DETERMINANTS OF EFFECTIVE CONTROL OF MAJOR ACCIDENTS IN THE PORT OF MOMBASA, KENYA

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Determinants Of Effective Control Of Major Accidents in the Port of Mombasa, Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

Signature… ……..Date……

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This thesis has been submitted for examination with our approval as the university supervisors

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DEDICATION

I dedicate this work to my family for their encouragement and support throughout the research period.

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LIST OF ABBREVIATIONS

ALARP	As Low as Reasonably Practicable
ANOVA	Analysis of Variance
COMAH	Control of Major Accident Hazards
HSE	Health and Safety Executive
ILO	International Labor Organization
IMO	International Maritime Organization
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KPA	Kenya Ports Authority
LDC	Least Developed Countries
NIOSH	National Institute of Occupational Safety and Health
OH&S	Occupational Health and Safety
OSHA	Occupational Safety and Health Authority
PTW	Permit To Work
QRA	Quantitative Risk Assessment
SMS	Safety Management System
SWL	Safe Working Load

ABSTRACT

Mombasa port plays a pivotal role in the economic development of East and Central African countries where goods of varying hazards transit the port. Ports are potential sources of accidents such as spills, explosions, fires, toxic fumes among others. This study aimed to show that major accidents at the Kenyan Port Authority harbor in Mombasa, occur due to low attention given by stakeholders in the industry. Moreover, the study identified measures that should enhance effective control and management of accidents in the port areas. The study employed a descriptive survey research design where structured questionnaires were used to collect data. Random sampling was used to identify 248 study participants from a population of 650 workers. Data was analyzed using SPSS version 20 at 95% confidence interval. Data was subjected to descriptive tests to determine proportions as well as Chi square test and presented using graphs and tables. The port was found to be a multi-stakeholder operations site with 20% of employees being contractors. A high percentage of 94.2% of respondents held the view that safe operations procedures would not help in control of major accidents in the port when jobs needed to be completed faster, showing the underlying poor safety culture levels in the organization. The rates of occupational accidents in Mombasa port were significantly high with 99.5% of the port workers reporting to have witnessed occurrences of accidents. Most of the accidents were related to equipment failure and private trucks and tractors operated by contractors. Training gaps existed and in various contexts where 53.1% of respondents said they had not undergone any training or awareness on prevention of accidents or hazards despite operating in a potentially risky environment. Accidents reported by port workers include crane failure, chemical spillage, fire accidents and explosions. The main container terminal had recorded the highest number of occupational accidents compared to other terminals. There was a significant association between training on accident hazards and improvement on understanding of accident prevention ($X^2 = 0.029$ $P= 0.05$ $DF = 1$). Study revealed that training on how to avoid and deal with accidents would help reduce accident occurrence. The cargo facility-related factors variable had a significant association with the occurrence of occupational accidents at Mombasa port were poor equipment maintenance, exceeding of safe working load, lack of equipment standardized replacement policy and inadequate funding towards equipment maintenance. There was no policy or regulation dealing with the control of major accidents that had been implemented. Results also indicated that cargo handling equipment contributed most accidents and fatalities at the port of Mombasa. A total of 11 fatalities were reported between 2016 to 2022 and ten were attributed to cargo handling equipment. There was poor control of contractor operations and the negative perception of contractors by employees made it difficult to enhance safety and prevent major accidents at the port. The risk assessment of operations did not involve the workers who do the job.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

According to COMAH regulations (2023), a major accident is defined in Control Of Major Accident Hazards, COMAH, regulation 2(1) to mean: an occurrence (including in particular, a major emission, fire or explosion) resulting from uncontrolled developments in the course of the operation of any establishment and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances.

The port of Mombasa plays a pivotal role in the socio-economic development of East and Central African countries where goods of varying hazards transit the port. Operations in port entails the risk of serious accidents, to which shores and especially port areas and their vicinities are highly exposed to huge quantity of hazardous substances. Crane incidents are happening with increasing frequencies in the ports around the world. Besides adverse and unpredictable weather, other causes of crane accidents in ports include poor standards of safety in crane operation and terminal operations and failing to keep up standards of crane maintenance (Larry & Peter, 2017). The importance of ports as a potential source of accidents of diverse types (spills, explosions, fires, toxic clouds) is closely linked to the function of the port itself and to the installations and activities associated to it, which feature transfer from water to land (and vice versa) of large amounts of waterborne cargo with a wide diversity hazardous material capable of causing major accidents (Tsenga & Nick, 2017).

According to a study carried out in Taiwan's Kaohsiung Port on causes of accidents in ports, fire, explosion and equipment (crane) failure accounted for close to 30 % of the total major accidents analyzed from the year 2010 to 2014.

Table 1.1 shows accidents that happened in a Taiwan port from the year 2010 to 2014 and gives a picture of the types of common accidents in the port areas.

Table 1.1: Causes of major accidents in Kaohsiung Port in Taiwan

Year	Total	Collisions	Grounding	Fire	Explosions	Loss of containment	Capsized	Machine failure
2010	80	39	9	3	0	0	0	25
2011	104	28	8	7	3	0	2	39
2012	70	25	5	1	1	2	2	7
2013	30	18	2	1	0	0	0	2
2014	21	19	0	0	0	2	0	1
Total	305	129	24	12	4	4	4	74
%		4.2	7.8	3.9	1.3	1.3	1.3	24.2

(Source: Tsenga & Nick, 2017)

A study carried out by researchers in the United Kingdom (Southampton Solent University) to review shipping accidents as shown in table 1.2, showed statistics of occurrence of major accidents in the ports despite efforts to control them (Butt et al., 2020). This gives a strong view that there is need to continuously develop effective control measures on occurrence of this hazards in the ports.

Table 1.2: Port industry accident statistics in the UK

Using over 7 days (New Criteria)	2010	2011	2012	2013	2014
Total number of employees covered	19508	18066	17526	16270	16338
Total number of fatal accidents	1	1	2	1	0
Total number of major accidents	37	33	17	30	13
Total number of >7 days accident	236	198	160	185	65
Total reportable accidents	274	232	179	216	78
Incidence rate	1.4	1.3	1	1.3	0.5
Total number of dangerous occurrences	73	51	30	24	5
Total number of industrial diseases	7	6	3	2	0

(Source: Butt et al., 2020)

A similar study in Barcelona, Spain, showing locations of major accidents in the ports indicated that majority of major accident hazards had occurred during

unloading/offloading from the ship or through use of handling equipment /cranes as showed in Figure 1.1

Figure 1.1 shows the statistics on the number of accidents that occurred in various locations of Barcelona port in Spain.

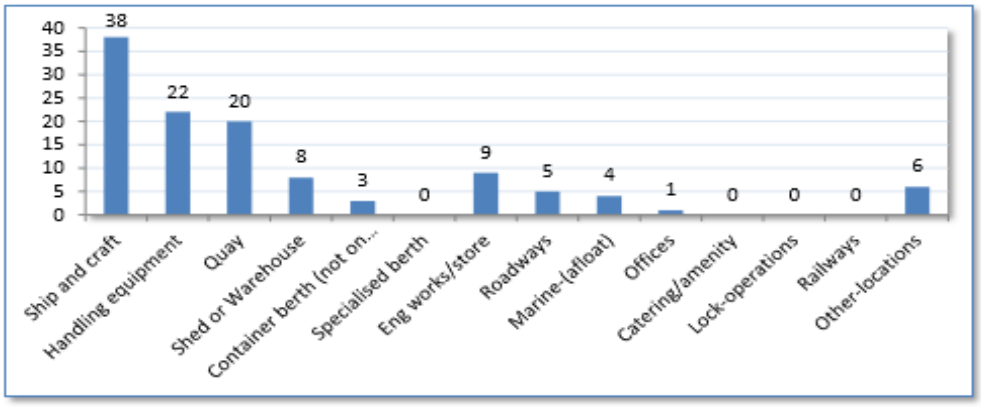


Figure 1.1: Top five locations for occurrence of major accident in the ports

(Source: Ronza et al. 2020)

Control of major accidents requires intact effective hazard control measures and robust safe systems of work.

1.2 Statement of the Problem

Ports are often challenging places to work. Workers deal with a whole range of cargoes and work alongside a wide variety of people and equipment. In addition, work at ports takes place throughout the day and night and in all types of weather and often involves several different employers and contractors who could all affect each other's activities.

The potential for major accidents to happen in ports and harbours has increased in the recent past due to increase in trade volumes. This is because aapproximately 50% of goods carried by sea and handled in the ports can be classified as hazardous and if

wrongly handled, could cause death of people, environmental disaster or destruction of property.

A review of the quarterly accident report for KPA provided at the site for the year 2017 showed that over 50% of them were from the container terminal. A major accident of fire, equipment failure, chemical spill etc. would lead to temporary shutdown or interruption of operations leading to huge direct and indirect losses. An ideal situation would be where adequate measure have been put in place to mitigate against occurrence of major accident at the port through safe systems of work, proper maintenance of equipment, training, conducting adequate and sufficient risk assessment among other measures Therefore, adequate measures must be put in place to counter any emergency. For instance, fire kills, destroys buildings and other property leading to massive losses when it happens.

Thus, the potential for major accidents in the port is high. The port of Mombasa has experienced major accidents ranging from fire, explosion, chemical spillage and lifting equipment failure in the past. An equipment failure such as crane collapse could lead to multiple fatalities or huge downtime losses in lifting of goods from or into a ship. The impact of this would cause huge losses to in-land manufacturing, transport and service industries which translate into massive financial losses besides possible loss of lives and property.

Hence potential for occurrence of major accidents at the port of Mombasa is high and such potential occurrences poses devastating losses to both the port and other numerous stakeholders both directly and indirectly and thus the status quo should not be left unattended. The approach should be to put in measures to ensure the likelihood of occurrence of major accident is reduced to as low as reasonably practicable to prevent loss of life, property damage and pollution of the environment.

1.3 Objectives of the study

1.3.1 Main objective

To evaluate the determinants of major accidents at the port of Mombasa

1.3.2 Specific objectives

1. To assess the effectiveness of safe systems of work implemented towards control of major accidents.
2. To assess cargo handling equipment maintenance and repair system in place towards ensuring effective control of major accidents
3. To identify training need gaps towards enhancing effective control of major accidents
4. To assess the current risk management process in place towards effective control of major accidents

1.4 Justification

The relatively low frequency of reported major accidents resulting from port operations can lead to inadequate attention being paid to systems and controls to reduce the risk of major accident hazards in the ports. All accidents come with attached costs, both direct and indirect. Examples of recent major accidents that have been recorded at the study location included: A fertilizer silo falling on a testing operator and fatally injuring two people and seriously injuring seven others; signaler fatally crushed by a crane and seriously injured three other staff; trailer hitting a container reach stacker thereby injuring seven staff and a cargo fall from a ship winch crane damaging the mobile crane and extensively damaging the cargo, among others. This example of recent occurrences shows that there is a need to identify and implement better ways to prevent and control the potential occurrence of accidents at the port areas. A reduction in costs (direct and indirect) associated with the occurrence of accidents in the workplace e.g. compensation, legal costs etc. will be achieved from the study and make the workplace safer thereby end up increasing the profitability and the morale of employees and hence the overall productivity of the organization.

1.5 Hypothesis

There are no determinants of effective control of major accidents at the port of Mombasa

1.6 Research Questions

1. Which are the contributions of safe systems of work in effective control of major accidents in the port of Mombasa?
2. How has lack of adherence to machines and equipment repair and maintenance schedule affected effective control of major accident in the port of Mombasa?
3. What has been the contribution of training in effective control of major accidents in the port of Mombasa?
4. How has risk assessment helped in effective control of major accidents in the port of Mombasa?

1.7 Scope

The study was carried out at the port of Mombasa. The staff included the harbor executive consisting of general managers, the harbor managers who are mostly head of departments and supervisors, the dock workers who are the majority doing ground operations and contractor staff who make up a third of the total population at the port. This study sampled from a total population of 650 workers spread across various sections of the container terminal. The research involved perusal of available records related to training, risk assessment, contractor control, equipment maintenance and accidents occurrence within the organization as well as interviews with the Safety and Health representatives, machine and equipment operators, maintenance and repair technicians among other dock workers, so as to obtain information related to control of major accidents in the port. The study considered the opinions of both permanent and contractual employees who were working in the organization at the time of collecting data. The results were analyzed to arrive at the conclusions and recommendations.

1.8 Study Limitations

Although the objectives of this research were achieved, some challenges were encountered. One, the unwillingness of some participants to provide the required information of the study until confidentiality was guaranteed. Two, some of the questionnaires were never returned and others were returned late leading to delays in data analysis. Three, taking of photos was not allowed.

1.9 Conceptual Framework

Despite high probability of occurrence and high potential for large-scale damage, major accident occurrence in Kenyan ports have not been sufficiently studied. The theoretical framework of this research aimed to: Provide recommendations that could help in ensuring effective control of major accident in ports and other hazardous installations in the country, identify some of the factors that could help determine how major accident could be managed proactively in the ports and highlight the gaps that may abound so as to recommend further studies in the thematic areas in the ports.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Principles

There seems to be a perception that ‘accidents will happen’ where so much human activity is being conducted. It has also been recognised for many years that certain commercial activities involving handling of dangerous substances with sophisticated equipment have the potential to cause accidents (Mejia et al., 2017). The effective control of major accidents risk requires an understanding of the theory of how accidents happen and energy transformations, if any, involved in potential major accident events. Without understanding how major accidents have occurred and how a combination of events and operations would lead to major accidents is deluding ourselves and the question becomes “when will our smoking gun explode?”. The various theories relevant to this study were studied to gain more understanding on occurrence and control of major accidents.

2.1.1 Theories Relevant to the Study

2.1.1.1 Domino Theory of Accident Causation

Pioneered by Heinrich, this theory describes the accident causation relationship in regard to, man and machine, unsafe acts and management controls. According to Heinrich domino theory is comprised of five standing dominos which will fall one after the other if the first domino falls (Berman, 2016). Heinrich suggested that removal of one of the factors would prevent the accident and resultant injury. The accident can be prevented only if the chain of sequence is disturbed, e.g. the unsafe act/condition can be eliminated in order to prevent the accidents and associated injuries.

Figure 2.1 shows how failure of one factor would lead to failure of another and ultimately lead to causation of accident under the Domino accident causation theory.

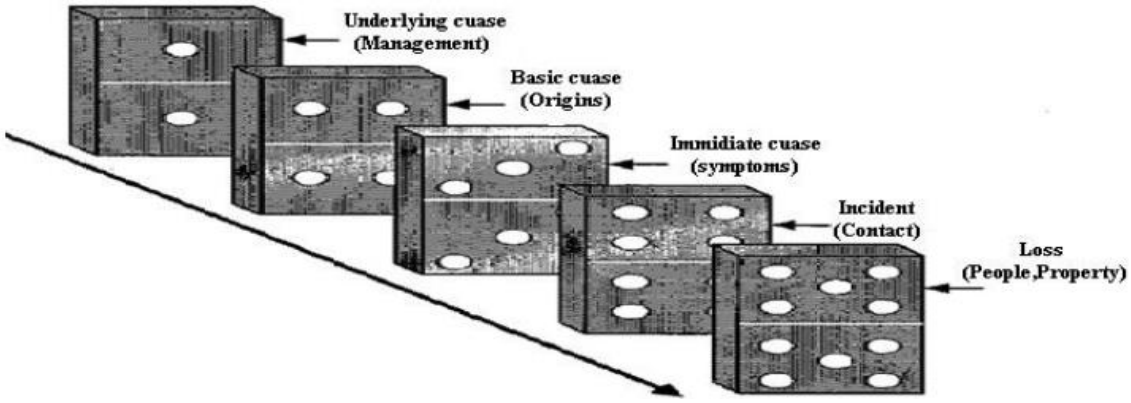


Figure 2.1: Domino accident causation theory factors

(Source: Berman, 2016)

This theory became the basis for many other studies on accident causation model with emphasis on management role in accident prevention. Management models believe that lack of management system (e.g., port safety management system) is responsible for occurrence of major accidents.

2.1.1.2 Multiple Causation Theory

It is an outgrowth of the domino theory, but it postulates that for a single accident there may be many contributory factors, causes and sub-causes, and that certain combinations of these give rise to accidents (David & Ditchurn, 2016). According to this theory, the contributory factors can be grouped into the following two categories: Behavioral category which includes factors pertaining to the worker, such as improper attitude, lack of knowledge, lack of skills and inadequate physical and mental condition. Environmental category which includes improper guarding of other hazardous work elements and degradation of equipment through use and unsafe procedures. The major contribution of this theory is to bring out the fact that rarely, if ever, is an accident the result of a single cause or act but a steady escalation of potential of occurrence from a lower level to a higher level or vice versa as shown in figure 2.2.

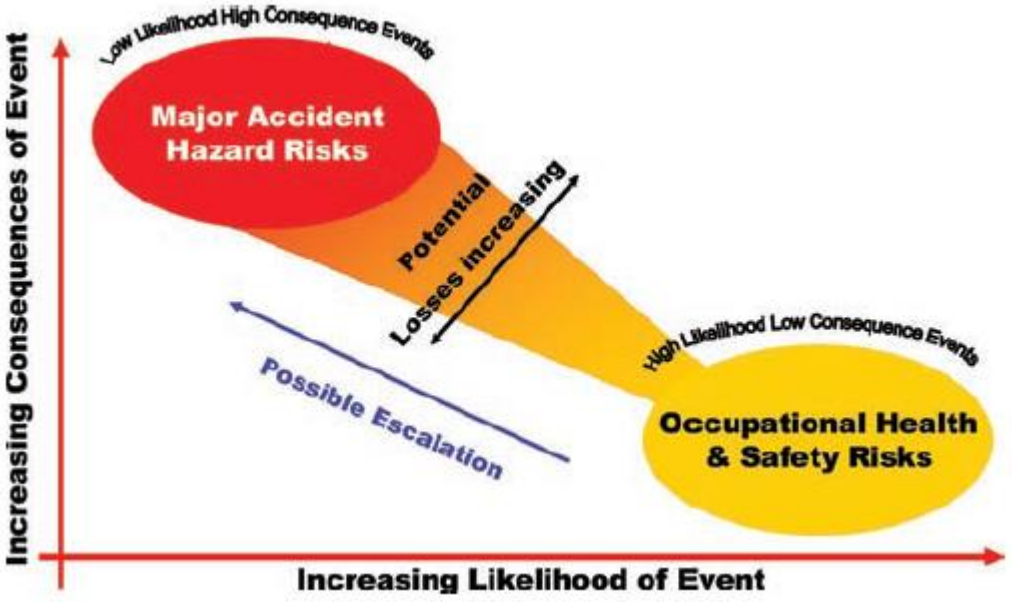


Figure 2.2: Major accident hazards escalation continuum

(Source: David & Ditchurn, 2016)

For instance, uncontrolled escalation of safety incidents can be the cause of major accident events although this factor is often overlooked or underestimated (Brandsæter, 2018).

2.1.1.3 The Energy Transfer Theory

It postulates that a worker incurs injury or equipment suffers damage through a change of energy, and that for every change of energy there is a source, a path and a receiver (Ronza et al., 2020). Kinetic energy is contained in an object that is moving. For example, a wrench falling from an overhead crane or the collapse of the crane structure. Chemical energy can occur in the form of chemicals reacting strongly with various parts of a human being as well as machines, equipment, and the environment.

Thermal energy can manifest itself in the form of fire or explosion, which can destroy people, property and the environment. Mechanical energy can also manifest in form of cargo handling equipment failure while pressurized energy in the forms of

pressurized gases and liquids in bulk which are offloaded from ships (Ronza et al., 2020). Major accident hazards have high potential to act as uncontrolled release of energy and should be well mapped in the port operation areas.

2.2 Major Accidents

Most developed nations have legislations dealing specifically with control of major accident. In them, they are required to develop an adequate and documented performance-based approach framework, under which operator of a hazardous facility (e.g. Kenya Ports Authority) establishes, implements and maintains appropriate systems, procedures and processes intended to prevent major accidents and near misses, and to minimize the effects of major accidents at the facility on people, property and the environment.

For example, in The UK the "Control of Major Accident Hazards Regulations" (COMAH) were introduced in Great Britain, replacing earlier legislation, with the aim of preventing major accidents involving dangerous substances and to limit the consequences to people and the environment of any which do occur (Chang-I & Craig, 2021). Some of the criteria for classifying major accidents were: On basis of fatalities, serious injuries that could be life threatening, involvement of many people and causing extensive damage to property, loss of income as well as spillage of hazardous substances to the environment causing pollution.

2.2.1 Controls for Major Accident Hazards

Major accidents are usually characterized by coincidental breakdowns of multiple barriers rather than as a sequential progression of precursor events. The initiating event may be minor, but as the successive barriers fail the resulting accident continues to grow in significance and consequence (Roberson, 2017). Barriers can be thought of as the controls and defenses installed e.g. engineering controls, administrative controls and safe systems of work. One cannot assume that the various barriers are completely independent of each other. For example, a company facing financial challenges is probably postponing preventive maintenance of key cargo

handling equipment and machines or foregoing key training of its staff who may be taking shortcuts on operating procedures and using suspect material and riskier technology (Neil, 2019).

2.2.2 Hazard Sources at Ports

According to Deane, 2018, any facility where hazardous substances that are explosive, flammable, toxic, reactive etc. such as ports, have a potential to cause major accidents (i.e. accidents that could seriously harm people, property or the environment) should be carefully managed. This potential is a result of the storage, handling (loading or off-loading), transport or processing of significant quantities of dangerous chemicals. The relatively low frequency of major accidents resulting from such operations can lead to inadequate attention being paid to systems and controls to reduce the risk of probable large-scale damaging events (Cătălin et al., 2017).

2.3 Training

It is the responsibility of operators of major hazard facilities to ensure that a comprehensive and effective training and education program is developed, implemented, maintained and improved at the facility. The main objective of a training and education program is to ensure that employees at a major hazard facility contribute to the minimization of risk of major accidents by working safely (Radojkovic, 2018). The importance of a training and education program is based on the recognition that the day-to-day operation dealing with major hazards is dependent on the skills, knowledge and attitude of the employees of that facility. The cases of major accidents causing serious damage to people, property and the environment where the cause of the accident is attributable, in part, to inadequate training, are well documented.

2.3.1 Training and Education Needs Analysis

The first step in the development of the training and education program in the port would be systematic identification of training needs. The analysis should identify the learning objectives required for the different working groups and individuals within

an organization. According to (Deane, 2018), one of the approaches used to identify training needs is to categorize the needs in accordance with the desired learning objectives. such as: General improvement of safety awareness, knowledge development for safe operation and influencing safety attitudes to encourage safe behavior.

The tasks or actions can be: Skill-based actions; Rule-based actions and Knowledge-based actions where different types of training are required for these different actions and behaviors (US Department of Labor, 2018). Rule-based training usually reinforces the behavior requiring employees to follow instructions and procedures. While this approach may be appropriate in certain circumstances, effective safe operations may require a training program to go beyond reminding the employees to follow rules.

Development of such a program should be based on consultation with employees in the organization to comprehensively cover all levels of employees as well as contractors and visitors, and all scope of their work. It should provide the merit of identifying the personal attributes, skills and qualifications when selecting the right person for a key position such as a crane operator (Deane, 2018). According to Cătălin et al. (2017), port authorities should aim to develop structured and comprehensive mechanism to establish a training program that is appropriately resourced, with competency standards for key positions that will effectively impart the knowledge and information to enable them to control occurrence of major accidents.

2.3.2 Training of Personnel at All Levels of the Organization

Induction training for new employees should provide, as a minimum, an initial level of understanding of the basic minimum requirements for working at the site. These may include elements such as: a site familiarization tour; an overview of site activities and processes; location of amenities, including the first aid rooms; an organizational structure, reporting mechanisms; General rules and procedures while on site; for reporting of unsafe conditions and general procedures during

emergencies, including location of alarms; site security arrangements and rules for access to the site (Radojkovic, 2018).

There is an international legislation that deals specifically with training of employees working in the port. ILO considers the convention Occupational Safety and Health (Dock Work) Convention (No. 152), 1979 highly relevant to port performance. This Convention includes several mandatory requirements regarding training. For example, Article 4, paragraph 1. (c) states the following: "National laws or regulations shall prescribe those measures complying with Part III of this Convention be taken as regards dock work with a view to providing the information, training and supervision necessary to ensure the protection of workers against risks of accident or injury to health arising out of or in the course of their employment" Article 4, paragraph 2. (r) states "the measures to be taken in pursuance of this Convention shall cover training of workers". Also, Article 38, paragraph 1 states "no worker shall be employed in dock work unless he has been given adequate instruction or training as to the potential risks attaching to his work and the main precautions to be taken", ILO Code of Practice on Safety and Health in Ports (ILO, 2017)

Dock Work Recommendation (No. 145), 1973: Convention concerning the Social Repercussions of New Methods of Cargo Handling in Docks. This Recommendation calls for training and retraining to enable dockworkers to carry out several tasks as the nature of work changes. Occupational Safety and Health (Dock Work) Recommendation (No. 160), 1979. This Recommendation includes a provision that states the following: "With a view to preventing occupational accidents and diseases, workers should be given adequate instruction or training in safe working procedures, occupational hygiene and, where necessary, first-aid procedures and the safe operation of cargo-handling appliances." ILO Code of Practice on Safety and Health in Ports (ILO, 2017). The provisions in this Code cover all aspects of port work where goods are loaded or unloaded to or from ships and includes work incidental to such loading or unloading activities in the port area.

A 2018 NIOSH study concluded that the role of training in developing and maintaining effective hazard control activities is a proven and successful method of

accident intervention. Therefore, appropriate training relevant to the specific job should be provided to employees at all levels. Training that is not regularly enforced is often forgotten. These employees should be trained not only on how to perform their job safely but also on how to operate within a hazardous environment or how to respond during an emergency in their work areas (Townsend, 2017).

2.3.3 Training of Contractors

Contractors need to be subject to all safety controls, including training requirements, which apply to site employees to ensure their practices do not jeopardize themselves, others and the facility (Deane, 2018). Training for this group of stakeholders must include a detailed analysis of the identified hazards, the risks involved in the operation and the effective use of control measures. Certain job assignments should be limited to contractors who are "certified," "competent," or "qualified"— meaning that they have had special previous technical training, in or out of the workplace. Thus, specialized training such as safe operation of port equipment and machinery, chemical and hazardous materials safety and accident prevention and safety promotion should be offered to employees who operate specialized equipment both at the container terminals, quay side and stevedores.

2.3.4 Training for Emergencies

Crew preparedness is an important element of safety at sea and ports and should therefore be a key focus of attention for all ports in managing major accident hazards. Proficiency in responding to emergency situations by the personnel should include ability to operate essential emergency equipment and general familiarization with the emergency situations (Jihong et al., 2019; Mejia et al., 2017). The crew also must demonstrate proficiency in assigned emergency duties and the equipment connected to these. The same should also apply to the ground crew in the fire safety department to ensure they are ready for any fire or explosion that may occur during ground operations. This should be demonstrated through scheduled drills.

2.4 Risk Assessment

In the world of international trade, nearly every business opportunity places a demand on port operations. In fact, the trends in international trade in strategic minerals and energy commodities, such as crude oil, have also been emphasizing marine transportation (IMO, 2017). The entry and presence of dangerous cargoes in port areas and any consequential handling should be controlled to ensure the general safety and security of the area, the containment of the cargoes, the safety of all persons in or near the port area, and the protection of the environment as well as the provision of emergency equipment appropriate to the hazards of the dangerous cargoes to be handled. Among the cargo being moved are strategic energy commodities and infrastructure, such as crude oil, liquefied petroleum gas (LPG), heavy machinery and hazardous chemical substances in loose or bulk essential to the global economy. In this regard the complex, fast-paced and high-volume global trade requires an effective risk profiling capability for ports and waterways for the safe and secure movement of these goods in the global supply chain (Stenek et al., 2018).

2.4.1 Port Operations and Common Good Practices

The concept of risk and risk assessment has been around since when it was first used primarily in the safety analysis of nuclear reactors after World War Two (WWII) (Altiok, 2019). Traditionally, risk assessments were based solely on expert opinion. Experts were asked to rate several incident scenarios, with instigators and consequences, using scales of some numbers. The numbers were then crunched, and risk was calculated. Expert opinion must be an integral part of risk assessment but should not comprise all of it.

However, a good practice in most ports in developed nations is to use a mathematical risk model to calculate risks for each scenario as they develop in the simulation model. For instance, in the case of handling explosive materials in the port, the operator (Port) should consider two broad categories of accidental initiation of explosives material: Initiation caused by accidents imparting high levels of energetic stimuli to explosives, e.g. crane failures, vehicle collisions and fires, ship fires etc.

and initiation brought about by the presence of unsafe items in explosives load and where an initiation may occur without there being any precursor accident of the types mentioned above (Stenek et al., 2018; Merrifield et al., 2021).

According to (International Chamber of Shipping, 2018), there is a great risk of a major hazard accident arising in the port operations as a result of the transport and handling in the ports of a hazardous substance in bulk. Most accidents can be avoided if the risks from the work are suitably and sufficiently assessed and appropriate control methods are adopted (SIP016, 2016).

According to (Stenek et al., 2018), in practice the application of a risk-based approach to port licensing may lead to real safety improvements against occurrence of major accidents through greater operator awareness of risk generating activities. For example, a full assessment of the risks from the handling of explosive substances in ports must take account of possible "domino effects" arising from potential interaction between explosives and other types of dangerous commodities.

2.4.2 Why Risk Assessment in the Port

According to (Brandsæter, 2018), many port management systems have been developed partly as a result of lessons learned from incidents and accidents. The risk assessment is applied to add value to the existing system, informing it for development into a coordinated system managing risk.

The likelihood of a hazardous incident and its potential consequences can also often be determined with reference to historical data (Merrifield et al., 2021). However, (Liwång, 2020), cautions that historical data alone will not provide a true assessment of the risk of the current port operations, nor will it necessarily reveal an extremely remote event. There must be focus on accidents with multiple fatalities because society is more concerned about single events with many fatalities and societal risk, than it is about several incidents with few fatalities per incident (Kilvington, 2017).

Consultation with regular users and organizations having interest in the port is important while undertaking risk assessment and ports are such types with multiple

stakeholders and users. This approach recognizes that the people best placed to identify hazards are often personnel working within the port, but that a "new pair of eyes" also notices items of significance that are accepted as normal in the system. According to Liwång (2020), risk assessment should be a consultative process that involves all stakeholders and creates synergy that ends up with a harmonized comprehensive risk assessment.

2.4.3 Port Risk Assessment Approaches and the "ALARP" Principle

According to (Abd el-al & Shaheen, 2019) a safe port is an efficient port, and this has become a buzzword in competition for shipping ports in the context of an intertwined world governed by global economies. It is critically important to be able to quantify risks in ports so that sound risk-mitigation policies can be developed to minimize major accident and damage to infrastructure that can, in turn, cause disruptions to the port's supply chain. (Altiok, 2010).

Quantitative Risk Assessment (QRA) requires vast amounts of incident data and significant resources to establish a numerical evaluation of the level of risk. For instance, to increase the amount of explosives that can be shipped through a port in the UK, risk assessment to justify this quantity is required (Merrifield et al., 2021). QRA can show whether the risks have been made ALARP (As Low As Reasonably Practicable). The qualitative approach uses risk in a comparative way to identify if one activity carries higher risk than another and is the most appropriate for a port risk assessment (Liwång, 2020). A useful way to compare risk levels is to base the risk assessment on a matrix approach where the product of frequency and consequence are used as guide for decision. Where frequency is extremely remote (rare) and consequence insignificant then the risk is termed acceptable, where hazards are defined as frequent and the consequence catastrophic, then risk is termed intolerable

At some point in the matrix there is a reasonable balance between the cost of further investment in risk management in relation to the consequence of outcome and the additional risk reduction achieved by the further investment. This area is termed ALARP (As Low As Reasonably Practicable) (Kilvington, 2017).

2.4.4 Risk Assessment Communication

When assessing risks, particularly risks associated with major accidents, it is unlikely that an operator will be able to demonstrate that risk has been eliminated or reduced to negligible levels. Instead, the operator will have to demonstrate that the risks are tolerable, on the basis that they are acceptably low, and cannot be cost effectively further reduced. (Stenek et al., 2018). All key findings should be disseminated throughout the workforce, to ensure that all employees understand the hazards and risks associated with the facility, the control measures in place to manage these risks, and their roles in the event of an accident (Deane (2018). The workforce could affect the effectiveness of the control measures and through understanding the potential for accidents to occur if the control measures are degraded, an appropriate focus on maintaining the control measures can be held. The level of understanding of the technical issues that may exist at the port will vary enormously and will require various levels of information and therefore communication that addresses these issues may require expertise from public relations experts (Deane (2018).

2.5 Safe Systems of Work

According to (Merrifield et al., 2021), it is no longer enough to demonstrate that a lack of incidents indicates effective hazard control. Rather, a proactive and positive approach to safety management must be developed, implemented, audited and reviewed. The port safety management system should be developed with significant input from persons working in the Port, as well as users of the port, and be supported by a series of risk assessments. Ports and terminals should have procedures ready for immediate implementation in case of emergency. These procedures should cover all type of emergencies that can be expected for example; a major oil spill or cargo leaks that result in a fire or explosion or a crane failure with multiple accident implications (Trujillo-Castellano & Nombela, 2019).

2.5.1 Port Safety Management System

Any safety management system inherently needs an assessment of risk to inform it of safety priorities and the performance of risk management systems managing those priorities. Since any system will be overlaid on existing risk management measures within the port, the true effectiveness of these needs to be considered at the assessment stage of the cycle.

There is a close relationship between risk assessment and the Safety Management System. A risk assessment defines the risks and the safety management system manages the risks (ABS, 2021). According to American Bureau of Shipping, (ABS, 2021) in all hazardous operations, it is now accepted good practice to have in place a Safety Management System (SMS) and to institutionalize safe working practices and attitudes through the development of a positive safety culture. The risk assessment will have identified the types of safety management systems that are needed with respect to those that are already in place (Kilvington, 2017).

No safety management system is complete without a process of audit and regular review (Helal, 2019). The system review is fundamental for the feedback and it is feedback that provides the safety management system with its intelligence (International Chamber of Shipping, 2018). With the review comes the opportunity to review procedures considering inherent major hazards in the port (Kilvington, 2017). According to Galhena (2017), a successful safety management system will evolve and be modified with the changing trade profile in the port and it will be a remit of the audit function to establish that this is happening.

2.5.2 Operation Procedures

According to a survey carried out by the World Bank on Least Developed Country (LDC) ports (World bank, 2019), many LDC ports have poorly educated and ill-trained equipment operators, who lack well-conceived and clearly understood operating procedures backed up by careful recruitment, selection and training. Lack of such procedures often encourage and subsequently legitimize routine violations

and short-cuts. Such violations are often quoted as one of the most common root causes of major accident within and outside of the ports, cites the report.

For example, a detailed procedure would be required to guide how explosive and flammable chemicals should be handled in the port areas with clear description of the procedures by which the operator would move explosives through the port (Merrifield et al., 2021). The procedures to be followed in an emergency, including the procedures to be followed in the event of an explosives load being suspected of being in an unsafe condition. According to Kilvington (2017), where written procedures are not in regular use, as is the case for the bulk of the work carried out within the port, there is an implicit assumption that the skills and knowledge embedded in the procedure have been provided in initial training and are regularly maintained via appropriate refresher training. There is a significant body of evidence that compliance with procedures is influenced by a wide range of factors and much of this evidence has come from detailed investigations which have followed major accidents (Merrifield et al., 2021; Frittelli, 2018)

2.5.3 Permit to Work (PTW) Systems of Work

A general rule should be all high-risk jobs should be approved through a permit to work system supported by a job safety analysis (Froese, 2016). The purpose of Permit To Work System is to ensure that hazardous work and operations in the ports are carried out in a way which minimizes any danger and meets appropriate safety standards and performance criteria.

Some of high-risk jobs requiring a permit include: Hot works like welding or grinding, working at height, excavation or drilling and all electrical works on light or heavy current etc. Where appropriate, contractors are required to work within or to procedures, which are at least equivalent to those of the Port Authority's Permit to Work procedures (Helal, 2019). Performing hot work in a port and terminal is a high-risk activity and must be controlled through a hot work permit system. The permit system also ensures that hot works are not carried out during loading and discharging

without permission, so that additional safety measures can be implemented (Froese, 2016).

2.5.4 Contractor Management System

At any given time in a port there are several different employers and third parties who can all affect each other's activities. These may include port authorities, dock operators, stevedoring firms, government agencies, haulers, ships' masters and crew (HSE, 2021), who may be less familiar with the port environment than permanent employees. It's the employer's duty to protect the health, safety and welfare of workers whether they are full-time, part-time, permanent, non-permanent or temporary. This includes workers who are on short-term contracts or rolling contracts.

Contractor activities which may impinge on port operations should be subject to either risk assessment or procedural review and a method statement produced prior to the start of work of identifying hazards, risk controls and communication procedures required. Violations should result in cessation of activities until appropriate steps have been taken to rectify. A working plan should be developed covering areas like the responsibilities of each party, how each party will do its part, how the different parties will interface, common issues and arrangements, e.g. for emergencies as well as how the work will be coordinated and controlled (Merrifield et al., 2021).

2.5.5 Emergency Response Systems

Emergency planning is the process by which an organization prepares to respond to a natural or man-made event that significantly impacts its operations. Unfortunately, as major accidents do not routinely occur and are rare events, many operations fail to review, improve and maintain their Emergency Operations Plan (EOP), an oversight that increases risk – moving what might have been a controllable incident into a disaster or catastrophic situation (Corson et al., 2018; Trujillo-Castellano & Nombela, 2019).

An emergency response can be triggered by occurrence of one of the major accidents discussed earlier on, such as crane failure, explosion, fire, environmental spill of a hazardous chemical or even a terrorist attack. The emergency plan must be properly incorporated within the overall facility safety management system as a control measure subject to the same regime as all other control measures (Abd el-al & Shaheen, 2019). Port authorities must always have emergency plans in case of accidents, and port workers must be trained on evacuation procedures. The development of the emergency response plan needs to include processes for testing, review, training and informing. This should ensure that it is understood by the workforce and other potentially affected people; and that it is subject to review, testing and update (Trujillo-Castellano & Nombela, 2019).

According to International Labour Organization, code of practice on security in ports, (ILO, 2017), ports should have plans for dealing with emergencies that could have a wider impact. There should be a written emergency plan if a major incident at the port could involve risks to the public, rescuing employees or co-coordinating emergency services. Ports must develop plans for emergencies that are based on risk assessments (Corson et al., 2018). Where a workplace is shared with another employer the emergency plans and procedures should be coordinated.

2.6 Cargo Handling Equipment

The growing move towards heavier lifting operations in ports is one trend that seems universally tipped to continue. Whether a port is large or small, it has a large investment in mechanical equipment and infrastructure that obviously needs to be maintained and protected. Amongst factors such as high efficiency, adequate infrastructure, good location and low port charges is reputation for cargo safety which is tied to maintenance of cargo handling equipment. Port efficiency is directly related to cargo handling equipment and is the most important factor in port selection and it is, therefore, essential that port operators and policy makers give top priority to improving equipment maintenance.

2.6.1 Care, Repair and Maintenance

Cargo handling equipment is part of infrastructure which in its widest context refers not simply to the number of container berths, terminal area, cranes and tugs but also to the quality of cranes and other lifting equipment provided for the operations in the port. According to Jihong et al. (2019), equipment and machinery failure is the third most common reason for major accidents in the ports, after contact damage and collisions. If not reported in due time and not addressed immediately, defective equipment will result in major accidents and property damage.

The management of port equipment maintenance is probably the most serious operational problem facing port managers in developing countries (World Bank, 2019). According to a survey conducted by the World Bank, many Less Developed Countries (LDCs) are experiencing serious port cargo handling equipment maintenance problems and, worse, that these problems are steadily increasing as their ports struggle to acquire and manage the more complex cargo-handling equipment needed to respond to the port stakeholder's demands. The port's equipment maintenance alone accounts for 15 to 25 percent of total port operating expenditures and is frequently a port's largest single expenditure item.

The subject of cargo-handling equipment and facilities raises the important question of mechanization. It is estimated that 40% of a port's capital budget is spent on the procurement and maintenance of cargo handling equipment. So, it is most important for port management to put the required emphasis on maintaining a proper inventory and maintenance of the equipment (Shahjahan, 2017; Corson et al., 2018).

For the port areas, all mechanical equipment used specifically for the transfer of dangerous goods should be taken into consideration. Cranes are used on the terminal premises to handle cargo transfer equipment. The main hazards associated with the operation of cranes in port areas and terminals includes exceeding the Safe Working Load (SWL) where SWL indicates the load a crane can safely lift, suspend or lower and should be clearly marked on the crane. While many port authorities and investors have been busy prioritizing container terminals, heavy lift facilities have been largely

neglected and instead there is continual use of old mechanical lifting equipment which are subject to failure and lead to major accidents in port areas (Shahjahan, 2017). Reduction of major accident hazards in the ports could be achieved through co-operation of multiple stakeholders that includes Shipping Lines, Vessel operators, individual container terminals, Freight Forwarders, Importers, Exporters, Share Holders and Investors of Terminals.

2.6.3 Equipment Preventive Maintenance and "Cannibalization"

Maintenance is related to fixing, repairing and service of devices and equipment and should be performed on planned schedules. It is important in all heavy industries particularly ports and terminals that are handling large quantities of dangerous goods because the failure to maintain port and terminal equipment regularly increases the risk of equipment breaking down, major accidents and compromising the safety of personnel (Chang-I & Craig, 2021).

In the absence of clear maintenance objectives, the complement of cargo- handling equipment seldom matches the workload imposed by the actual cargo traffic and equipment is frequently kept in service well beyond its economic lifespan. Many ports tend to perform most of the preventive maintenance (PM) and corrective work in-house and rely on outside contractors for only the most specialized tasks, even though the in-house staff and equipment might not be able to perform the work reliably or cost effectively. This leads to equipment failure and could be the cause of serious accident.

One maintenance practice that is common in Least Developed Country (LDC) ports concerns "cannibalization," which refers to the use of parts from one "down" unit of equipment to repair another. This approach has become widespread in LDC countries because of the extensive delays in the procurement of vital spare parts and materials. Usually, the cannibalization is self-defeating because it continues indefinitely, and the equipment unit is never restored until such a time that a serious failure accompanied by a major accident leading to injuries or damage to property and infrastructure happens (World Bank, 2019).

2.6.4 Substandard Equipment, Maintenance Facilities and Environment

Even in cases where some effort had been made to establish a maintenance program, the facilities used for maintenance purposes are usually substandard. The maintenance department is often relegated to whatever building that happens to be available, and space and lifting facilities fall far short of being adequate (Shahjahan, 2017).

A port's equipment and infrastructure must be kept in a good condition so that it is readily available when needed by the operations staff. Effective maintenance can only be carried out under the right conditions. The quality of the port's workshops, servicing areas, stores and staff facilities must not only be appropriate for the tasks but also create a feeling of pride and responsiveness. If the lifting slings are not the approved type or are used beyond their capacity or the cranes are not inspected or tested at regular intervals, and the safety and warning devices are not working properly, there are grave concerns. If during loading and discharging the crane, slings or equipment fails, packaged dangerous goods could fall, leading to the release of toxic gases, flammable vapors, pollution and commercial losses. Cranes failing can also cause fatalities and severe injuries for personnel and damage to property and equipment (Ronza et al., 2020).

2.6.5 Equipment Replacement Policy and Standardization

According to the World Bank (2019), there are too many different makes of similar kinds of equipment in ports. The ports find it difficult to concentrate on a few manufacturers - largely because of the sources of funding, but this becomes a major problem in the long-term. Thus, the maintenance task is made more difficult because of the need for increased training, more manuals and stocks of spare parts.

The lack of a systematic and consistent equipment replacement policy also causes enormous problems for maintenance. Thus, you will find many fleets consist of a variety of makes and models of equipment. Consequently, their operating, maintenance, and financial problems tend to be more serious than in fleets with more

standardized equipment. In such instances few operators are trained and qualified to handle all the different types of equipment, productivity tends to be lower in these ports, more accidents occur, and there is more equipment damage. Ports need to avoid outdated safety practices at the equipment and machine operational level and embrace safety technology practices that focus more on anticipation of hazards than on reaction to their occurrence (Ludwig et al., 2020).

2.6.6 Port Equipment Maintenance Funding

If maintenance is not funded at an adequate level, port equipment will deteriorate and probably lead to major accident, cargo handling rates will decline, and the revenue earned by the port will be reduced (Frittelli, 2018). However, port maintenance can be a costly activity. Unavoidably, even the smaller ports have a large investment in port mechanical equipment and an even larger investment in infrastructure; all of which requires proper funding.

Unfortunately, as ports struggle to meet the demands of the ship operators, they must acquire more complex cargo handling equipment and thus the funding is steadily becoming more difficult. Very often, too much effort is expended on attempting to keep time expired equipment operational without regard for the costs involved - sometimes on the misguided principle that this will save scarce foreign exchange (Larry & Peter, 2017). Many ports have outmoded legislation that makes it difficult to dispose of old equipment and hence there is a tendency to try to keep them going disregarding the consequences of failure which can be major accident in form of damage to property, spillage and injury to people in operational areas (SIP007, 2017).

2.7 Gaps Identified from the Literature

Port state control regimes which were established more than 30 years ago to help prevent accidents in shipping are obviously not enough to correct or prevent all major accidents. According to Chang-I and Craig (2021), delivering effective major accident management has never been easy, and the penalties for failure, in terms of

impact on people, environment, reputation and finances are becoming more extreme (Atubi, 2016). Major accident happens in different ports across the world but how the response to the accident is handled is the concern.

The review showed that there was not a specific legislation in Kenya dealing conclusively with handling of occurrence of major accident hazards in the ports or hazardous installation sites like in some other countries. Various researchers have worked on other areas of accidents and disasters. Wachira and Smith (2017) studied the emergency services and development training and how it affects lack of proper coordination during major disasters in Kenya. Other research in this theme has focused on road accidents (Consolata et al., 2019) and construction site accidents, Raymond & Julius (2016).

There have been no attempts by researchers to discuss occurrence of major accidents in the ports in Kenya, perhaps because there had not been reported occurrence of major accidents in the port in the recent past. However, the potential for occurrence of major accidents in our ports is enormous and the question is how to alleviate the impacts when our smoking gun explodes.

The theoretical review also showed that many countries have tried to put in place measures aimed at reducing major accident as they have always had serious negative impacts to the economy of a country and its surrounding neighbors. Many of the countries especially in developed nations have come up with legislative frameworks aimed at controlling major accident hazards so as to prevent loss of life and damage to property and the environment but despite of this, history shows that five of ten biggest man- made explosions happened in port areas (Tarmo, 2020) and that according to statistics most maritime accidents related to dangerous cargo handling happened in ports and harbours (IMO, 2017).

Furthermore, effects of major accident hazards and factors that can help to determine how effectively the hazards can be controlled are not thoroughly researched and reported in Kenya. This may have been because of unavailable relevant data in this area since most data associated with major accidents lean towards petroleum tankers

and collapse of buildings in construction sites. It was also noted that, although there had been an attempt to quantify risk in other busy ports across the world, most ports had only analyzed their major accident risk qualitatively hence the quantitative analysis of in ports in Kenya and Africa should be pursued.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

The study adopted a descriptive survey research design where collection of data was done by interviewing and administering questionnaire to a sample from the population and using observation checklist. The use of a survey research design helped to describe the specific characteristic of a large group of persons, objects or institutions. It also allowed for extensive collection of data to describe characteristics of the variables of interest in the situation. Both qualitative and quantitative data was used to give exploratory analysis. The research participants were drawn from all levels of management including also the dock workers' union employees and the contractor staff working in the port.

The descriptive design helped the researcher to acquire information from different respondents using self-administered questionnaires, interview and from observation. The design was used for this study because it was expected to be the best approach for obtaining suitable responses to questions concerning the status of the variables under this study.

3.2 Study Area and Population

The target population included 650 workers from the KPA human resource records for staff drawn from various departments. The study also included contractor employees working on various projects in the port.

The figure below shows the map of the study location where the current main container terminal at KPA is located and contained a total of 17 berths that were active and in use. However, there was ongoing construction of another berth within the first terminal and a second container terminal that was not yet open for access to public.

Figure 3.1 shows the location of the study at the port of Mombasa at the container terminal 1. A second container terminal was under construction at the time of the research.

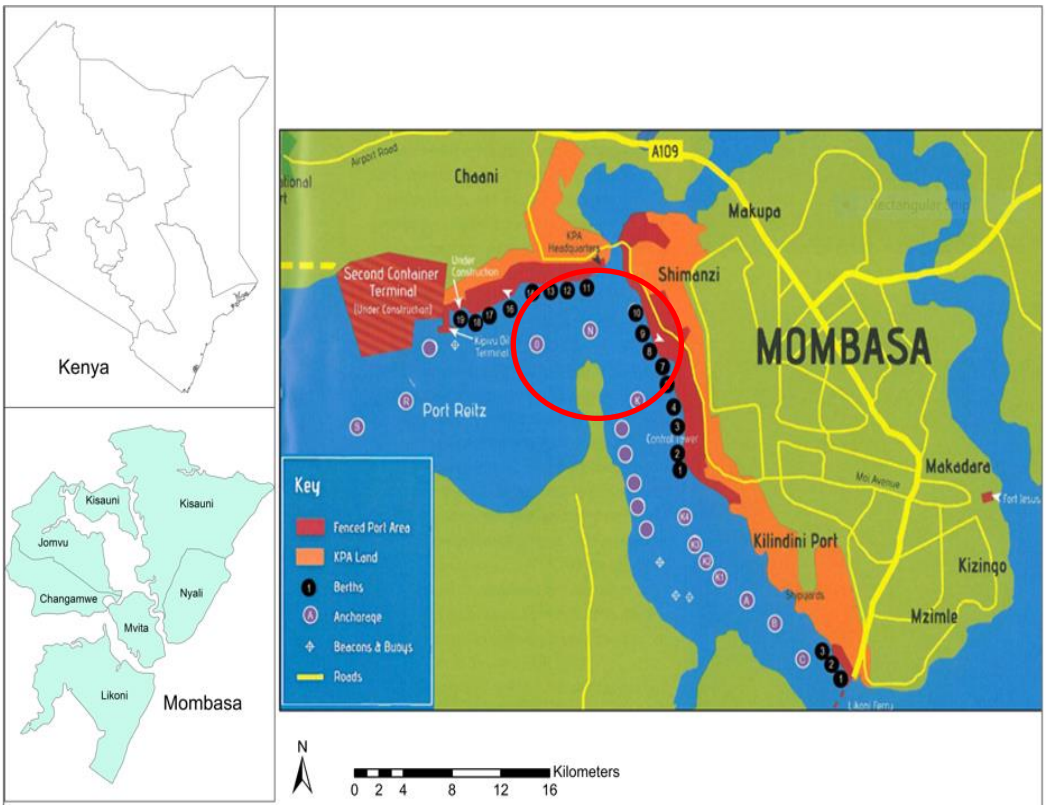


Figure 3.1: Study area map

(Source KPA, 2019)

3.3 Sampling

A good sampling design would result in a truly representative sample, and in a small sampling error whose study results can be applied in general, for the whole population with some reasonable level of confidence.

3.3 Sample Size and Sampling Procedures

Slovin's formula was used to estimate sample size as follows; (Singh & Masuku, 2014). Slovin's formula was used to calculate a representative sample from a known

population. It was used because it is comparatively easy to use by substituting known figures to get the required sample size. This formula was also preferred when the researcher knows nothing about a population of interest or its behaviors so as to figure out what sample size is needed.

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

Where:

n = Sample size

N = Total population

e = Error tolerance/margin of error

$$247.6 = \frac{650}{(1+650\,(0.05)^2}$$

The sample size as determined above was 248.

The study was based on a 95% confidence interval and an estimated sampling error (e) of 5%. The sampling technique used while issuing questionnaires in this research was stratified random sampling. The main advantage of random sampling is that each item in the population has an equal chance of inclusion in the sample and each of the possible sample has the same probability of being selected. The procedure was that the researcher issued the questionnaires to study participants selected randomly within the departments in the target population. Regarding the conducting of interviews the researcher randomly selected respondents from the targeted departments for the interview process and conducted observation using a hazard checklist during the process of data collection.

3.4 Data Collection Instruments

Data collection instruments that were used are questionnaires, interview and observation checklist.

3.4.1 Questionnaire

The questionnaires were randomly administered to employees in the selected areas. Primary data was collected using questionnaires. Data collected using questionnaire included demographic information of the respondents. Data on hazard awareness and on their training, safe systems and cargo handling equipment in use was also collected. Data on emergency response system in use and the respondent's view on risk assessment was also collected.

Closed-ended questions had responses from which respondents could pick an answer that described the situation. However open-ended questions gave the respondents an opportunity to give their own opinion on an issue.

3.4.2 Interview Questions

These were directed to the respondents sampled for the interview and helped to collect additional information on employees view on the safe systems of safety implemented. Their responses about current risk assessment infrastructure was also discussed as well as the actual occurrence of accidents during the course of their operations. The interview were unstructured in that the researcher interviewed respondents at random as he walked through the workplace during data collection exercise. The interviews conducted helped to supplement to the feedback received from the questionnaires and to get the opinion of the respondents on the four objectives studied in this study in order to better understand the determinants of control of major accident.

3.4.3 Hazard Observation Checklist

The checklist helped the researcher to gather additional information on maintenance and use of the equipment and machines and information regarding other hazards like fire and chemicals.

3.5 Pilot Study

Validation of the data collection instrument was done at Mombasa Container Terminal depot where four sample questionnaires were piloted. Corrections were made on the demographics section of the questionnaire and the response ratings were harmonised and simplified so as not to confuse the respondents when answering the questionnaires ensure the language used was simple and clear before distribution of the main study questionnaires.

3.6 Data Collection Procedures

Data was collected from primary and secondary data sources. The primary source of information was by administration of questionnaires, interviewing of the respondents sampled and observation through checklist. The questionnaires were distributed to the respondents with the help of supervisors working at KPA. Secondary data was gathered from the library and internet to provide additional information on research in the thematic area. Additional information was also be collected through hazard observation checklist.

3.7 Data Processing and Analysis

The returned questionnaires were checked for any errors, accuracy and consistency. Thematic analysis was used where questions that addressed same or similar theme were analyzed. Data was then transferred to a computer in order to perform analysis.

The study used both qualitative and quantitative methods of data analysis where the qualitative procedure of analysis was used to analyze qualitatively the views of different respondents by grouping together those views that converged and came up

with uniform themes. On the other hand, quantitative method was used to analyze quantifiable responses from the questionnaire. Tables were used to show various categories of data and their respective frequencies and percentages of occurrences. From these tabulations emerging patterns and trends were identified to make it possible to establish relationship between variables and to draw conclusions. The study data was presented in form of graphs and tables for ease of analysis and interpretation.

3.7.1 Data Analysis and Presentation

The study data collected from questionnaires was classified into categories. It was then analyzed using Statistical Package for Social Science (SPSS) version 20. Using SPSS, the researcher was able to obtain the mean, frequency and percentages applicable to each variable. Data was edited, entered, coded and summarized based on objectives. Where necessary, some data was analyzed qualitatively using content analysis. The study used descriptive statistics to show distribution, relationships between variables under study and proportions in terms of percentages interpretation. This helped to provide an insight on the determinants to effective control of major accidents in the port of Mombasa.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Response Rate

The target sample size was 248 out of which 206 took part in the study equivalent to 83% response rate. All the returned questionnaires which were properly filled and hence had completeness on data correctness were used for data analysis.

4.2 Demographics

Figure 4.1 shows the distribution of gender in sample used for this study.

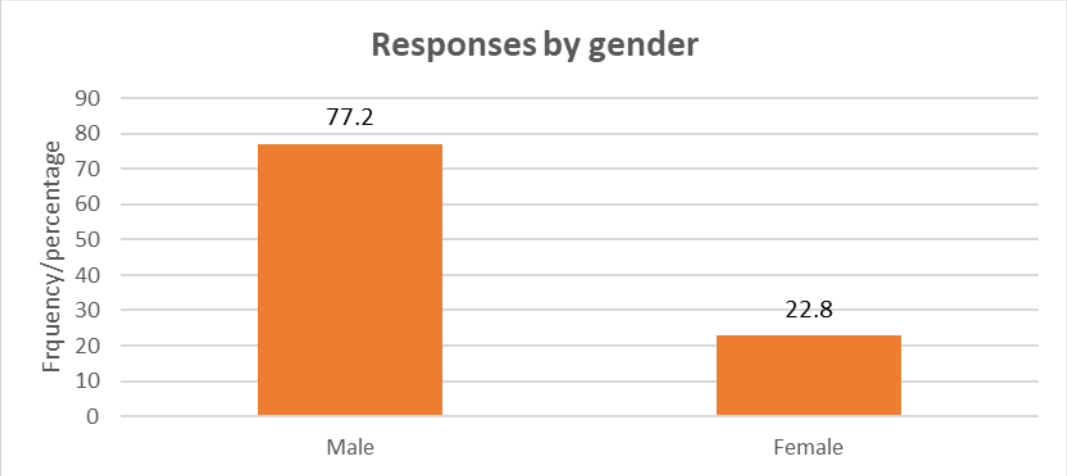


Figure 4.1: Study location demographics showing distribution by gender

Results showed that there were more male respondents (77.2%) compared to female respondents (22.8%) as shown in the Figure 9.1

Majority of respondents were above thirty years of age and had studied up to the level of diploma in their education as shown Figure 9.2 and 9.3

Figure 4.2 shows the distribution of the respondents in the sample by their age

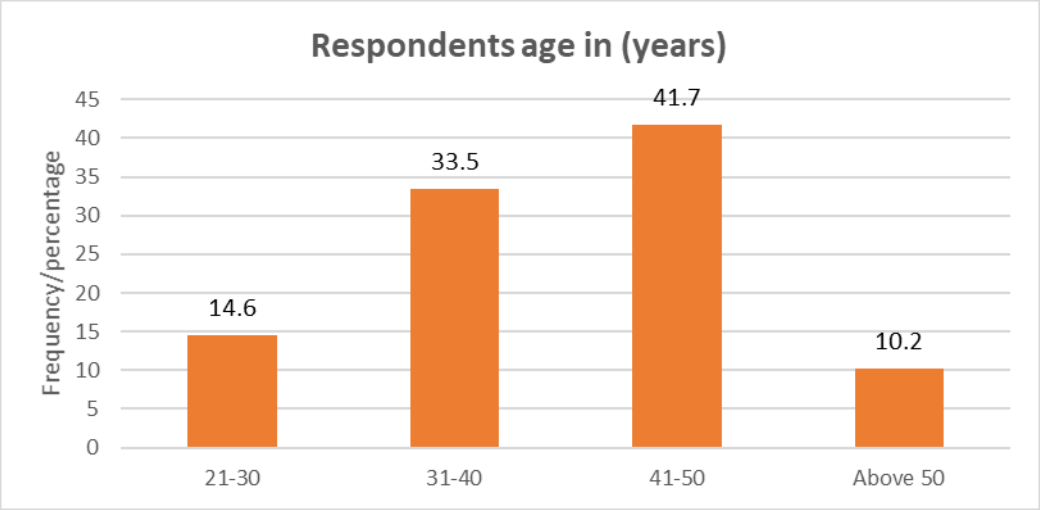


Figure 4.2: Showing age distribution of the respondents

Figure 4.3 shows the distribution of the respondents in the sample by education level and number of years worked

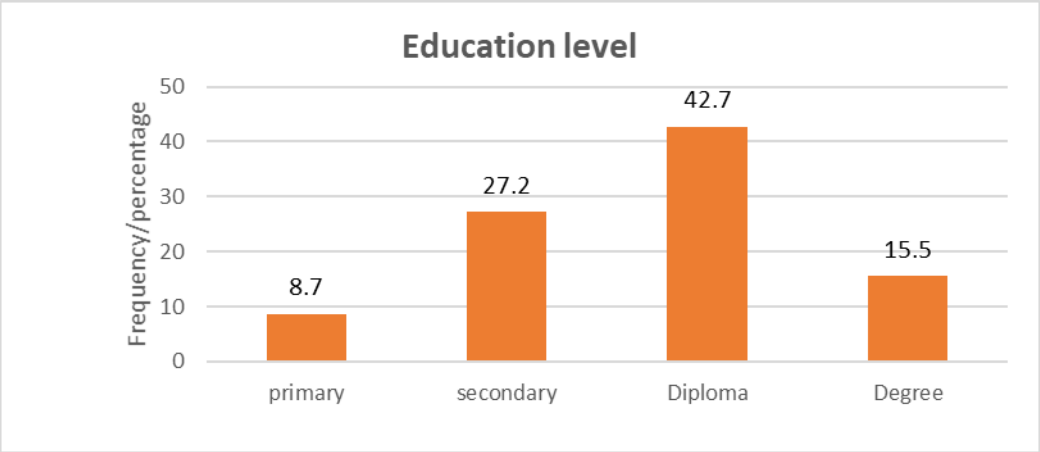


Figure 4.3: Showing education levels of the respondents

In terms of experience majority of the respondents had worked for the organization for more than ten years as shown in Figure 4.4

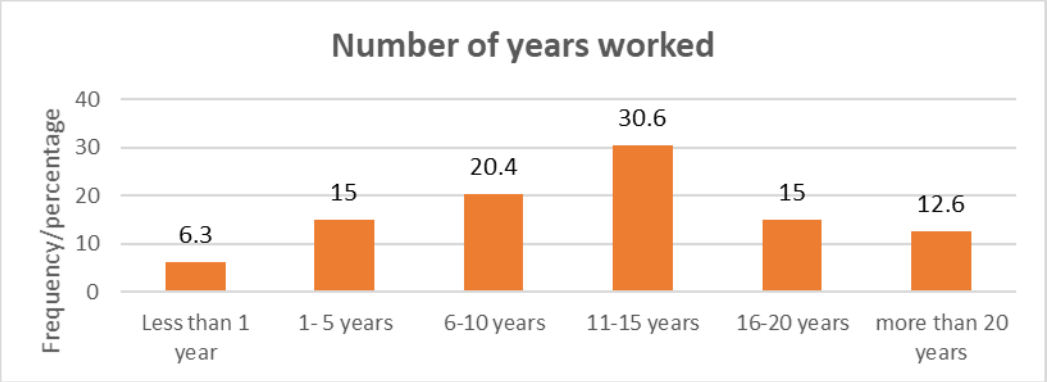


Figure 4.4: Showing years of work experience of the respondents

A great number of respondents, 48.5% were from the operations department majority of whom were dock workers spread across the container terminal, as well as the contractor staff.

Table 4.1: Distribution of respondents by department

Department	N	Percent
Operations	100	48.5
HR and Administration	13	6.3
Technical services	29	14.1
Infrastructure/projects	48	23.3
legal services	16	7.8
Total	**206**	**100.0**

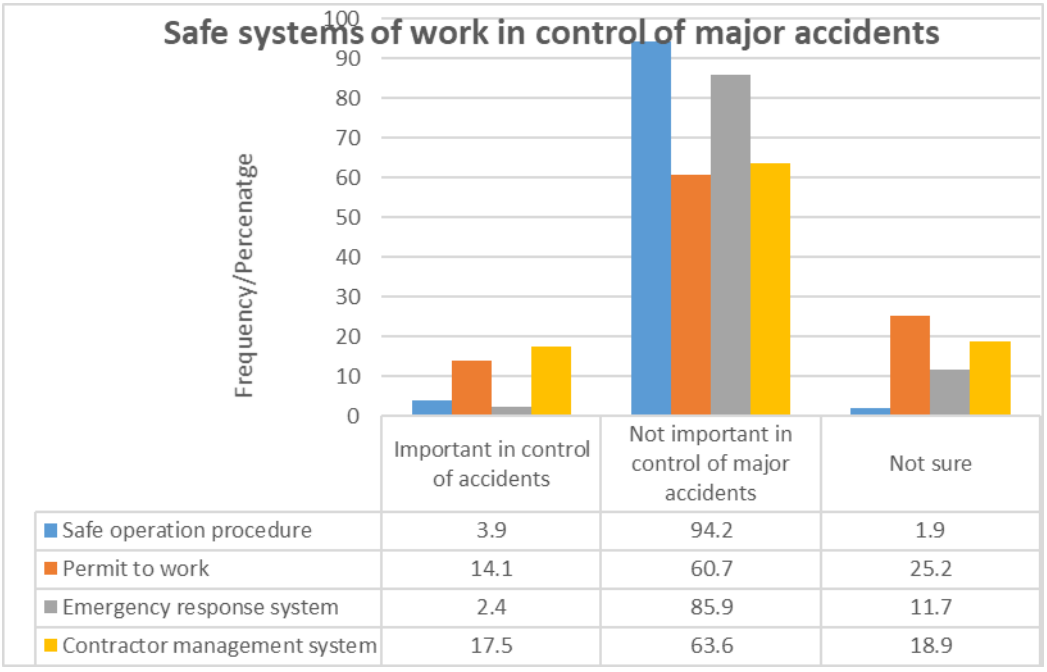
The ratio of contractors on site to KPA staff was confirmed by personnel department to be 1:4

4.2.1 Safe Systems of Work

Some of the safe systems of work in use were Permit to Work, checklist, operational procedures, shift handover notes etc. The port was found to be a multi-stakeholder operations site with 20% of employees being contractors. The two safe systems that were used to control contractors were permit to work system and contractor management system (access control). However, these two systems were lowly rated by respondents where they held the view that contractor management system and permit to work would have less effect compared to use of operation procedure and

emergency response system in control of major accidents in the port as shown in the Figure 4.5. This agreed with an observation made under the training objective, where some respondents held the view that training of contractors was not as important as that of KPA employees. The number of respondents who were not sure or thought that the safe systems in place were not important showed that more awareness creation and training was required for all staff in the company.

Figure 4.5 shows the responses to the various safe systems to work that the respondents were asked about in order to find out how relevant they are and levels of enforcement in control of major accidents at the port areas.



	Important in control of accidents	Not important in control of major accidents	Not sure
Safe operation procedure	3.9	94.2	1.9
Permit to work	14.1	60.7	25.2
Emergency response system	2.4	85.9	11.7
Contractor management system	17.5	63.6	18.9

Figure 4.5: Response on importance of safe systems of work

A high number of 94.2% of respondents as shown in Figure 4.5 held a view that safe operations procedures would not help in control of major accidents in the port. This could mean that there are deep seated poor safety culture behavior and that sometimes the procedures would be disregarded to get the job done.

An Analysis of Variance (ANOVA) on the responses to the question on the importance of the safe systems in control of major accident at the port as shown in

the Table 4.2 was done. Results showed that only the permit to work system responses had significant variation from the mean since Sig=0.074>p=0.05, DF=3 at 95% confidence interval. There was no significant variation from mean of the other three safe systems since for safe operation procedures Sig=0.0302<p=0.05, DF=3, emergency response system Sig=0.013<p=0.05 DF=3 and contractor management system Sig=0.034<p=0.05 DF=3 as shown below. This meant that the permit to work safe system would not be very effective in control of major accidents.

Table 4.2: ANOVA for responses of different safe systems versus control of accidents

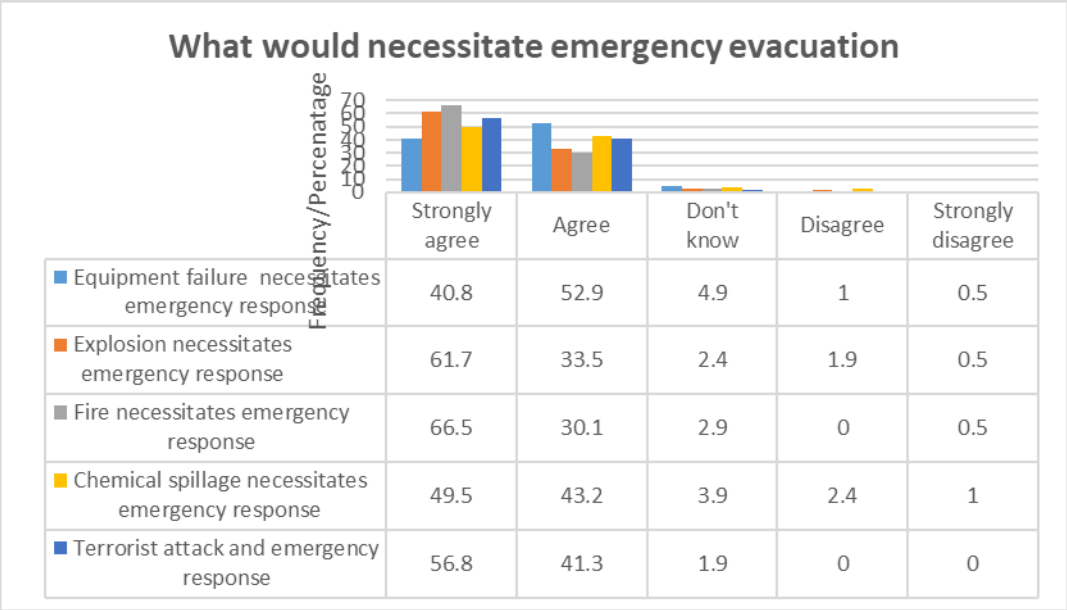
Safe systems critical in control of major accident	DF	Mean squares	F	Sig
Safe operation procedures	3	0.334	1.204	0.032
Permit to work system	3	0.226	0.291	0.074
Emergency response system	3	1.149	2.016	0.013
Contractor management system	3	0.98	2.64	0.034

This was confirmed also during the interview where some staff said that procedures tend to waste time when the employees are under pressure to finish the job. This could be interpreted to mean that short cuts would be taken to meet the target and emergency alarms would be ignored but, in the process, major accidents would be incurred.

There emerged, during the interview and from analysis of results a general feeling of low perception towards the contractors working in the port areas. They felt that that their training on prevention of accidents was not as important as that of KPA employees. Secondly, that risk assessment should be used to license their operations to reduce accidents caused by them in the port. Thirdly, that use of permit system would be useful in control of accidents caused by contractors. Such low perception of contractors, if held by the top management, would mean that they would be disregarded in committing resources to improve contractor safety standards and implementation of major accident control measures such as training.

The risk perception of occurrences that would necessitate emergency response in the port was tested among the respondents. The five common potential major accidents in the ports: Equipment failure, fire, explosion, chemical spillage or terrorist attack, were tested and each received over 90% approvals as occurrences that respondents felt could cause major accidents and necessitate emergency response as shown in Figure 4.6. This meant that staff were aware of what had the potential to cause a major accident leading to an emergency evacuation.

In the Figure 4.6, various emergency scenarios that would occur in the port and cause major accidents were posed to the respondents in order to show their awareness of emergency scenarios and hence response to control major accident occurrence.



	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
Equipment failure necessitates emergency response	40.8	52.9	4.9	1	0.5
Explosion necessitates emergency response	61.7	33.5	2.4	1.9	0.5
Fire necessitates emergency response	66.5	30.1	2.9	0	0.5
Chemical spillage necessitates emergency response	49.5	43.2	3.9	2.4	1
Terrorist attack and emergency response	56.8	41.3	1.9	0	0

Figure 4.6: Response on emergency evacuation need at KPA

However, when respondents were asked to state the frequency of testing emergency response procedure for the period they worked at the port, there were mixed responses with 75.2% saying it was done annually as shown in the Figure 4.7. This could mean that the procedure is not well entrenched in the company. Through interviews, some staff confirmed that the testing was done only in selected areas of the port by the fire department.

In Figure 4.7, the researcher sought to confirm the frequency of testing the emergency response in form of drills in order to further check the awareness of the evacuation that would be necessitated by the major accidents occurrence at the port.

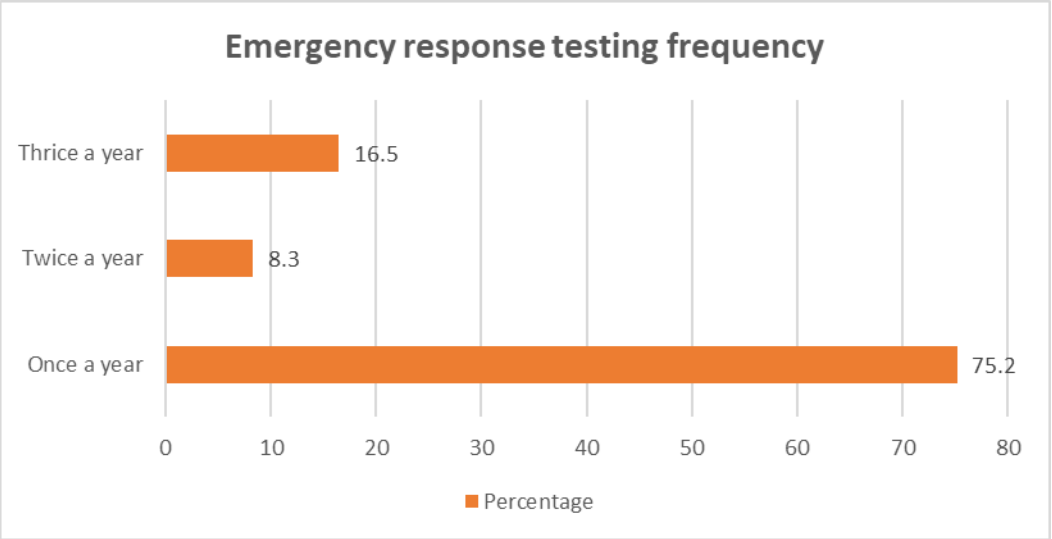


Figure 4.7: Response on emergency response testing frequency at KPA

From data analyzed, it emerged that the respondents did not appreciate that safe systems of work would be critical in control of major accidents in KPA. The issue of contractor management and associated safe systems like safe port operation procedures were not well entrenched in the port as some of the respondents disapproved them as being not effective in control of major accidents. This disapproval also would point to entrenched negative perceptions levelled against contractors. The disapproval of safety procedures by 94.2% of respondents as not important towards control of major accidents could mean unsafe behavior such as shortcutting are rampant.

The fire department was fully resourced and aware of all the facilities and areas from the maintenance documents reviewed. However, respondents interviewed and information from the hazard checklist used showed that they were not fully conversant with the process of emergency response and evacuation procedure in place during a major accident. This is because the respondents who were interviewed gave conflicting reports about the response to emergencies and the testing frequency

of the emergency response system including the fire drill. However, there were those who said that they had not witnessed testing of fire alarm or participated in any emergency drill during their employment. This conflicting statement about the same thing from respondents showed that probably the system was not well entrenched within the organization.

4.2.2 Cargo Handling Equipment

Several port cargo handling equipment were observed being used to facilitate movement of the cargo to and from the ship's side, transit shed, warehouse, barge, railway wagon or road vehicle. Cargo handling equipment seen at the port included: Cranes (rubber-tired gantry or rail mounted gantry), container handlers (top picks and side picks), forklifts (mostly by contractors), bulk handling equipment (tractors, loaders) etc.

When respondents were asked whether use of equipment would cause a major accident, a great number of respondents, 89.8%, held the view that cargo handling equipment had potential to lead to occurrence of major accidents.

In Figure 4.8, respondents view as to whether equipment would be responsible for occurrence of major accidents was tested. This helped to understand their view of risky operations involving complex equipment as sources of accidents at the port areas.

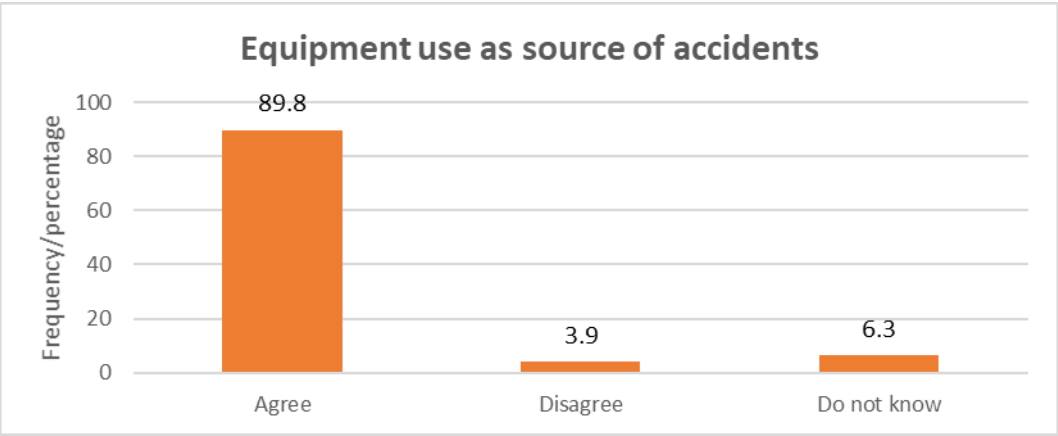


Figure 4.8: Responses on equipment as causes of accidents at KPA

When asked whether they had witnessed occurrence of a major accident for the period they had been employed at KPA, respondents said they had witnessed various major accident occurrences such as fire and spillage that were related to cargo handling equipment as shown in Figure 4.9. Through the interview, some respondents confirmed that there had been recent and past fatality incidents related to use of equipment. However, the most common occurrence was property damage and spillage of hazardous chemicals.

In the Figure 4.9, the forms or ways in which equipment have caused accident at the port areas was tested on the respondents using questionnaires in order to understand the ways by which equipment have caused accident sat the port of Mombasa.

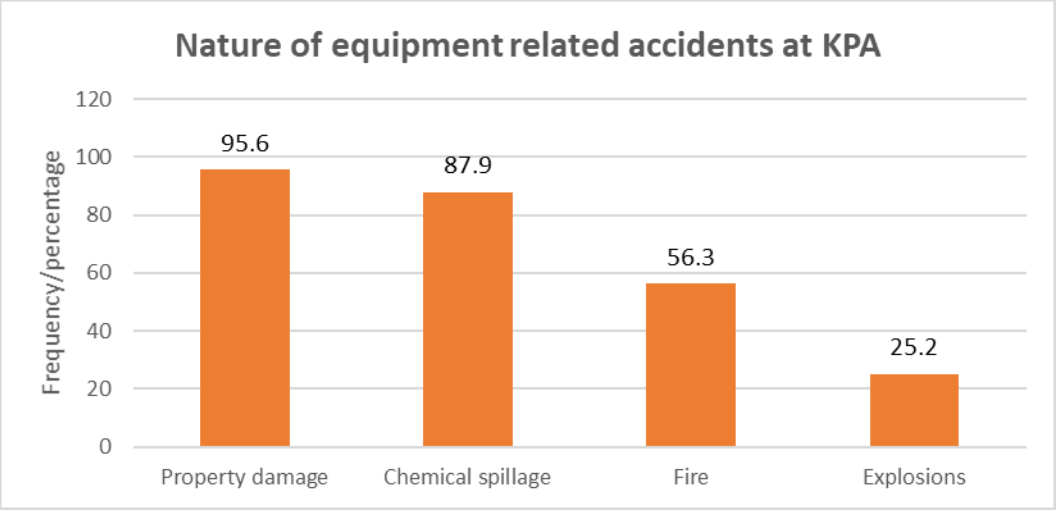


Figure 4.9: Responses on equipment related accidents at KPA

An analysis of variance (ANOVA) was applied to the responses received regarding the nature of the accidents related to equipment witnessed by the respondents in the port as shown below. Equipment related accidents that led to fire at Sig=0.029<p=0.05 DF=3, equipment related accidents that led to explosion at Sig=0.015<p=0.05 DF=3, equipment related accident that led to environmental spillage at Sig=0.024<p=0.05 DF=3 and equipment related accidents that led to property damage at Sig=0.0232<p=0.05DF=3 showed that there was no significant

variation from the mean and therefore statistical evidence that major accidents would result from the equipment.

Table 4.3: ANOVA for responses on equipment related accidents versus the nature of accidents

Equipment related accident		Sum of Squares	df	Mean Square	F	Sig.
Accident due to fire	Between Groups	0.922	3	0.307	1.248	0.029
	Within Groups	49.757	202	0.246		
	Total	50.68	205			
Accident due to Explosion	Between Groups	0.395	3	0.132	0.691	0.015
	Within Groups	38.479	202	0.19		
	Total	38.874	205			
Accident due environmental spillage	Between Groups	0.445	3	0.148	1.393	0.024
	Within Groups	21.521	202	0.107		
	Total	21.966	205			
Accident due to property Damage	Between Groups	0.056	3	0.019	0.874	0.023
	Within Groups	16.356	202	0.081		
	Total	16.413	205			

The four equipment maintenance safety aspects: Old and obsolete, exceeding Safe Working Load, operation by non-qualified staff and poor policies, were posed to the respondents who agreed for each aspect, by over 86%, that this would have a bearing on occurrence of major accidents as shown in Figure 4.9. Interview with third party operators and observation of maintenance stickers of some equipment in operation revealed that some equipment was overdue for maintenance and servicing while others were not enrolled into any repair and maintenance program.

Table 4.4: Inspection status of equipment sampled at KPA

Equipment	KPA	Contractor	Inspected
Rubber tired gantry crane	2		YES
Straddle carrier	1		YES
Reach stacker	2		YES
Forklift		5	NO

A total of ten pieces of cargo handling equipment out of fifty-two were sampled during the day shift. Equipment sampled included rubber-tired gantry cranes, straddle carriers, forklifts, and reach stackers. Although no photos were allowed to be taken, it was found that all of the equipment for the KPA was inspected, contained inspection stickers, and was found to have been enrolled in a preventive maintenance program. Most of the equipment in use by the contractors were the forklift trucks, of which three were found not to have been inspected while the rest had expired inspection stickers. None were under a preventive maintenance schedule

Table 4.5: Reported fatalities in KPA for the period 2016 – 2022

Year	Fatalities	Causes
2016	2	Ran over by Truck Crushed by tractor
2017	1	Drowned in the water during offloading operations
2018	1	Hit by Forklift
2019	4	Operating 25T Crane, Hit by Gantry Crane, Slipped from boat and drown in water, Fell from height
2020	1	Knocked by reversing trailer
2021	0	
2022	2	knocked from behind by tractor knocked by tractor

Source DOHSS Mombasa (2023).

An analysis of accidents reported to the Directorate of Occupational Health & Safety Services (DOHSS), obtained from the DOHSS office in Mombasa, as shown in Table 4.5, showed that over the six-year period, there had been a total of eleven fatalities arising from different equipment and machines being operated at the port for cargo handling operations. The year with the highest fatalities was 2019, with three of the fatalities arising from the crane operations. In addition, ana analysis of other accidents reported to DOHSS was done and were categorized. There was a total of 52 reported accidents arising from falling objects handled by the cranes and other lifting equipment. The objects included items such as container, chain link, billets, gearbox, rail bars, ropes, hooks and sacks of sugar. In terms of accidents arising from site transport, there was a total of 35 reported cases from hits or crush by a forklift, tractor or truck. The number of Slip Trip & Fall (STF) reported accidents were 45 resulting from washrooms, staircase, raised surface edges and slippery floors. Other accidents reported were 5 cases of surface crus accidents.

In Figure 4.10, the equipment safety operation aspects as advised to the various ports by the world bank through the world bank (2019), was tested on the respondents the port in order to understand the aspects that were responsible for occurrence of accidents at the port.

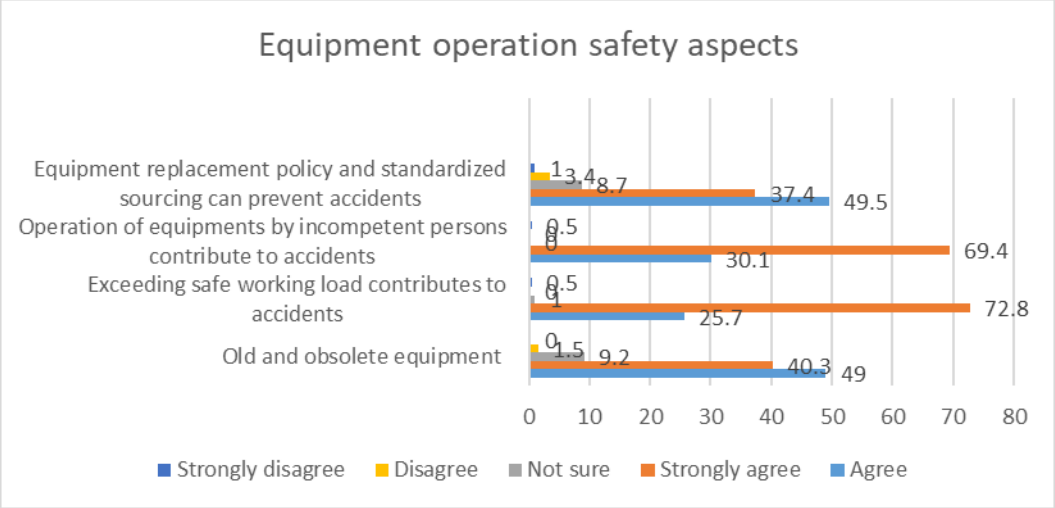


Figure 4.10: Responses on equipment maintenance related safety aspects at KPA

A Pearson's Chi-Square test of association was done at p-value=0.05**,** to establish whether there was any significant association between inadequate/poor equipment maintenance with the various equipment-related nature of accidents: Fire, explosion, chemical spillage and property damage, cited by respondents at KPA as shown in table 4.6, 4.7, 4.8 and 4.9. Since p= 0.031, P=0.039, p=0.027 & p=0.016 ≤ α=0.05 at 95% confidence interval, it means that there is a statistically significant association between poor maintenance of equipment and likelihood to lead to major accident of either fire, explosion, chemical spillage or crane failure and property damage a shown in table 4.6, 4.7, 4.8 and 4.9.

Table 4.6: Association of equipment maintenance versus fire accident

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	3.865[a]	4	0.042
Likelihood Ratio	3.537	4	0.044
Linear-by-Linear Association	1.027	1	0.031
N of Valid Cases	206		

Table 4.7: Association of equipment maintenance versus explosion accident

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.518[a]	4	0.016
Likelihood Ratio	6.702	4	0.015
Linear-by-Linear Association	0.717	1	0.039
N of Valid Cases	206		

Table 4.8: Association of equipment maintenance versus chemical spillage accident

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.610[a]	4	0.015
Likelihood Ratio	5.067	4	0.028
Linear-by-Linear Association	0.124	1	0.027
N of Valid Cases	206		

Table 4.9: Association of equipment maintenance versus crane failure accident

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.220[a]	8	0.019
Likelihood Ratio	3.463	8	0.029
Linear-by-Linear Association	0.21	1	0.016
N of Valid Cases	206		

Further interview revealed that there had been near misses and accidents arising from overdue maintenance. There was no established preventive maintenance schedule for the equipment used by contractors mostly the forklift trucks and reach stackers as was established through the hazard checklist and interview. Some cranes had no clearly visibly marked safe working load and there was observed employees moving under the operating cranes loaded with containers in the yard completely oblivious of the danger involved.

Interview with respondents revealed that employees were unaware of the existence of the Factories (Dock) rules of 1962 despite majority of them belonging to the Dock workers union. This regulation, Factories (Docks) Rules, was a Legal Notice of 1962 (L.N.306/1962) of the former Factories and other places of work Act, which was repealed to the current OSH Act 2007, and has not been reviewed since then. It has largely dealt with ship, equipment and machinery inspection but provides no guidelines for dealing with control of major accident hazards occurrence in the port. There is currently no regulation in Kenya or a policy in KPA that comprehensively addresses the control of major accident hazards in the ports and related industries despite the increased port services demand and rapid expansion of the port facilities and associated inland dry ports and major hazard installations e.g. Chemical industries in Kenya and the region.

The Figure 4.11 presents the respondents view on various cargo handling equipment safety and maintenance aspects that helped the researcher to get more insight about the equipment safety status at KPA.

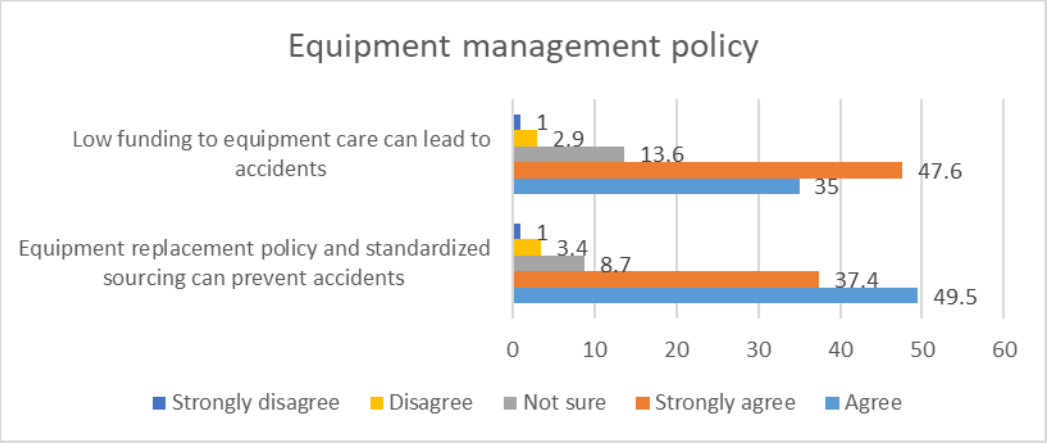


Figure 4.11: Responses on equipment management policy at KPA

The aspects of equipment replacement and standardized sourcing was also approved of by the respondents where 86.9% held the view that it would help in controlling occurrence of major accidents. The operator respondents interviewed said that some equipment were easier to operate than others and that there were some operators who had not received training in safe operation of some equipment on assumption that all

equipment operation was the same, and therefore, high chances of causing accident when they operate equipment that they were not familiar with. This was because of having various models of equipment sourced from different manufacturers but doing the same job. The issue of funding for equipment replacement was also tested on respondents whereby 82.6% agreed that low funding would result to accidents. Through interview the researcher found out that low funding had led to delayed procurement of some critical spare parts and therefore continued use of some equipment requiring replacement of parts and in some cases cannibalizing of other equipment so as to provide spare parts for another due to lack of funds to buy new spare parts. Through check on service stickers and observation the researcher witnessed some equipment overdue for service being used by the contractors on site to handle cargo.

It was found out that there had been accidents at the port attributable to cargo handling equipment and that the accidents had been in the forms of fatality, fire, explosion, spillage and property damage. Further through interview, there had been accidents attributable to each of the equipment safe maintenance and operation aspects assessed i.e. poor maintenance, old and obsolete equipment, exceeding SWL and incompetent operation. Majority of respondents and those interviewed agreed that a regulation dealing with prevention of major accident in port areas would help to control occurrence of major accidents in the ports. A review of the accident occurrence from the quarterly report of Oct to Dec 2017 had a total of 139 accidents. Container terminal had the highest number of accidents at 88 compared to conventional terminal which had 51. Less accidents at the conventional terminal would probably be because of less equipment used and less traffic compared to the container terminal. Most of the accidents were related to equipment failure and private trucks operated by contractors colliding with packed container.

4.2.3 Training Gaps

According to Deane, 2018, one of the approaches used to identify training needs is to categorize the needs in accordance with the desired learning objectives such as: General improvement of safety awareness, knowledge development for safe

operation and influencing safety attitudes to encourage safe behavior. Ports should be "socio-technical" systems because, in practice, operations in port terminals are carried out by a partnership between human beings and technology. This partnership can only be successful if appropriate emphasis is given to training of employees.

It was found out that the number of those who had not been trained on major accident almost the same as to the number of those who had been trained as shown in Figure 4.12. It was evident from the responses given that training gaps existed and in various contexts where 53.1% of respondents said they had not undergone any training or awareness on prevention of accidents or hazards despite operating in a potentially risky environment. A review of the training curriculum also showed that there were no topics covering major accidents awareness or prevention.

Testing of training on accidents was done for the respondents in order to identify any training needs gaps that needed to be addressed.

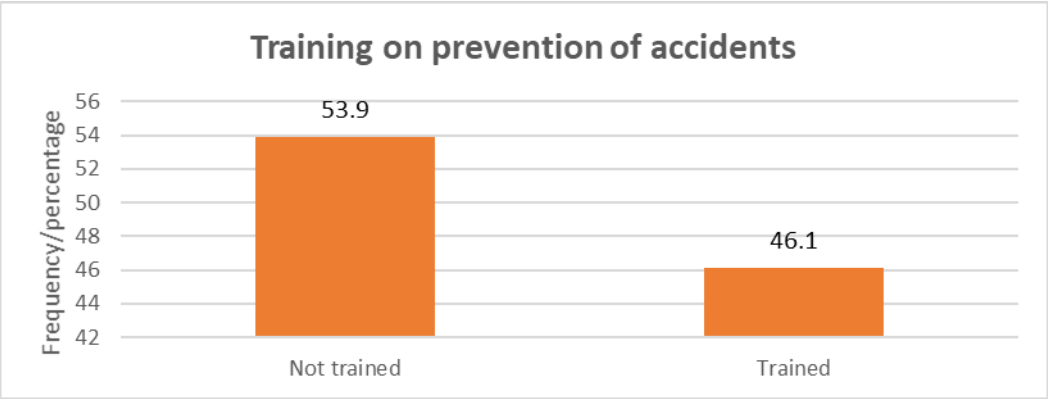


Figure 4.12: Responses on number of respondents trained on accidents at KPA

Furthermore, majority of respondents either did not know or disagreed with the expectation that the training topics offered improved their knowledge on major accidents.

In the Figure 4.13, the researcher wanted to find out whether the training that the respondents had received had in any way improved their knowledge about the major accidents occurrence and prevention at the port of Mombasa.

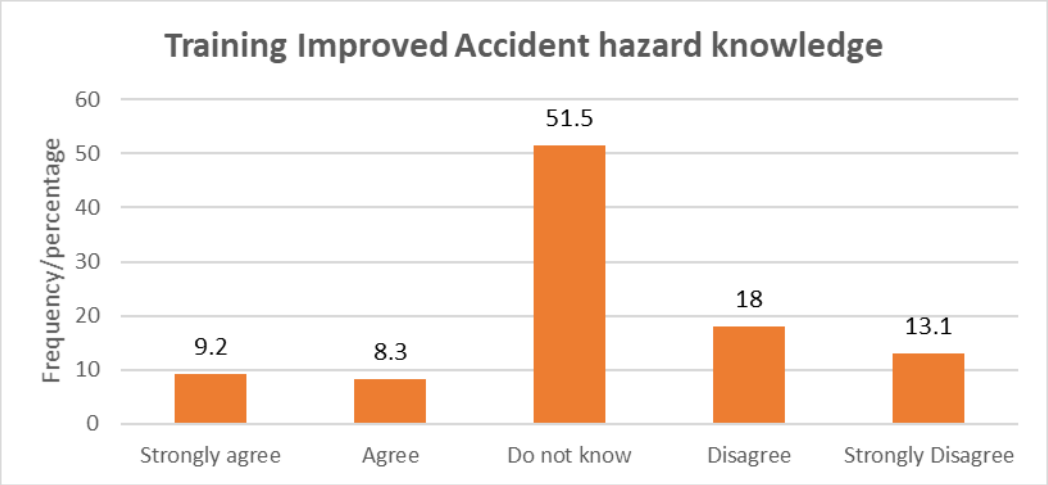


Figure 4.13: Responses on improvement of major accident awareness after training at KPA

A Chi-Square analysis test for association was done where there was a significant association between training on major accident hazards and improvement on understanding of major accident prevention as shown in table 11; $X^2 = 0.029$ p=0.05 DF=1

Table 4.10: Chi-Square analysis between training and improvement on major accidents prevention at KPA

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	135.851[a]	8	0
Likelihood Ratio	163.649	8	0
Linear-by-Linear Association	4.791	1	0.029
N of Valid Cases	206		

This could mean that training on major accident would help in increasing employees understanding and response to major accident events which was found to be lacking at the time of the research. It was found out that 82.5% of respondents in Figure 4.14, felt that the training they had received had not given them the confidence required in terms of responding to or handling major accidents if they did occur in their workplaces. This would be interpreted to mean that the training did not achieve the

desired impact, or the content covered was irrelevant to accident prevention. The fact that 82.5% of respondents in chart below said they had no confidence in dealing with major accident after the training shows that the topics covered did not address the major accident hazards and this is an area that the organization could improve on when conducting safety training.

In the Figure 4.14, the researcher wanted to find out whether the training that the respondents had received would help them to increase awareness about the response to the accidents at the port areas.

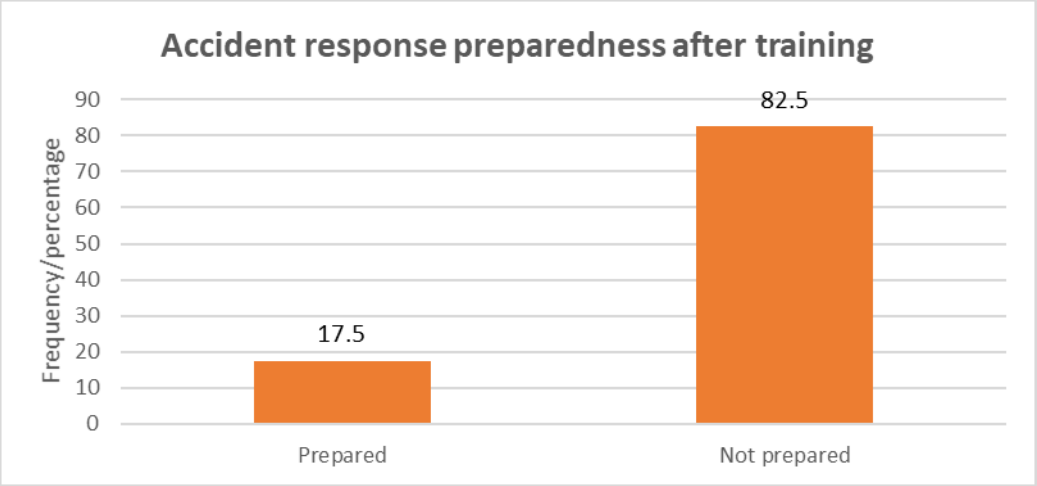


Figure 4.14: Responses on accident response preparedness after training at KPA

It was noted that 96.6% of respondents agreed training of all staff on accidents was important but only 81.1% agreed that training of all contractors was important. This showed a negative perception about contractors which could affect the attention that they are given regarding training on awareness of preventing accidents.

In Figure 4.15, the respondent gained more information as whether the training offered at the port included the third-party employees and this gave more insight on how the training was carried out at the port.

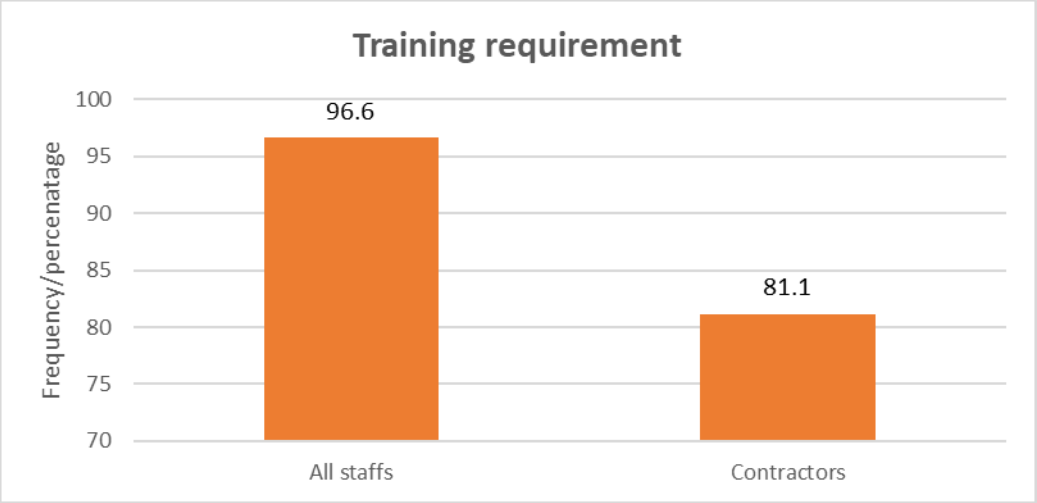


Figure 4.15: Showing respondents view on importance of training to both staff and contractors at KPA

In addition, a Chi-Square analysis test of the period worked (experience) also had significant influence on awareness on major accidents occurrence since it was found to improve awareness on major accident occurrence as shown in table12 X^2= 0.013 P=0.05 DF=1 as shown in Table 4.11.

Table 4.11: Chi-Square analysis between experience of respondents and improvement on awareness on major accidents prevention at KPA

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	86.293[a]	20	0
Likelihood Ratio	63.297	20	0
Linear-by-Linear Association	6.167	1	0.013
N of Valid Cases	206		

An aspect of training gap identified was to do with contractors on site. This included contractor staff who were doing housekeeping, construction jobs and those working in leased berths e.g. the grain bulk terminal. The ratio of these contractors to the KPA staff on site was found to be 1:4 and they were spread out in all areas including container and conventional terminals hence need to have them trained.

Contractor staff interviewed on site confirmed that they had neither received any form of training on accident prevention in the ports from their employers nor from the KPA, contrary to requirement by OSH Act 2007 section 17(1- 4), that requires provision of information and training for non-employees of the occupier. The contractor employees interviewed said that there was no training program to instruct them on safety on site including safe operation of equipment as was also revealed by the hazard checklist information. Lack of tight control on contractors might lead to operation of machines by incompetent people increasing chances of occurrence of a major accident. In the current global era of privatization of berths there is need to dispel the notion that training of contractors on control of major accident hazards is not as important as that of employees of Kenya port yet they worked in the same environment and exposed to the same hazards. Training was not standardized and offered to both employees and contractors to raise the risk perception levels regarding major accident occurrence in the ports.

Figure 4.16 below shows the respondents view on training duration, that helped the researcher gain more understanding on the training status at the site.

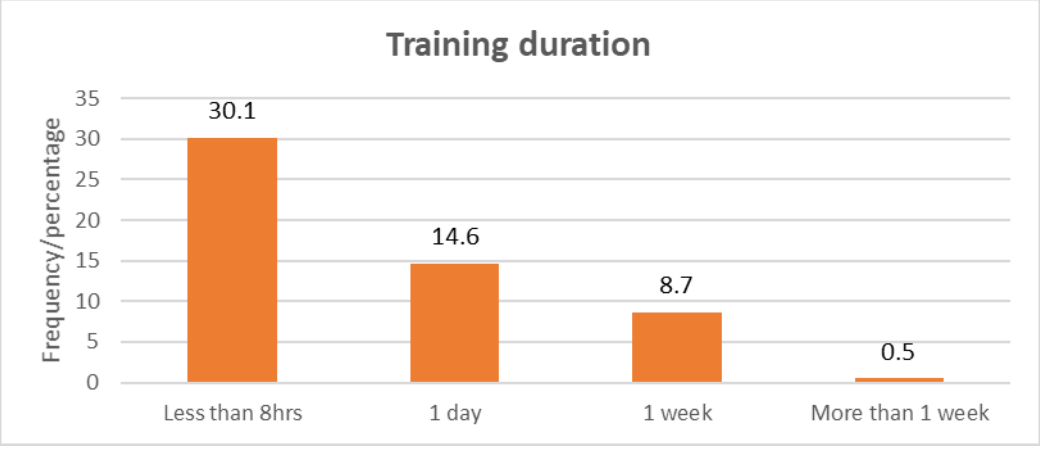


Figure 4.16: Responses on training on accident prevention duration at KPA

Most of the trainings lasted for less than a working day and were mostly facilitated internally as shown in Figure 4.17. This would be interpreted to mean that the duration of training was not enough to achieve the required impact, to impart

knowledge and skills on major accident prevention since the respondents said the training did not improve their major accident awareness. It would also mean that internal facilitators may have not delivered the training in a manner likely to increase awareness of major accident prevention by the trainees.

Figure 4.17 shows the respondents view on the training facilitation at the study location that helped in understanding training facilitation preference by the employees.

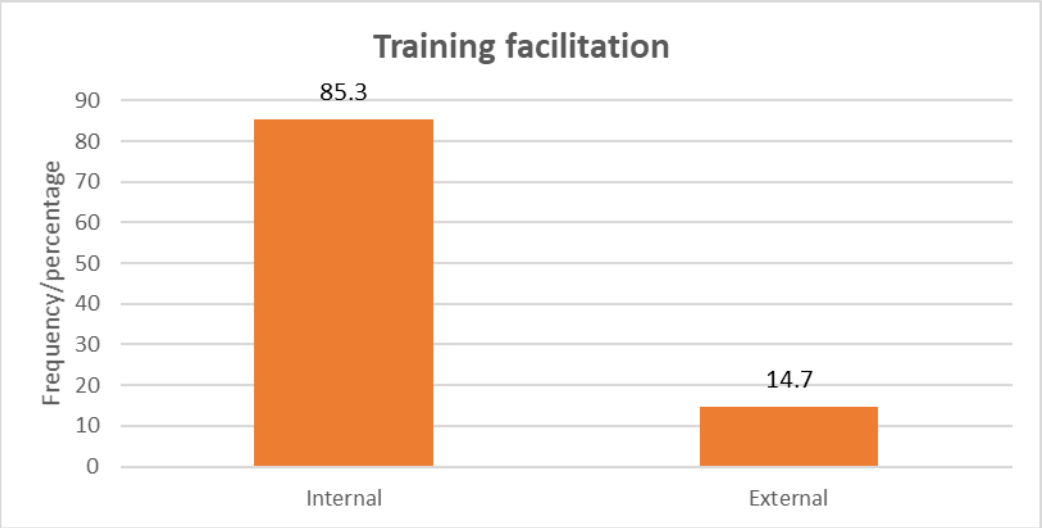


Figure 4.17: Responses on training facilitation at KPA

It was found out that most of the trainings, 85.3%, have been done by internal trainers. Training is supposed to give knowledge and instill confidence, perhaps the internal facilitators had not been able to train the staff to the levels that would give them confidence to handle major accident scenarios, or probably the duration of training had not been enough or possibly irrelevant content was covered. These were some of the training gaps aspects that needed to be scrutinized and addressed. There should be made available training programmes to cover all employees to ensure they have basic awareness on major accident hazards in the port areas.

An ANOVA on the responses received regarding various training aspects: Whether training improved knowledge on major accidents, topics covered improved

understanding of major accident occurrence or whether they would be able to respond appropriately during accidents after training compared to their job cadre was done as shown below. Major accident knowledge improved after training on major accident versus job cadre Sig=0.041<p=0.05 DF=2, topics covered improved understanding of accident occurrence versus job cadre Sig=0.038<p=0.05 DF=2 and respondents felt confident to respond appropriately to a major accident versus job cadre Sig=0.035<p=0.05 DF=2, showed that there was no significant variation from the mean and therefore the trainings offered did not improve the knowledge on major accident or understanding of their occurrences. In addition, the staff trained did not feel confident to handle any emergence response arising from an accident.

Table 4.12: ANOVA for responses on various training aspects versus the respondent's job cadre

Variable	DF	Mean squares	F	Sig
Major accident knowledge improved after training versus job cadre	2	0.881	2.439	0.041
Topics covered improved understanding of accident occurrence versus job cadre	2	1.144	1.043	0.038
Feel confident to respond appropriately to a major accident versus job cadre	2	0.332	2.247	0.035

4.2.4 Risk Assessment Process

Good safety management practice requires a proactive approach toward safety that aims to identify risks early and control them, instead of waiting for occurrence of an accident to trigger risk assessment. The risk assessment framework was found to be one where risk assessment was carried out by the safety department or line managers without involving or consulting other employees especially the operators, who do the job.

In Figure 4.18, the researcher sought to get more information about the involvement of the respondents in conducting risk assessment at the workplace in order to understand more on worker consultation when carrying out risk assessment.

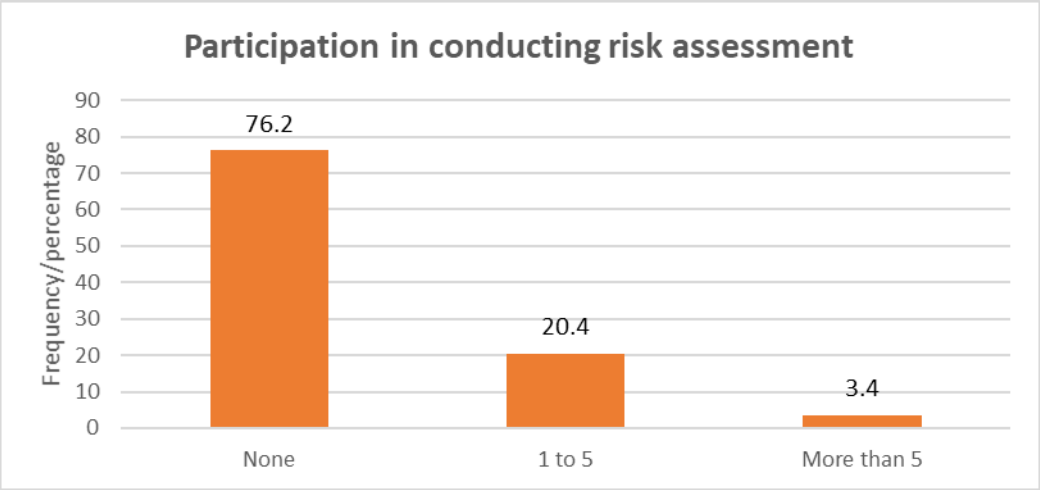


Figure 4.18: Responses on participation in risk assessment at KPA

Only 23.8 % of respondents as shown on Figure 4.19 had taken part in conducting risk assessment. The rest had not participated either individually or in a team in any form of risk assessment. The reason given was that this was done by the safety department and the supervisors or line managers meaning this was not a consultative process involving all employees who actually do the job.

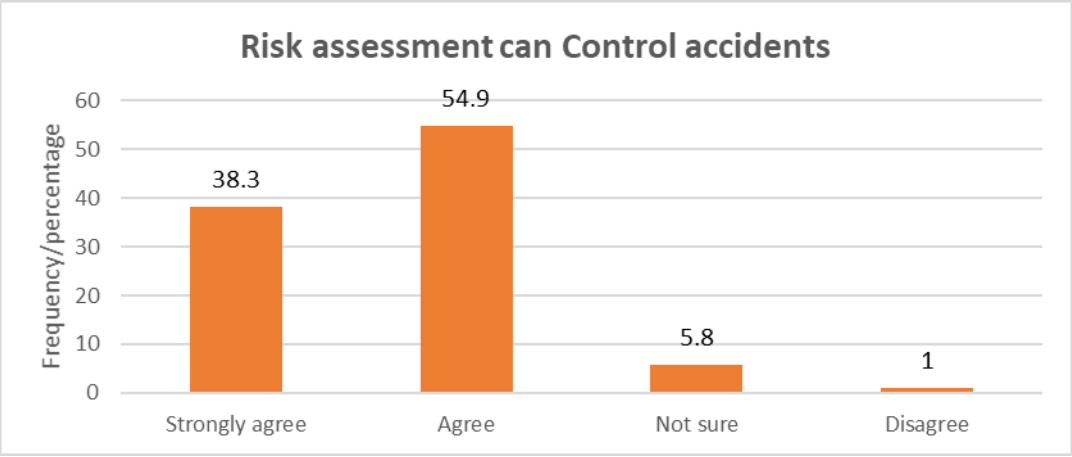


Figure 4.19: Responses on importance of risk assessment in control of accidents at KPA

The finding that majority of 93.2% were of the view that risk assessment of hazardous installations would help in prevention of major accident hazards showed that respondents held the view that risk assessment, if done thoroughly and extensively for all the port operations and the recommendations implemented as required, would help in effective control of major accidents in the operations. But they would need to be involved to appreciate the importance of risk assessment in control of major accident.

There was a mix up of responses, during the interview, regarding risk assessment framework in terms of how it should be conducted, who should conduct and how often it should be conducted. Which showed that this process was not well entrenched in the organization. This was contrary to OSH Act 2007, part II, General duties of the occupier, where one of the duties of the occupier is to ensure Safety & Health of all persons working in the workplace. The Act (OSH Act 2007 part II 6(3)) has instructed carrying out of risk assessment in respect to chemicals, machinery, equipment, tools and processes under the control of the occupier to ensure no risk to safety and health of employees. A good practice would be to involve all employees when conducting the risk assessment. It was found out that majority of the employees did not know much about risk assessment and had no practical working knowledge of conducting any risk assessment in their daily work including the technical departments.

The researcher gained more information on the perception of the respondents towards the third parties operating at the port regarding the risk assessment of their operations

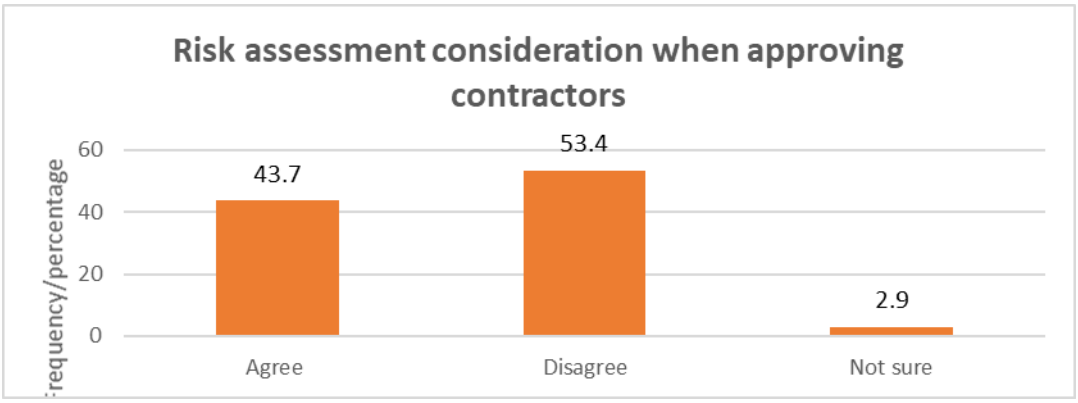
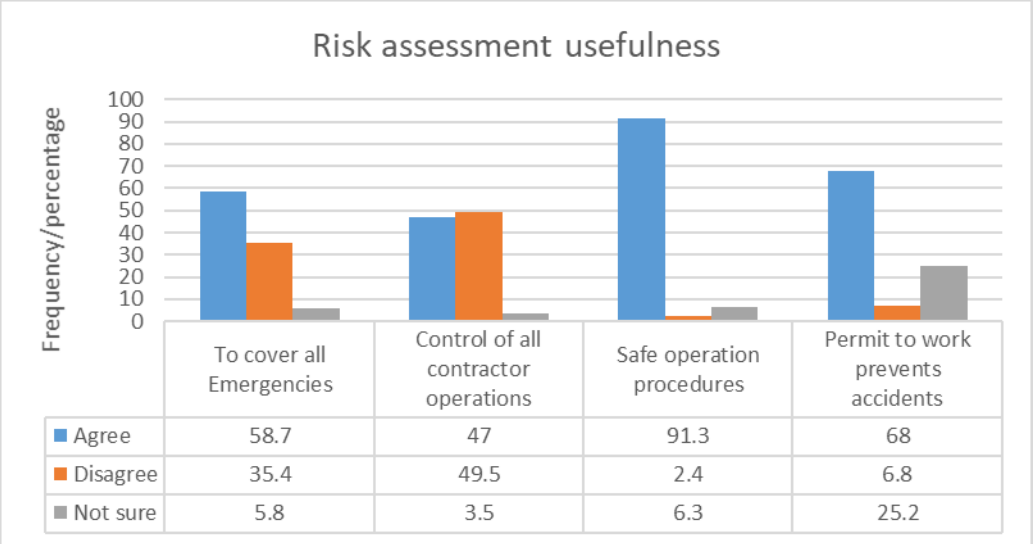


Figure 4.20: Responses on need for risk assessment in authorizing contractors at KPA

It was noted that 43.7% of respondents as shown in chart above believed that risk assessment should be used in determining which contractor to be allowed to operate in the port while only 53.4% of the respondents disagreed.

In Table 4.21, the researcher tested the importance of risk assessment in the operations at the port and the responses helped in understanding more about the awareness on safe systems of work and the importance of integrating risk assessment in port operations.



	To cover all Emergencies	Control of all contractor operations	Safe operation procedures	Permit to work prevents accidents
Agree	58.7	47	91.3	68
Disagree	35.4	49.5	2.4	6.8
Not sure	5.8	3.5	6.3	25.2

Figure 4.21: Showing respondents view on usefulness of risk assessment at KPA

The extent of implementing risk assessment came into focus during the interviews with most respondents saying they were not involved in any way, and where it was done the recommendations were ignored because some would require approval by many people which would take long time to implement due to bureaucratic processes. Interviewed respondents who were operators said they would want to conduct the assessment themselves because they were the ones who operated the plants and equipment. Therefore, the risk management framework was found to be one where the risk assessment was conducted by line managers and the safety

department without involving or consulting other stakeholders, and the recommendations were delayed due to long processes of approval.

It was noted that the respondents held the view that use of risk assessment as a way of approving contractors operating in the port and approving hazardous installations in the port would help to control major accidents in the port if well implemented and sustained. This was a view also strongly supported by the respondents who were interviewed and therefore provides a huge opportunity to minimize occurrence of major accidents in the port. While respondents were not fully supportive of the training of the contractors on major accidents in the port as they were for the KPA employees, the same respondents, 97.1%, held the view that risk assessment, if used in approving port contractor operation license, would lead to prevention of major accidents. This showed that the respondents appreciated the value risk assessment would have on control of major accident although they may not have had practical knowledge of doing risk assessment as it was not a well-entrenched system in the port operations.

4.2.5 Discussion

In this study, a significantly high number of workers have reported that they have witnessed the occurrence of major accidents at the port. Furthermore, the main accidents witnessed at Mombasa port were crane failure, chemical spillage, fire, and explosions. These findings compared very closely with those of a study done by Tsenga and Nick (2017) on "Causes of major accidents in Kaohsiung Port in Taiwan". According to this study, fire, explosion, and equipment (crane) failure accounted for close to 30% of the total major accidents analyzed from the years 2010 to 2014.

The safe systems found in use were access control, permits to work, and shift handover notes. Control of entry of third parties into the port was mainly done by the use of access control only, as opposed to risk assessment of their jobs and permits to work. There was a poor contractor management system in the port in that the control of contractor activities in the port as one of the safe systems of work was not well

entrenched, to the extent that the contractor activities and operations were neither regulated nor closely monitored to avoid the occurrence of major accidents. There was no system of ensuring contractor compliance once they were inside the port and working on different projects. The safe operation procedure as well as other safe systems of work like the PTW were not enhanced to the extent of improving compliance and minimizing major accident occurrences.

These results confirmed the findings of a study done by Jihong et al., 2019, on Port State Control where he studied control of contractors in the port area and found out that the levels of compliance management of different port contractors in Malaysia were different. There was no standardized way to ensure compliance by all contractors that was applied uniformly across the port, and this could create gaps and ultimately lead to the occurrence of occupational accidents in the port. The results were also compared closely with the study done by Helal (2019), who studied Safety and Security around the Egyptian Coasts (Security and Safety in Short Sea Shipping Operations) and found out that the contractor management system of using the Permit To Work (PTW) system was not adhered to and applied to all the contractors in the port.

Cargo handling equipment was found to be the largest contributor to accidents occurring in the port by way of fatalities, spillages and property damage. There was no preventive maintenance schedule for the equipment used by the contractors on site. In addition, some equipment in operation by the contractors and port staff was found to be overdue for service and maintenance. Others were not enrolled in any repair and maintenance schedule, as discovered through the checklist and during the interview, although they were under operation. Poor equipment maintenance, exceeding the safe working load, a standardized replacement policy for equipment, and insufficient funding for equipment maintenance were all found to be significantly associated with the occurrence of occupational accidents in this study.
These findings compared closely with the findings of the research by (Larry & Peter, 2017) on "Crane Accidents and Emergencies—Causes, Repairs, and Prevention". They found out that a significant percentage of major accidents in the port are

attributable to cargo handling equipment and that 53% of accidents occurred in container terminals. Ideally, it is expected that in order to prevent occupational accidents, machines need to be properly maintained, there should be adequate funding to ensure continuous improvement, standard operating procedures need to be adhered to, and there should be a supportive regulatory framework.

Through observation and maintenance records review, there was no clear documentation on equipment preventive maintenance or statutory inspection schedule for equipment used by contractors. This showed that cargo handling equipment maintenance and repair systems were not well enforced. It was also found out that there was no enforced national regulation guiding control of major accidents in the ports or a major accident prevention policy in place that would help in enforcement of control of the occurrence of major accidents in the ports.

Although the majority of the respondents had worked for the company for more than ten years, some had not received any form of training on the control of major accidents, as only 46.1% of the respondents had been trained in other areas like first aid awareness. The results of this study cited a significant association between the type of trainer and the occurrence of occupational accidents whereby port workers reported that lower rates of accidents were witnessed when training was done by an external facilitator. This could probably mean that the external trainers may be more objective and are not prone to any biases while carrying out the training on various topics. For those who had been trained, they did not feel that the training offered them the required competency and confidence to respond to an emergency arising from the occurrence of a major accident.

This could mean that the training did not have the required impact either because of the relevance of the content covered, the duration of training, or the competency of the facilitators in covering topics in major accident prevention. Furthermore, there emerged a general perception that the training of contractors was not as important as that of Kenya Ports Authority employees, even if they worked in the same environment and the consequences of a major accident would not discriminate between the two groups.

The findings were similar to those of a study done by Froese (2016) in Germany on effective operations in ports, where it was concluded that a lack of training programs on major accidents contributed to the occurrence of major accidents. In addition, the findings on training compare with those of the study by (Abd El-Al & Shaheen, 2019). They studied "The risk assessment and effect on improving the productivity in Egyptian container terminals" and found out that the accident awareness was improved after training of the workers and would help in case of emergencies such as accidents in the port.

It was observed that risk assessments were conducted by line managers and the safety department without involving the operators who did the job, implying that the operators were not empowered to conduct adequate and appropriate risk assessments whenever they engaged in any activity or operation in the port. This finding confirmed the finding of a study done by Det Norske Veritas (2019), where it was concluded that managing risk in a workplace set up requires a consultative process involving all stakeholders, especially those who actually do the job, like the contractors, through a risk assessment process so that they can fully understand what the job entails, the risks inherent in it and the mitigation for each of the risks identified.

In addition, Kilvington (2017), in a study titled "Port and Harbour Risk Assessment and Safety Management in New Zealand," concluded that risk assessment helped in awareness of hazards in the port areas. This was a gap compared with the finding of this study that there was no standardized method that was known by all staff for reviewing or updating the risk assessment to ensure changes in risks had been mitigated. The recommendations and proposed actions from the risk assessment were not implemented to the extent recommended because of the bureaucratic approval process and low allocation of resources. This may lead to delays in conducting repairs and maintenance, thereby creating an opportunity for the occurrence of a major accident.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The safe systems of work in place for contractors and third parties included access control, permit to work, emergency testing and shift handover notes and were found to be ineffective towards control of major accidents at the port due to poor implementation and enforcement.

Cargo handling equipment were found to be the largest contributor to accidents occurring in the port by way of a fatalities, spillages and property damages.

Cargo handling equipment maintenance and repair system was not well enforced. Some cargo handling equipment in use at the port by the contractors on site were not under any preventive maintenance plan. In addition, some equipment in operation by the contractors and port staff were found to be overdue for service and maintenance.

Training content of employees was found not to contain any elements of major hazards and accidents prevention and in some cases, employees had not been trained at all in any safety topics in the workplace.

The training was skewed towards KPA employees against the contractors and other third-party workers in the port. Hence there was a general perception that the training of contractors was not as important as that of the Kenya Ports Authority employees even if they worked in the same environment and consequences of a major accident would not discriminate on workers.

It was found out that risk assessment was done by line managers and safety department without involving the operators who actually do the job meaning there was no empowerment of the operators to conduct sufficient and suitable risk assessment whenever they undertake any activity or operation in the port.

The recommendations and proposed actions from risk assessment were not implemented to the extent recommended because of bureaucratic approval process and low allocation of resources. This may have led to delays in conducting repairs and maintenance thereby creating opportunities for occurrence of fatalities and property damage accidents.

5.2 Recommendations

The following are the recommendations based on the results analyzed.

a) KPA should develop and implement a robust safe system of control of contractors and other technical operations in the port and streamline it to align with the port safety management system to ensure close monitoring and control of all contractor activities.
b) KPA should include in the staff training curriculum the topics in prevention of occurrence of major accidents to all employees in the port including contractors. The facilitation should be done by consultants who are competent in their technical areas.
c) It is recommended to KPA management to develop and implement a major accident control policy that covers all KPA and third parties scope of operations, and that draws from the port operations emergency and business continuity plans.

5.2.1 Recommendations for Future Research

Carry out an in-depth analysis of the number of accidents attributable to the contractors at KPA and how a robust safe system to manage their operations could reduce those numbers.

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APPENDICES

Appendix I: Questionnaire

Evaluation of determinants of effective control of major accidents at Kenya Port Authority

Serial no: .....

Date: .....

Organization: ..... Section:

.....

Position: .....

INSTRUCTIONS

The questionnaire has 3 sections. Section I will be on demographic information, section II will be on hazard awareness and section III will include the various variables concerned in this research. Kindly tick (√) the appropriate answer(s) or write brief notes where appropriate.The questionnaire will take approximately 40 minutes. You are assured that your answers will be treated confidentially. Hence, do not provide your name. All the data collected will be kept secure and no other person, besides the researcher and the supervisor will have access to the completed questionnaire. There is no correct or wrong answer and you are encouraged to answer the questions to the best of your knowledge.

SECTION I: Demographic information

1. What is your gender?

   Male ( ) Female ( )

2. What is your age? .....years

3. What is your level of education?

   Primary education ( ) Secondary education form ( )

   Mid-level College education ( ) University education ( )

SECTION II: Hazard awareness

4. How long have you worked at KPA? ……. years

5. During this time have you witnessed any kind of major accident in your workplace?

   Yes ( ) No ( )

6. Which one below describes the way the accident happened?

   Fire ( )

   Explosion ( )

   Chemical spillage ( )

   Container crane failure ( )

   Any other **(Please describe):**

   ……

   ……

   ……

7. What is your opinion on the statement: Handling of explosives and flammable chemicals at the port **CAN** lead to occurrence of a major accident?

   Agree ( ) Disagree ( ) Not sure ( )

SECTION III: Determinants of effective control of major accidents

8. How many trainings on major accident hazard awareness have you attended in the last one year? ……..
9. How long did the training take?

a) More than one hour ( )

b) Less than one day ( )

c) One week ( )

d) More than one week ( )

e) Other …….

10. Were the trainings by an internal or external facilitator

    Internal ( ) External ( )

11. Would you say that the topics covered increased your understanding of major accident hazards occurrence in the port?

    a. Strongly disagree ( )

    b. Disagree ( )

    c. Neither agree nor disagree ( )

    d. Strongly agree ( )

    e. Agree ( )

12. How would you describe your knowledge of the major accident hazards after the training?

Poor ( ) Average ( ) above average ( )

13. Has the training offered prepared you to respond appropriately in case of occurrence of a major accident hazard in the port?

Yes ( ) No ( )

14. Would you say the following is important or not important?

a) Training of all staff on major accident hazards management

Important ( ) Not important ( )

b) Training of contractor/port stakeholder's employees on major accident hazards control

Important ( ) Not important ( )

15. How many times have you conducted risk assessment either individually or as a team in the last five years?

None ( ) 1 – 5 ( ) 5 – 10 ( )

16. What is your opinion on the following statements:

a) Risk assessment of critical and hazardous port operations can be useful in control of occurrence of major accident hazards

a. Strongly disagree ( )
b. Disagree ( )
c. Neither agree nor disagree ( )
d. Strongly agree ( )
e. Agree ( )

b) If port operations risk assessments are conducted suitably and sufficiently and recommendations implemented adequately, occurrence of major accident hazards would be effectively controlled

a. Strongly disagree ( )
b. Disagree ( )
c. Neither agree nor disagree ( )
d. Strongly agree ( )
e. Agree ( )

17. How often are new risk assessment done or existing risk assessments updated

Monthly ( )

Every six months ( )

Annually ( )

Who conducts risk assessment in your organization?

Line manager ( )

Technical/engineering team ( )

Team appointed by CEO ( )

External consultants ( )

18. Give your opinion on the following statement by ticking where appropriate:

	Strongly disagree	Disagree	Neither agree nor disagree	Strongly agree	Agree
Risk assessment should be considered in licensing and renewing license for all contractors operating in the port					
Risk assessment in the ports should cover all types of emergencies that should be expected from hazards due to all operations in the port					

19. Control of the operations of the contractors in the ports is critical in controlling occurrence of major accidents in the port

    Agree ( ) Disagree ( ) Not sure ( )

20. What is your opinion on the following statements:

    a) Port safe operations procedures CANNOT help in effective control of major accident hazards

       Agree ( ) Disagree ( ) Not sure ( )

    b) Permit To Work System is very useful in controlling works of contractor jobs and by extension controlling occurrence of major accident hazards.

       Agree ( ) Disagree ( ) Not sure ( )

21. How often is the emergency response system plan tested

    Once per year ( ) Twice per year ( ) Others ( )

22. The following statements test your perception towards occurrence of major accident hazards that may call for emergency response. For each statement

please give a single response by circling any of the five options in a scale of 1 to 5.

1-Strongly disagree

2-Disagree

3-Neither agree nor disagree

4- Strongly agree

5- Agree

Emergency response would be necessitated by the following

Critical equipment failure e.g. Container crane failure	1	2	3	4	5
Explosion	1	2	3	4	5
Fire	1	2	3	4	5
Environmental spill of a hazardous chemical	1	2	3	4	5
terrorist attack	1	2	3	4	5

23. Risk assessment and port safety management system complement each other in control of major accident hazard at KPA

    Agree ( ) Disagree ( ) Not sure ( )

24. Rate by ticking the following safe systems of work according to your opinion on their ability to help in effective control of major accident hazards at KPA

The following safe systems of work are very critical in control of major accident hazards at KPA	Important	Not important	Not sure
Safe operation procedures			
Permit To Work System			
Emergency Response system			
Contractor management system			

25. Equipment contribute to smooth operations and efficiency in the port but can also lead to occurrence of major accident hazards in the port

    Agree ( ) Disagree ( ) Not sure ( )

26. How many major accidents attributable to cargo handling equipment have you witnessed in your workplace in the recent past? ……. incidents

27. What was the nature of the accident?

Fire ( ) Explosion ( ) Environmental spillage ( ) property damage ( )

28. Poor port equipment care, repair and maintenance would predispose occurrence of major accidents in the ports.

    Agree ( ) Disagree ( ) Not sure ( )

29. The following statements help you to rate the cargo handling equipment aspects in relation to control of major accident hazard. For each statement you will **circle** a single response on a scale of 1 to 5 below.

    1-Strongly disagree

2-Disagree

3-Neither agree nor disagree

4- Strongly agree

5- Agree

The following cargo handling equipment aspects would contribute to occurrence of major accident in the port

Old and obsolete port equipment	1	2	3	4	5
Poorly repaired and maintained port equipment	1	2	3	4	5
Exceeding the Safe Working Load (SWL)	1	2	3	4	5
Operation by incompetent operators	1	2	3	4	5

30. On a scale of 1- 5 below tick your opinion on the following statements:

	Strongly disagree	Disagree	Neither agree nor disagree	Strongly agree	Agree
Adherence to cargo handling equipment replacement policy and establishing a standardized sourcing could have a bearing on controlling accidents attributable to equipment failure in the ports.					

Low cargo handling equipment maintenance funding can ultimately lead to occurrence of a major accident hazard					

31. Which of the following statements would fit your opinion on the need for legislation dealing with control of major accident hazards in the ports

    A Legislation dealing with issues of control of major accident hazards in the ports would help control major accident hazards

    B Legislation dealing with issues of control of major accident hazards in the ports would **NOT** help control major accident hazards

32. In your opinion what should be done to effectively control the major accident hazards in the ports?
    ……
    ……
    ……

Appendix II: Hazard Inspection Checklist

	Y	N	NA	comments
General work environment				
Is the worksite generally clean and orderly?				
Is there available combustible debris and waste stored safely				
Hoist & auxiliary equipment				
Are hoisting equipment available and with characteristics appropriate for the task?				
Is the rated load of each hoist legibly marked and visible to the operator?				
Is there a regular program of safety inspection of machinery and equipment?				
Are there affixed inspection stickers giving status of equipment?				
Are condemned equipment identified and removed from use?				
Is all machinery and equipment kept clean and well maintained?				
Is there a training program to instruct employees on safe methods of machine operation?				
Is the operator instructed to avoid carrying loads over people?				

	Y	N	NA	comments
Are only employees who have been trained in the proper use of hoists allowed to operate them?				
Is it prohibited to use chains or rope slings that are kinked or twisted?				
Are hazard warning device installed in each cage-controlled hoist?				
Are only trained personnel allowed to operate forklifts and other cargo handling equipment?				
Crane checklist				
Does each industrial truck have a warning mechanism which can be clearly heard above the normal noise in the areas where operated?				
Does the mobile crane brakes prevent it from moving when at rest?				
Are the cranes visually inspected for defective components prior to the beginning of any work shift?				
Is there an established crane preventive maintenance schedule?				
Does each crane have a certificate indicating that required testing and examinations have been performed?				
Is the Safe Working Load visibly marked on each crane?				
Is sufficient illumination provided night operation?				
Are cranes equipped with boom stops to prevent fall over backward?				
Are operating controls clearly identified?				
Are crane inspection and maintenance records available for inspection?				

Appendix III: Interview Guide For Operations Supervisors And Line Managers

Department……..

Job Title ……..

Date……

Interview subjects guide.

Training

1. Levels of training provided.
2. Training needs gap analysis and identification
3. Specialised training for machine operators and major hazards

Risk assessment

4. Extent to which risk assessments are conducted and actions implemented
5. Use of external risk assessment consultants

Safe systems of work

6. Testing of emergency response systems; Internally or externally
7. Control of risky contractor activities in the ports
8. Current port safety management system in place and interaction with other systems

Cargo handling equipment maintenance

9. Equipment preventive maintenance schedule
10. Testing and inspection of lifting equipment in the ports
11. Old equipment replacement
12. Past accidents or incidents attributable to any of the above variable