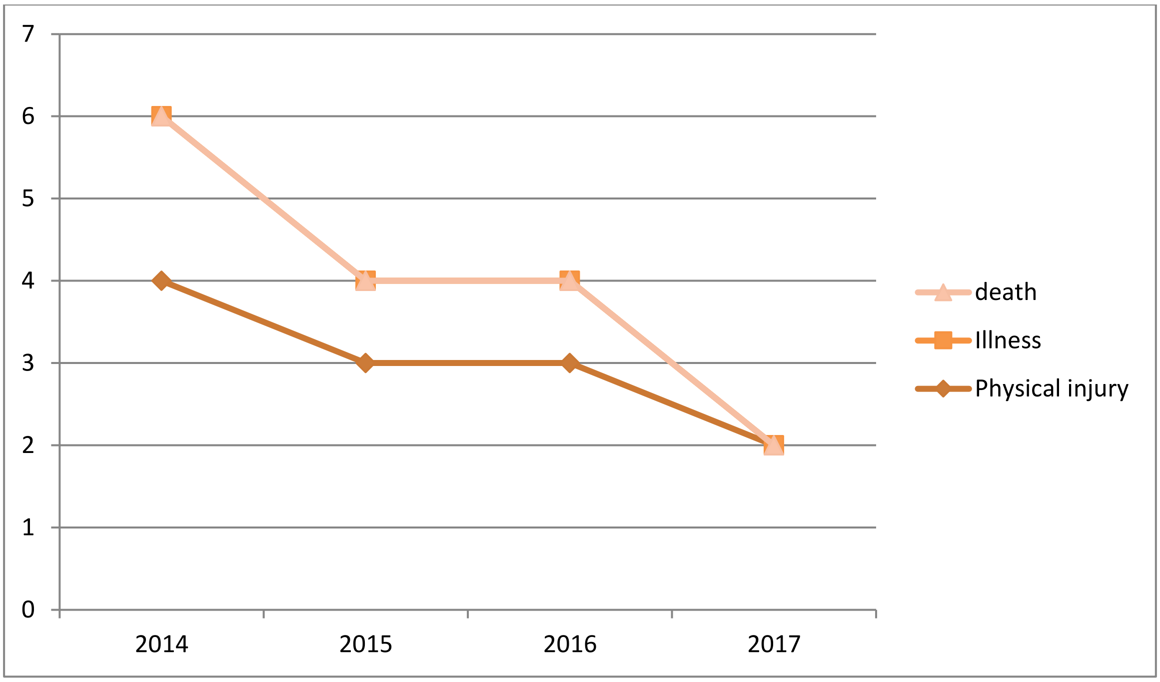


Figure 4.3: Trend line of risks of physical injuries, illness and death related to workplace hazards in the shipyard
Source: Prepared by the author

Table 4.12: Degree of Risk to Workers Health Posed by determinant workplace hazard types in the Shipyard

Hazards types	formula	Degree of risks to workers health posed by determinant workplace hazard types in the shipyard
Welding & cutting hazards =	$\frac{20}{29} * \frac{360}{1}$	248.6
Chemical fumes & dust hazards	$\frac{5}{29} * \frac{360}{1}$	62.1
Noise hazards	$\frac{2}{29} * \frac{360}{1}$	24.8
Vibration hazards	$\frac{2}{29} * \frac{360}{1}$	24.8

Source: Authors calculation

The result on table 4.12 indicate that over the 4 years period covered in the study, an aggregate of about 29 suffered various forms of physical injury and illness related to occupational hazard. The implication is that some dockworkers suffered multiple (more than one form of) injury and/or illness type, given that an aggregate of 12 persons had physical injury while 4 people had illnesses related to workplace accident in the shipyard between 2014 and 2017 as shown in Figure 4.4. The result equally indicate that of the 29 person aggregate who suffered injuries and illnesses over the period, 20 of them corresponding to

248.6 degrees of risk, had injuries caused by exposure to welding & cutting hazards, 5 of them corresponding to 62.1 degrees of risk had illnesses caused by exposure to chemical fumes and dust hazards, while 2 each corresponding to 24.8 degrees of risk had injuries and illness caused by each of noise hazards and vibration hazards.

Thus, exposure to welding and cutting hazards caused most of the injuries and illness dockworkers in the shipyard suffer. See figure4.4 below for the pie chart presentation of the degrees of risk of injury and illness caused by each determinant workplace hazard type in the shipyard over the period.

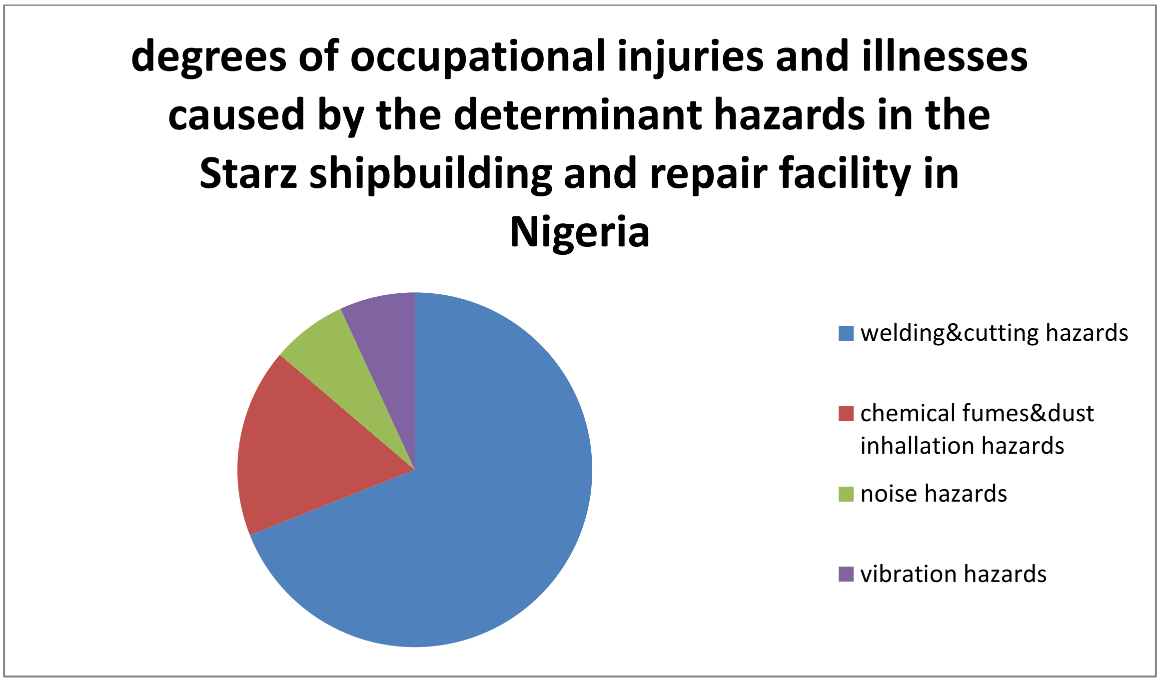


Figure 4.4: Degrees of occupational injuries and illnesses caused by the determinant hazards in the Starz shipbuilding and repair facility in Nigeria

Source: prepared by the author

It is evident that welding and cutting hazards caused more than half of the health risks suffered by dockworkers in the shipbuilding and repair sector. The various physical injury and illness types caused by welding and cutting hazards and the number of dockworkers affected over the period covered in the study is shown in the figure4.5 below:

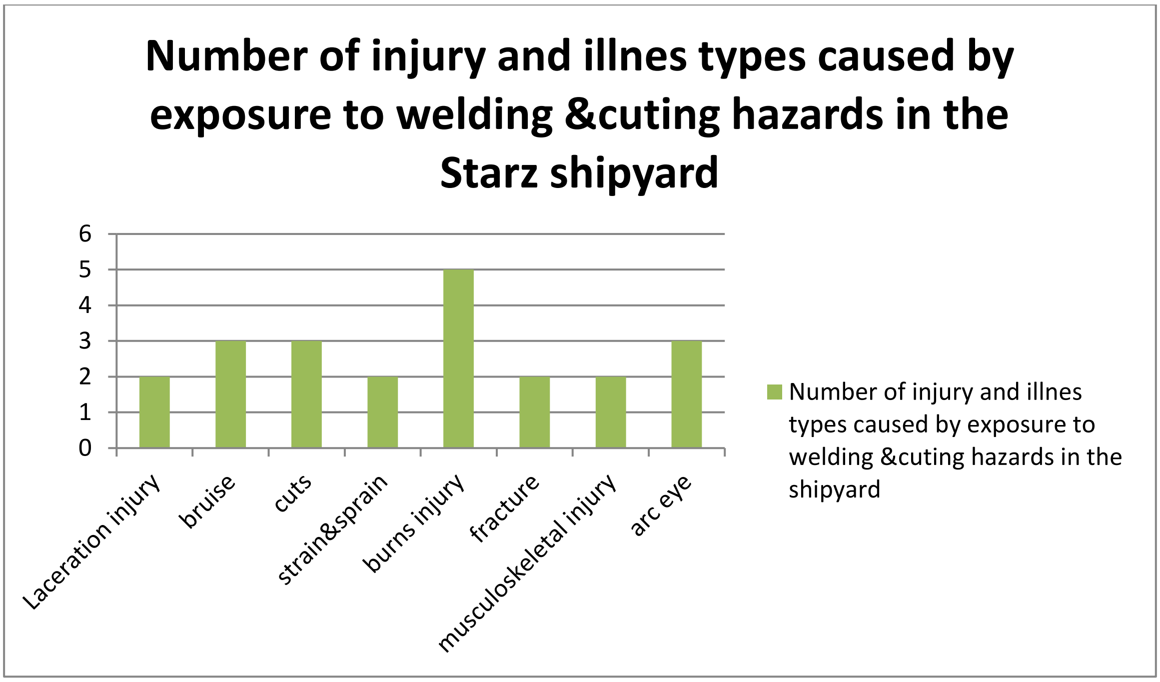


Figure4.5: injuries and illness types and the numbers caused by exposure to welding &cutting hazards in the Starz shipyard

Source: authors' calculation

From the figure 4.5 shows, burns injury constitutes the greatest injury types suffered by dockworkers as a result of exposure to welding and cutting hazards. About 5 dockworkers had burns injury over the period covered in the study. This is followed by bruise, cuts and arc eye injury each with about 3 dockworkers affected over the period. Lastly, 2 dockworkers had each of laceration injury, fracture, musculoskeletal injury and strain & sprain over the period covered in the study.

Similarly, exposure to chemical fumes and dust from sandblasting and painting operations caused the second highest number of injuries and illnesses to dockworkers in the shipbuilding and repair sector over the period. The illnesses caused by this hazard category constitute majorly of Rhino rhea illness and eye irritation with respective of 3 and 2 dockworkers affected over the period.

Exposure to noise hazards in the shipyard caused 2 dockworkers to have tinnitus illness while exposure to vibration hazards caused 2 dockworkers to develop headache.

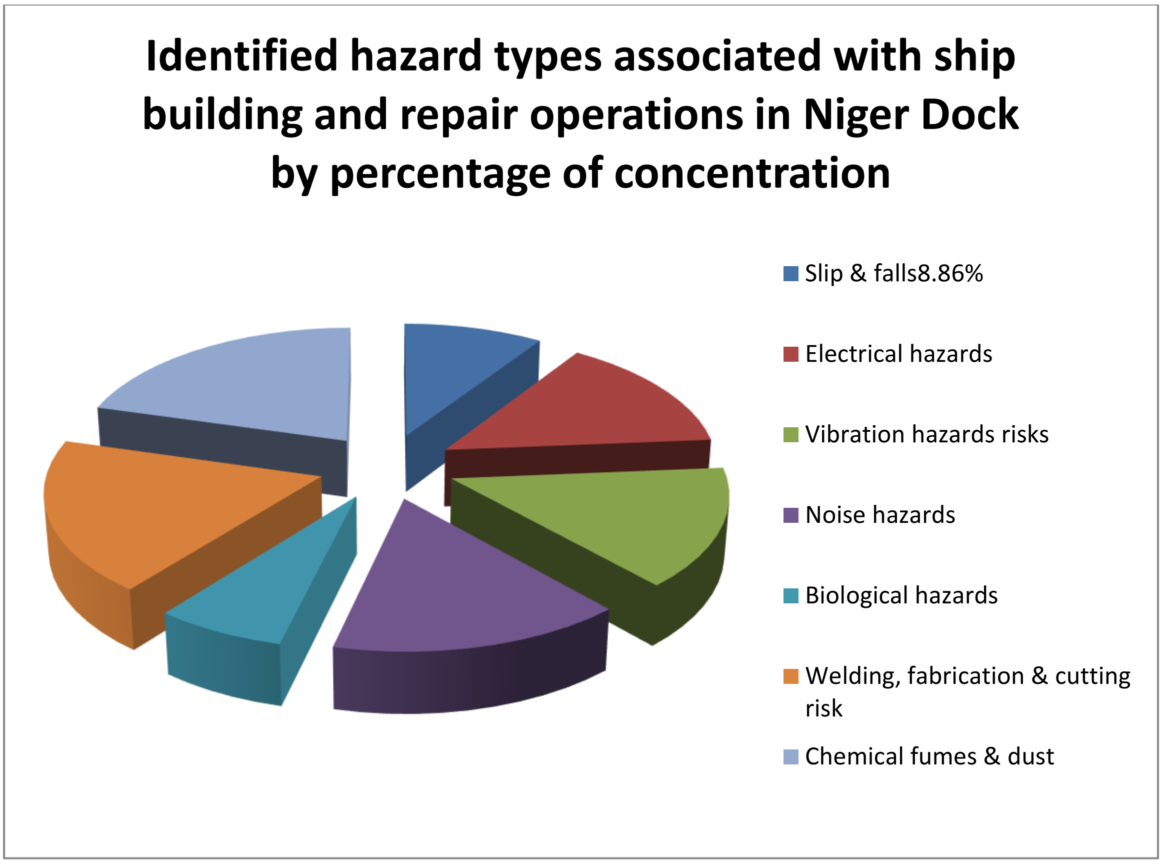


Figure 4.6.: Categories of Occupational Hazards identified in the Niger Dock Shipbuilding and Repair yard in Lagos Nigeria
Source: Prepared by the author

The result offigure 4.6 indicates that similar the result of the survey conducted at Starz shipyard, Onne; eight occupational hazard types were identified by the workers in Niger Dock as the risks to which they have been exposed over the years in the shipyard. The result indicates that about 18.14% of the dockworkers identified that they are routinely exposed to health risk associated with inhalation of chemical fumes & metallic dust particles. In a similar manner, about, 16.63%, 13.61%, 12.96% and 12.74% of workers in the dockyard respectively identified welding fabrication and cutting risks, noise hazards, and hazards associated with vibrations occasioned by the use of heavy equipment and tools as components of the overall categories of the risk of health hazards to which they are exposed routinely in the course of their work in the Niger Dock facility. Lastly, about 12.74%, 11.02%, 8.86% and 6.05% of the respondents respectively identified the existence of risks of electrical hazards, fire and explosion risks, slips & trip risks and risk of exposure to biological hazards in the shipbuilding and repair facility. The result is similar to the result obtained from the Stars shipyard; which indicates similarities in the types of risk of health hazards to which employees in the shipbuilding and repair sector in Nigeria are exposed. Thus it is necessary that the determinant types of risk of hazards to the health of dockworkers in Niger Dock be determined as basis for prioritizing the control of occurrence of industrial accidents as a result of exposure to hazards in the shipbuilding facility as shown in the table below.

Table 4.13: Determinant Risks of Occupational Hazards in Niger Dock Shipbuilding and Repair Facility in Nigeria

	Mean	Std. Deviation	Analysis N
electricalhaz	2.30	.48714	88
vibrationhazards	4.80	.46718	88
noisehazards	6.80	.40139	88
biologicalhaz	1.80	.16667	88
weldingcuthaz	8.31	.23231	88
Fireexplosion	2.65	.23231	88
Falhazards	1.40	.56121	88
chemfumesdusthaz	5.50	.42134	88

Communalities

	Initial	Extraction
electricalhaz	1.000	1.000
vibrationhazards	1.000	1.000
noisehazards	1.000	1.000
biologicalhaz	1.000	1.000
weldingcuthaz	1.000	1.000
Fireexplosion	1.000	1.000
Falhazards	1.000	1.000
chemfumesdusthaz	1.000	1.000

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.504	25.059	25.059	1.504	25.059	25.059
2	1.304	21.740	46.800	1.304	21.740	46.800
3	1.100	18.341	65.140	1.100	18.341	65.140
4	1.059	17.647	82.787	1.059	17.647	82.787
5	1.033	17.213	88.210	1.033	17.213	88.210
6	-4.977E-016	-8.295E-015	100.000			
7	-3.676E-016	-9.371E-015	100.000			
8	-2.543E-016	-9.622E-015	100.000			

Source: Author's calculation

The result of the Principal Component Analysis (PCA) implemented using SPSS analytical software is shown in the table 4.13. The result shows the decisive occupational hazard types in the Niger Dock shipbuilding and repair facility in Lagos Nigeria. It indicates that risks of occupational accident and injury associated with electrical hazards, biological hazards, and slips & trip hazards in the Niger Dock facility have respective mean values of 2.30. 1.80 and 1.40 with respectively with respective Eigen values of -8.295E-015, -9.371E-015 and -9.622E-015. The implication is the risk of occupational accident cum injury faced by workers in the shipyard associated with exposure to electrical hazards, biological hazards and slips & trip (fall) hazards is not significant and as a result, are not major component and determinant hazard types affecting workers in the Niger Dock shipbuilding facility.

The result also indicate that the risk of occupational accidents and injury facing dock workers in the facility as a result of exposure to hazards indicates that welding, fabrication & cutting hazard, noise hazards, exposure to chemical fumes and metallic dust particles, vibration hazards and fire & explosion hazards have mean scores of 8.31, 6.80, 5.50, 4.80 and 2.65 respectively with respective Eigen values of 25.059, 21.740. 18.341, 17.647 and 17.213 respectively. Each of welding, fabrication & cutting hazard, noise hazards, exposure to chemical fumes and metallic dust particles, vibration hazards and fire & explosion hazards have Eigen value greater than1, which indicates that each is a significant type of hazard to which dock workers are exposed in the Niger Dock shipbuilding and repair facility. The results thus indicate that in Starz shipyard in Port-Harcourt, Nigeria, the five (5) principal component hazard types which occupational health risks to the workers in Niger Dock shipbuilding and repair facility include welding fabrication & cutting hazards, noise hazards, chemical fumes and metallic dust particles inhalation hazards, vibration hazards and fire & explosion risks each with Eigen values greater than one (Eigen>1). The five represent the significant and major occupational hazards prevalent in the Niger Dock shipbuilding and repair facility in Nigeria. The influence of the eight identified risk/hazard types on the occupational accident and health safety in the Niger Dock shipbuilding facility in Lagos is ranked as shown in figure 4.7:

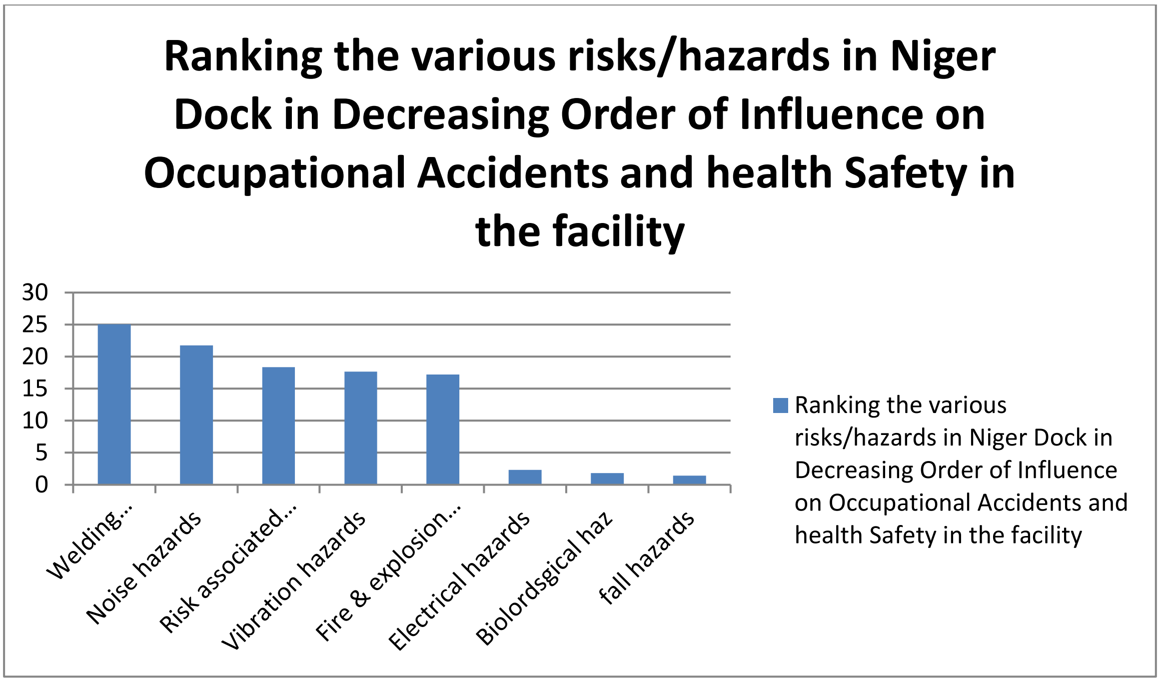


Figure 4.7: Bar chart showing the Ranking of various risks/hazards in Niger Dock in Decreasing Order of Influence on Occupational Accidents and health Safety in the facility

Source: Prepared by author

4.3: Estimating of Risk of Physical Injuries, illnesses and death to dockworkers associated with exposure to workplace hazards in Niger Dock Shipbuilding Facility, Lagos Nigeria

Recall that we explained in chapter three that the consequence (c) of exposure to workplace hazards in forms of physical injury, illness and death to workers is inversely proportional to probability of frequency of occurrence (P). Thus the mathematical relationship is such that:

$$C = \frac{Constant}{P} \qquad (2.3)$$

Table 4.14: The level of Risk of Physical Injuries, illnesses and death to dockworkers associated with exposure to workplace hazards in the shipyard in Nigeria

s/n	Occupational injury/illness type	Probability of occurrence (P)	Consequences (C)	Risk = (PC)
1	Laceration injury	0.03	2	0.06
2	Headache	0.07	5	0.35
3	Rhino rhea illness – due exposure to dust from sandblasting operation	0.11	8	0.88
4	Eye irritation	0.05	4	0.2
5	Tinnitus illness – due to exposure to noise from heavy equipment	0.12	9	1.08
6	bruise	0.08	6	0.48
7	cuts	0.11	8	0.88
8	Strain & sprain	0.05	4	0.2
9	Burns injury	0.15	11	1.65
10	fracture	0.04	3	0.12
11	Musculoskeletal injury	0.08	6	0.48
12	Arc eye	0.09	7	0.63
sum		1.0	73	7.01

Source: Authors Calculation.

The result in table 4.14 indicates that burns injury associated with welding fabrication and cutting has the highest occurrence probability coefficient of 0.15. This is followed by Rhino illness associated with exposure to chemical fumes and metallic dust particles, cuts injury associated with welding & fabrication, and tinnitus illness associated with noise pollution with respective occurrence probabilities of 0.11, 0.11 and 0.12. Laceration injury has the least occurrence probability of 0.03 and is associated with welding fabrication and cutting. Arc eye injury, musculoskeletal injury, bruise, strain & sprain, and fracture are other injury types associated with welding fabrication and cutting with each having occurrence probabilities of 0.09, 0.08, 0.08, 0.05, and 0.04. Headache illness is associated with vibration of equipment and has occurrence probability of 0.07 while Eye irritation with occurrence probability of 0.05 is occasioned by exposure to chemical fumes and dust particles.

The risk of occurrence of burns injury is 1.65 (165%) which is the highest over the period between 2014 and 2017. Rhino illness, cuts injury, tinnitus illness and Arc eye injury have respective risks of occurrences of 0.88 (88% level of occurrence), 0.88(88%), 1.08 (108%), and 0.63(63%). Musculoskeletal injury, bruises, headache, strain & sprain, and fracture have risk of occurrence levels of 0.48(48%), 0.48(48%), 0.35(35%), 0.2(20%) and 0.12(12%). Eye irritation injury has risk of occurrence level of 0.20(20%) while lac ration injury has the least risk of level of 0.06(6%).

The implication is that the management of the Niger Dock shipbuilding facility should prioritize the elimination and/or reduction of burns injury, tinnitus illness, Rhino illness and cuts injury which poses the highest risks of occurrence and consequences to the shipyard. The figure below shows the bar graph of risks levels and probabilities of occurrences of the various occupational injury and illness types associated with shipbuilding and repair in Niger Dock Nigeria limited between 2014 and 2017.

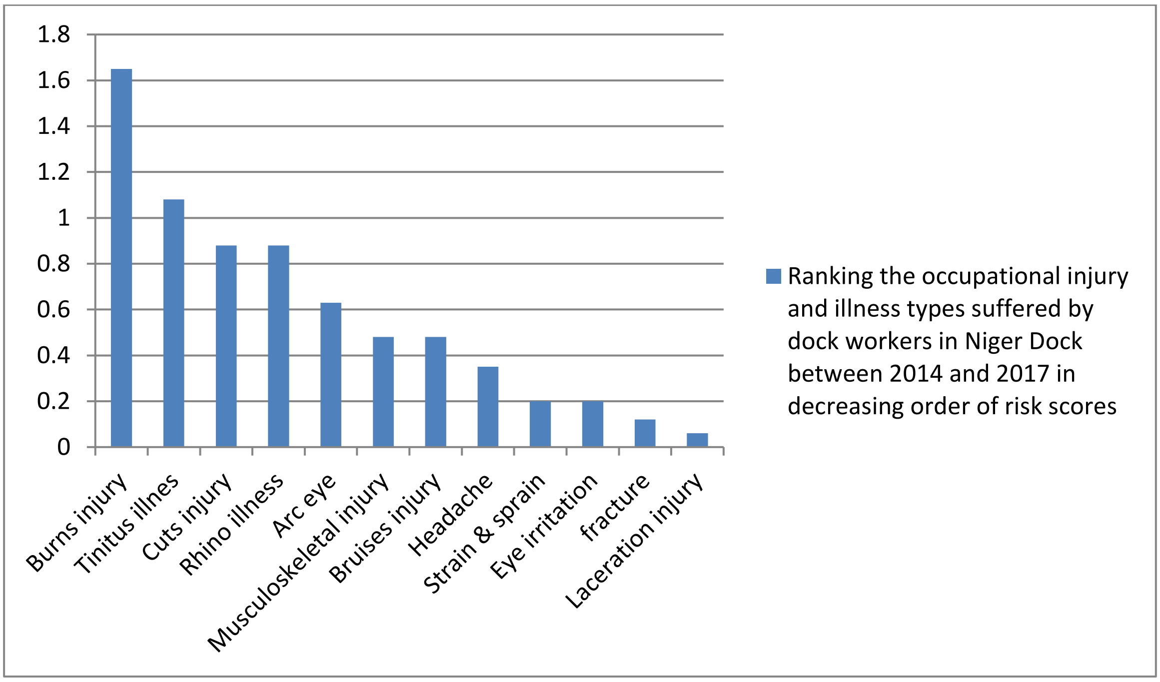


Figure 4.8: Bar chart showing Ranking of the occupational injury and illness types suffered by dock workers in Niger Dock between 2014 and 2017 in decreasing order of risk scores
Source: Prepared by Author

4.4 Discussion of Findings and Policy Implications

The results show that welding and cutting hazards, chemical fumes and dust inhalation hazards, and noise hazards with Eigen value for each exceeding 1 (Eigen value>1) as shown in tble4.9, constitute the determinant hazards of the shipbuilding and repair industry in Nigeria. Exposure to welding and cutting hazards achieves the highest Eigen value of 2.813 and as such, remains the most sources of risks of injuries and illnesses to dockworkers in the shipbuilding sector. It is also noted that electrical hazard, vibration hazard, fire & explosion hazard, fall hazards (slips & trips), and biological hazards, each of them achieving Eigen value lower than 1 (e.g: -9.067E-007<1); does not significantly influence the level of risks of injury and illness faced by dockworkers in the shipbuilding and repair sector in Nigeria as shown in table4.9. This corroborates the findings of Muhammad (2013) and Abu, et al (2021) who also found that exposure to chemical fumes and dust from sandblasting operations constitute a major hazard in the ship repair sector in Bangladesh.

The implication of the above findings for hazard control in the shipbuilding and repair sector in Nigeria is that in order to reduce the risk of injury, illness and death faced by dockworkers in the sector, the shipbuilding and repair industry must first address the determinant sources of hazards of shipbuilding which include: welding and cutting hazards, chemical fumes and dust inhalation hazards, and noise hazards. This can be achieved by the application of hazard identification and control mechanisms in shipbuilding and repair operations. This will subsequently ensure that the injury and illness risks faced by workers induced by the above determinant sources of hazards in shipbuilding and repair operations are reversed.

In Niger Dock shipbuilding facility Lagos, risk of hazards associated with welding fabrication & cutting, noise hazards, chemical fumes & metallic particles inhalation, hazards linked to vibration of equipment and hazards linked fire and explosion each have Eigen value greater than 1, thus the formed the determinant hazards in the shipbuilding and repair facility to which worker are exposed.   Though this corroborates the findings of Muhammad (2013) and Abu, et al (2021); it is also in similar to the findings of the survey conducted in Starz shipyard, however, the difference is that workers in Niger Dock are further significantly exposed fire and explosion hazards and hazards linked to vibration of equipment in addition to the three hazard types (welding and frication hazards, noise hazards and chemical fumes & dust particles inhalation risks) to which workers in Starz shipyard are significantly exposed. The implication is that dock workers in Niger Dock are exposed significantly to greater number of occupational hazard types than those in Starz shipyard, implying that workers in the shipbuilding and repair sector in Nigeria are exposed to similar hazard types, but significance or proportion of exposure to each hazard type is a function of the shipyard. It is dependent on the shipyard itself and may be influence by factors such as the type of equipment in use, the level and frequency of pose operations prevailing in a given shipyard, among other factor.

The findings of the study also indicates that burns injury, Rhino illness, cuts injury and Tinnitus illness pose the greatest levels of risk of occurrence in Niger Dock. The implication of this is that the shipyard, the shipbuilding and ship repair sector in Nigeria should take as priority, the control, reduction and elimination of the occupational injury and illness types that pose the greatest risk of occurrence and consequences in Nigeria.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The results show that welding & cutting hazards, chemical fumes and dust inhalation hazards, and noise hazards with Eigen value for each exceeding 1 (Eigen value>1), constitute the determinant hazards of the shipbuilding and repair industry in Nigeria. Exposure to welding & cutting hazards achieves the highest Eigen value of 2.813 and as such, remains the most source of risks of injuries and illnesses to dockworkers in the shipbuilding sector. It shall be noted that electrical hazard, vibration hazard, fire & explosion hazard, fall hazards (slips & trips), and biological hazards, each of them achieving Eigen value lower than 1 (e.g: -9.067E-007<1); does not significantly influence the level of risks of injury and illness faced by dockworkers in the shipbuilding and repair sector in Nigeria. This corroborates the findings of Muhammad (2013) and Abu et al (2021) who also found that exposure to chemical fumes and dust from sandblasting operations constitute a major hazard in the ship repair sector in Bangladesh.

The implication of the above findings for hazard control in the shipbuilding and repair sector in Nigeria is that in order to reduce the risk of injury, illness and death faced by dockworkers in the sector, the shipbuilding and repair industry must first address the determinant sources of hazards of shipbuilding which include: welding & cutting hazards, chemical fumes & dust inhalation hazards, and noise hazards. This can be achieved by the application of hazard identification and control mechanisms in shipbuilding and repair operations. This will subsequently ensure that the injury and illness risks faced by workers induced by the above determinant sources of hazards in shipbuilding and repair operations are reversed.

In Niger Dock shipbuilding facility, Lagos, risk of hazards associated with welding fabrication & cutting, noise hazards, chemical fumes & metallic particles inhalation, hazards linked to vibration of equipment and hazards linked fire & explosion each have Eigen value greater than 1, thus the formed the determinant hazards in the shipbuilding and repair facility to which worker are exposed. Though this corroborates the findings of Muhammad (2013) and Abu et al (2021) and is also in similar to the findings of the survey conducted in Starzs shipyard, however, the difference is that workers in Niger Dock are further significantly exposed to fire and explosion hazards and hazards linked to vibration of equipment in addition to the three hazard types (welding and fabrication hazards, noise hazards and chemical fumes & dust particles inhalation risks) to which workers in Starz shipyard are significantly exposed. The implication is that dock workers in Niger Dock are exposed significantly to greater number of occupational hazard types than those in Starzs shipyard, implying that workers in the shipbuilding and repair sector in Nigeria are exposed to similar hazard types, but significance or proportion of exposure to each hazard type is a function of the shipyard. It is dependent on the shipyard itself and may be influence by factors such as the type of equipment in use, the level and frequency of operations prevailing in a given shipyard, among other factor.

The findings of the study also indicates that burns injury, Rhinorrhea illness, cuts injury and Tinnitus illness pose the greatest levels of risk of occurrence in Niger Dock. The implication of this is that the shipyard and the shipbuilding and repair sector in Nigeria should prioritize the control reduction and elimination of the occupational injury and illness types that pose the greatest risk of occurrence and consequences in Nigeria.

5.2 Recommendations

From the foregoing, it is recommended that:

(i) The shipbuilding and repair industry in Nigeria in order to limit the occurrence of physical injuries, work related illness and death of dockworkers as a result of exposure to occupational hazard in the shipyards should strategically focus on the determinant hazards associated with shipbuilding and repair operations

(ii) Hazard control methods should prioritize the control of dockworkers exposure to welding and cutting hazards.

(iii) Proper use of PPE should be adopted in all dockyards as a result of exposure to welding and cutting hazards.

(iv) Shipyards should also prioritize the limitation of the occurrence of the most frequent illnesses associated with exposure to hazards in the shipyards.

5.3 Contribution to Knowledge

The study has for the first time determined that:

(i) Three (3) occupational hazard groups namely welding and cutting hazards, chemical fumes and dust inhalation hazards and noise hazards, each with eigen values greater than one (Eigen>1) constitute the determinant occupational hazards to which the dock workers in the shipbuilding and ship repair industry in Nigeria. They represent the significant and major occupational hazards prevalent in the shipbuilding and repair sector in Nigeria.

(ii) The probability of occurrence of physical injury to dock workers in the shipbuilding and repair sector in Nigeria 0.75 while it is 0.25 for occupational illnesses other than physical injury implying that dockyards, in order to protect workers against the effects of exposure to occupational accidents, should prioritize implementing programmmes and policies that are aimed at reducing the occurrence of physical injuries to dock workers since physical injuries have the highest probability of occurrence and risk level.

(iii) The risk of occupational accidents and injury facing dock workers in Nigeria as a result of exposure to hazards indicates that welding, fabrication and cutting hazard, noise hazards, exposure to chemical fumes and metallic dust particles, vibration hazards and fire and explosion hazards have mean scores of 8.31, 6.80, 5.50, 4.80 and 2.65 respectively with respective Eigen values of 25.059, 21.740. 18.341, 17.647 and 17.213 respectively. Each of welding, fabrication & cutting hazard, noise hazards, exposure to chemical fumes and metallic dust particles, vibration hazards and fire & explosion hazards have are all significant hazards to which dock workers are exposed in the Nigeria shipbuilding and ship repair sector.

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Apendix-1: Survey data on respondents score of the prevalence of the workplace hazards in shipyards

Vibrat	electr	biolog	noise	fire	welding	fall	chem.&dust
2	6.00	4.00	7.00	1.00	8.00	3.00	5.00
1	4.00	3.00	6.00	2.00	8.00	3.00	7.00
1	4.00	3.00	6.00	2.00	8.00	1.00	7.00
1	4.00	3.00	6.00	2.00	7.00	1.00	5.00
2	4.00	3.00	6.00	1.00	7.00	1.00	5.00
2	4.00	3.00	7.00	1.00	7.00	1.00	5.00
1	5.00	4.00	5.00	2.00	8.00	3.00	7.00
2	4.00	3.00	6.00	1.00	8.00	3.00	7.00
1	5.00	4.00	6.00	2.00	8.00	3.00	7.00
1	5.00	3.00	6.00	2.00	8.00	3.00	7.00
2	4.00	3.00	6.00	1.00	8.00	3.00	7.00
2	5.00	4.00	6.00	1.00	7.00	3.00	5.00
2	5.00	5.00	6.00	1.00	7.00	3.00	5.00
1	4.00	3.00	6.00	2.00	8.00	1.00	7.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
1	5.00	4.00	6.00	2.00	8.00	3.00	7.00
1	4.00	3.00	5.00	2.00	8.00	1.00	7.00
1	5.00	4.00	6.00	2.00	7.00	3.00	5.00
2	4.00	3.00	5.00	1.00	7.00	1.00	5.00
2	5.00	4.00	6.00	1.00	7.00	3.00	5.00
2	4.00	3.00	5.00	1.00	8.00	1.00	7.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
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1	5.00	4.00	6.00	2.00	7.00	3.00	5.00
2	5.00	4.00	6.00	1.00	7.00	3.00	5.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
2	4.00	3.00	5.00	1.00	8.00	1.00	7.00
2	4.00	3.00	5.00	1.00	8.00	3.00	7.00
1	5.00	4.00	6.00	2.00	8.00	3.00	7.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
1	5.00	4.00	6.00	2.00	7.00	3.00	5.00
2	5.00	4.00	6.00	1.00	7.00	3.00	5.00
1	4.00	3.00	5.00	2.00	7.00	1.00	5.00
1	5.00	4.00	6.00	2.00	8.00	3.00	7.00
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2	4.00	3.00	5.00	1.00	3.00	1.00	9.00
2	5.00	4.00	6.00	1.00	8.00	3.00	7.00
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1	4.00	3.00	5.00	2.00	8.00	3.00	7.00
1	4.00	3.00	5.00	2.00	8.00	3.00	7.00
1	5.00	4.00	5.00	2.00	8.00	3.00	7.00
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1	6.00	5.00	7.00	2.00	8.00	3.00	7.00
1	4.00	3.00	5.00	2.00	8.00	3.00	7.00
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