ASSESSMENT OF OCCUPATIONAL SAFETY AND HEALTH ISSUES IN LIQUEFIED PETROLEUM GAS RETAIL BUSINESS IN KIAMBU COUNTY, KENYA

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Assessment Of Occupational Safety And Health Issues In Liquefied Petroleum Gas Retail Business In Kiambu County, Kenya

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DECLARATION

This research is my original work and has not been submitted for the award of a degree in any other University.

Signature……. Date…….

James Karori Nyabuto

This thesis has been submitted with our approval as the University supervisors.

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JKUAT, Kenya

DEDICATION

To all those who believe enlightenment is our liberation.

ACKNOWLEDGEMENT

My sincere thanks go to my supervisors Dr. Mburu and Dr. Gichuhi, for their immense support, encouragement, and positive criticism without which this work could not have been realized.

To God, be the glory.

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LIST OF ABBREVIATIONS

API - American Petroleum Institute

BLEVE - Boiling Liquid Expanding Vapour Explosion

BPS - Board of Post Graduate Studies

CGK - County Government of Kiambu

DOSHS - Directorate of Occupational Safety and Health Services

EHS - Environment, Health, and Safety

EPR - Emergency Preparedness and Response

EPRA -Energy and Petroleum Regulatory Authority, Kenya

GoK -Government of Kenya

GIIP -Good International Industry Practice

HSE - Health and Safety Executive

IEET -Institute of Energy and Environment Technology

ILO - International Labour Organisation

ISO - International Organization for Standardization

JKUAT -Jomo Kenyatta University of Agriculture & Technology

Kg - Kilogram

KNBS - Kenya National Bureau of Statistics

Lpg - Liquefied Petroleum Gas

NACOSH - National Commission for Occupational Safety and Health

NDT -Non-Destructive Test

NFPA - U.S. National Fire Protection Association

O&M - Operation and Maintenance

OSH - Occupational, Safety, and Health

PPE - Personal Protective Equipment

WHO -World Health Organisation

WLPGA -World Liquefied Petroleum Gas Association

ABSTRACT

Liquefied petroleum gas (Lpg) is primarily used as a thermal fuel. It's a clean, green, and efficient energy source that reduces deforestation, and poses no ground or water pollution hazards. However, Lpg cylinder accidents are devastating. This study aimed at assessing the level of awareness of occupational safety and health issues in Lpg cylinder retail business among retailers in Kiambu County; examining the current OSH practices put in place, and exploring the challenges hindering good OSH practices in this business. The study adopted a descriptive-diagnostic research design; and from a population of 400, a sample of 292 was arrived at. Stratified purposive sampling was employed in selecting the study sites. Data was collected through observation, the use of interview schedules and measurements. Subsequently, the data collected was analyzed using SPSS ver.25 and excel 2019: descriptive and inferential statistical analyses were effectuated and presented in the form of charts, graphs, and tables. The study established that 77% of the respondents were not aware of the occupational safety and health issues in the Lpg cylinder retail business. Similarly, 71% of the respondents did not employ safe occupational safety and health practices in their operations. The association of awareness of how to use a fire extinguisher and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=1) =4.999, since p=.025. The association of awareness of the health and safety policy and respondents' experience was statistically significant at a 95% confidence level with χ^2 (df=4) =32.204, since p= <.001. The association of housekeeping and age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =7.268, since p=.026. The association of cylinder handling and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =14.193, since p=<.001. It was ascertained that 29.2% and 46.7% of the 13kg and 6kg Lpg cylinders respectively were non-conforming concerning weight measurements and non-destructive testing. Challenges to the application of good OSH practices included lack of sensitization on the importance of safety, ignorance, and high costs associated with Lpg cylinder safety enhancement. The study recommends that relevant regulatory agencies should undertake routine inspections and monitoring in all Lpg retail centers. Similarly, Lpg suppliers, in partnership with the County governments should raise public awareness about Lpg cylinder safety; through safety tailored campaigns on local television/radio stations, print media, and social media platforms. Technological breakthroughs should also be embraced in Lpg cylinder safety enhancement.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Occupational safety and health (OSH) is the science of the anticipation, recognition, evaluation, and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment. This domain is necessarily vast, encompassing a large number of disciplines -in this case, liquefied petroleum-gas cylinder retail business- and numerous workplace and environmental hazards. (Alli, 2008).

Lpg is the abbreviation used to describe liquefied petroleum gas, a group of hydrocarbon gases typically containing three or four carbon atoms per molecule. The normal constituents of liquefied petroleum gas are propane, propylene, butane, and butylene. (Competition Commision of South Africa, 2017). Energy is a vital part of any nations' existence, and is the "lifeblood'' that drives economic and social development without which it becomes essentially difficult for an individual, community, or a nation to survive. (Hammeeda., 2016).

Although there are many variations of liquefied petroleum gas, it is primarily made up of propane (60%) and butane (40%), and it is compressed into liquid form for ease of transport, storage, and handling. Liquefied petroleum gas is either produced as a by-product of the oil and gas refinery process; or extracted from oil or 'wet' natural gas streams as they emerge from the ground. It is normally stored in liquid form in pressurized tanks and transported by road in tanker trucks or in cylinders. Liquefied petroleum gas is primarily used as a thermal fuel in numerous applications. It burns cleanly, releasing a few sulfur emissions and posing no ground or water pollution hazards. (Competition Commision of South Africa, 2017).

Lpg is odorless, but a stenching agent, mercaptan, is added to assist in its detection in case of leakage. (Alok, 2014).

Accidents involving gas cylinders can cause serious injury or even death. That being the case, enhancing occupational safety and health in liquefied petroleum-gas cylinder

retail business is key. Liquefied petroleum gas cylinder retailers have to provide a safe workplace and safe work equipment. Gas cylinders are a convenient way to transport and store gases under pressure. (Health and Safety Executive, 2012).

1.2 Statement of the problem

A lot of liquefied petroleum gas cylinder retailing shops have come up in the urban and peri-urban areas of Kiambu county. This is because a large percentage of people now prefer clean, green, faster, and efficient energy to charcoal or paraffin (Kiambu County, 2015). A report by the ministry of forestry and wildlife, in 2013, established that wood harvesting for charcoal and firewood is the most dominant direct driver of forest cover loss in Kenya. Consequently, using liquefied petroleum gas reduces deforestation and promotes entrepreneurship (Ministry of environment and forestry, 2018)

However, liquefied petroleum gas cylinder accidents are disastrous (Beheshti et al., 2018). Liquefied petroleum gas retailers face the risk of serious injury or death while undertaking the retailing activities. Data from EPRA indicates that at least 25 accidents involving gas cylinder explosions have been recorded in the last 24 months (see Appendix X). Further, an inspection of liquefied petroleum gas retail activities in Juja town revealed little observance of safety and health measures in the Lpg retail business. Some of the fascinating issues arose from the location of the business, housekeeping, cylinder handling, transportation, and storage. There is therefore, a need for providing simple, practical advice on eliminating /reducing the risks associated with retailing of liquefied petroleum gas. This necessitated a study on the various occupational safety and health issues in liquefied petroleum-gas cylinder retail business in Kiambu county, with an overall aim of promoting a positive safety culture in the gas cylinder retail business.

1.3 Justification of the study

Lpg cylinder accidents are disastrous. Lpg is potentially hazardous if mishandled, and therefore the promotion of good safety practice in this retail industry is key. (Beheshti et al., 2018). Little research has been carried out in Kenya with regards to OSH awareness of Lpg cylinder retailers. The importance of this study is that it will reveal the level of awareness of safety and health in Lpg retail business, the current

occupational safety and health practices among retailers, and the challenges to the application of good safety and health practices. This will provide important information to the regulatory agencies (EPRA, DOSHS, and County Governments); for policy formulation / implementation, that is the first step necessary to ensure that safety and health in the Lpg retail business, which is a legal requirement, are implemented for the well-being of all stakeholders (investors, suppliers, retailers, consumers).

1.4 Objectives

1.4.1 Main Objective

To assess occupational safety and health issues in the Lpg retail business in Kiambu County, Kenya.

1.4.2 Specific Objectives

1) To assess the level of awareness, by retailers, on occupational safety and health issues in Lpg business.
2) To examine the current occupational safety and health practices in Lpg retail business.
3) To explore the challenges to good occupational safety and health practices in Lpg retail business.

1.5 Research questions

1) What is the level of awareness, by retailers, on occupational safety and health issues in liquefied petroleum gas retail business, in Kiambu County?
2) What are the current occupational safety and health practices in the liquefied petroleum gas retail business, in Kiambu County?
3) What are the challenges to good occupational safety and health practices in liquefied petroleum gas retail business, in Kiambu County?

1.6 Scope of Study

The study will focus on liquefied petroleum gas cylinder retailers in Thika, Kiambu, Limuru, and Juja towns. The overall population comprised of 968 Lpg cylinder retailers in Kiambu County. The population of the selected study sites comprised of 400 Lpg cylinder retailers undertaking the Lpg cylinder retail

business. The study sites were arrived at after taking into consideration the budget, time, personnel, and other resource limitations.

1.7 Conceptual Framework

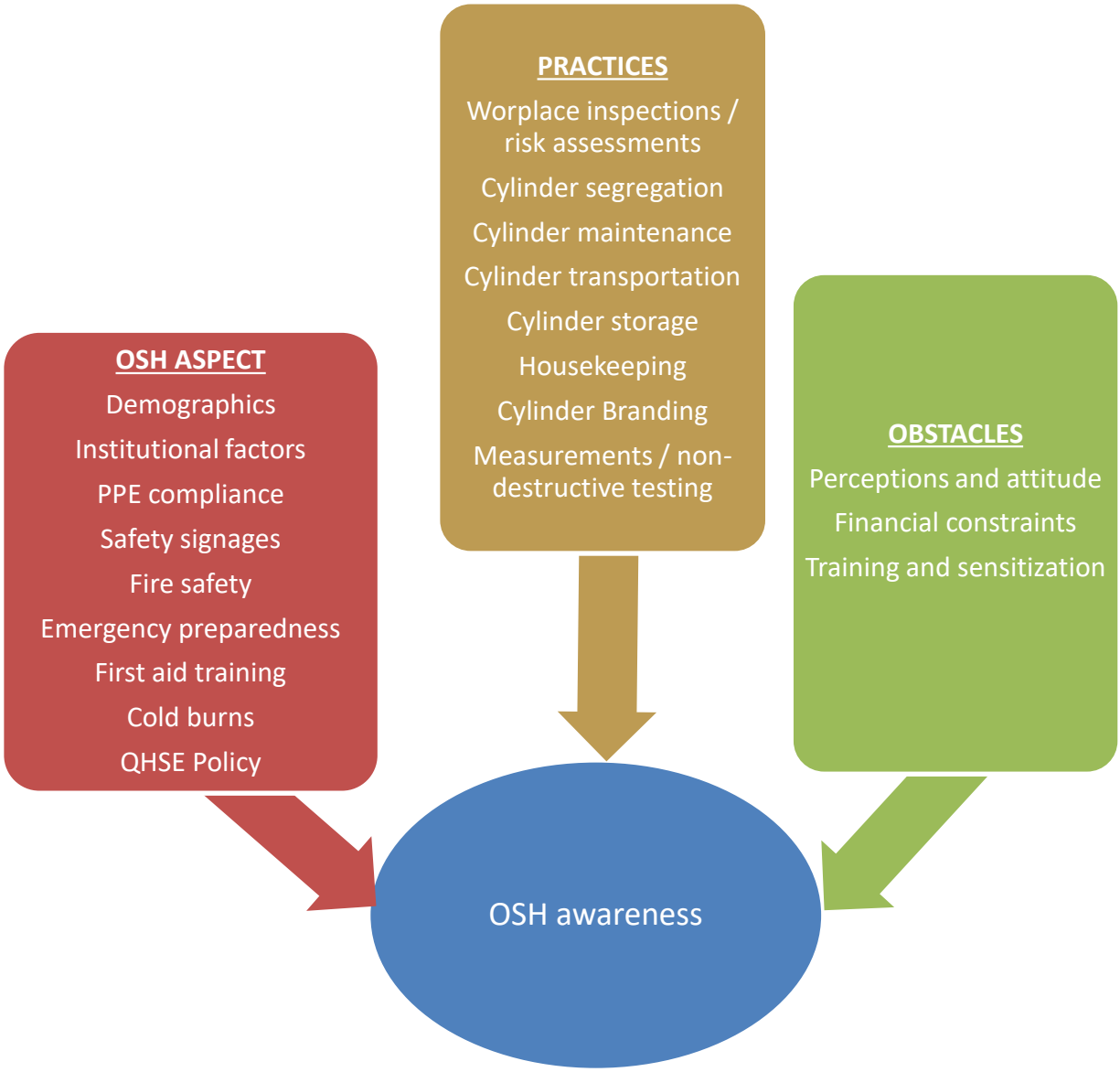


Figure 1.1: Conceptual framework

OSH awareness is the dependent variable; whereas OSH aspect, practices and obstacles are independent variables.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical principles

2.1.1 Liquefied petroleum gas and safety concerns

Liquefied petroleum gas (Lpg) is a by-product of the refinement of crude oil. Lpg is also produced when natural gas is extracted from the gas fields and dried. Lpg, which comprises Propane and Butane.Lpg is an increasingly popular fuel for cooking and manufacturing. It is transported and stored as a compressed liquid in pressurized canisters ranging in size between 1kilogram and 22.5 kilograms for ordinary domestic use and larger canisters of between 22.5 kilograms and over four tones for industrial use. For household use, gas is conveyed via simple regulators and pipes to cookers or lamps, which are specially made for Lpg use. (Njogu, 2012)

Njogu (2012) further stresses that: “to overcome illegal dealers and the escalating malpractices which hamper growth and consumer safety, the energy regulatory commission (ERC), now EPRA, should continue to enforce Lpg inspections and track monitoring, compliance in the industry as well as engage the industry players for joint solutions.” Moreover, EPRA should reign in the unscrupulous traders and protect consumers as well as legitimate marketers. Strong and effective law enforcement measures must be put in place to attract new investors in the sector. (Njogu, 2012).

Lpg has its special hazardous characteristics. Lpg safety comes from understanding these characteristics and behavior and from the exercise of control under both normal and abnormal conditions. The behavior of Lpg is predictable, and the technology for control is well understood. Good technical and safety expertise is to be found in the primary supply and marketing companies and the major equipment manufacturers. The application of this expertise becomes progressively more challenging as Lpg is moved along the distribution chain and away from the direct control of the primary suppliers and marketers. (World Lpg Association, 2015)

The hazards commonly associated with Lpg are fire and explosion. Since uncontrolled releases of Lpg can have serious consequences, the prime objective of an Lpg safety program is to prevent uncontrolled releases by containment. (Beheshti et al., 2018).

Butane and propane are the predominant constituents of Lpg. Butane, propane, and butane/propane mixtures are handled and distributed separately, and for safety, one product should not be mistaken for the other. (World Lpg Association, 2016)

The consumer receives Lpg at the end of the distribution chain. In practice, this can mean transportation over long distances. Lpg safety must consider hazards associated with the mode and duration of transport, including the risk of traffic accidents and delays and their possible consequences. Adequate combustion air and ventilation are essential for safety. The products of Lpg combustion, or product released due toe of leakage, should be vented to avoid a possible build-up of hazardous secondary products. The retailer and the consumer have major roles in this aspect of Lpg safety. (Health and safety executive, 2012).

The vast range of Lpg uses and of appliances, as well as the variable scale of installations, adds to the complexity of Lpg safety. The introduction of new applications, especially when accompanied by changes in distribution practices, present new hazards and may call for the introduction of additional safety practices. The safety procedures in a marketer's bulk plant may not be adequate at an automotive re-fuelling station. The safety requirements of a household installation with several appliances, will differ from those of a consumer using a single appliance directly attached to a cylinder. (World Lpg Association, 2018)

2.1.2 Physical Properties

Lpg is produced in crude oil refining and the processing of natural gas liquids. Commercial, or fuel grade, Lpg mainly consists of butane and propane with small amounts of lighter and heavier fractions, such as ethane and pentane.

Table 2.1: Typical properties of liquefied petroleum gas

Typical Properties of LPG			
Property	**Propane**	**IsoButane**	**n-Butane**
Boiling point at 101.3 kPa (°C)	-42.1	-11.8	-0.5
Liquid density at 15 °C (kg/m3)	506.0	561.5	583.0
Absolute vapour pressure at 40 °C (kPa)	1510	530	375
Flash Point (°C)	-104	-83	-60
Upper flammable limit (% vol. in air)	9.5	8.5	8.5
Lower flammable limit (% vol. in air)	2.3	1.9	1.9
Vol. vapour per vol. liquid	269	221	235
Relative vapour density (air = 1)	1.55	2.07	2.07
Coefficient of expansion (liquid) per 1°C	0.0032		0.0023
Minimum air for combustion (m^3/m^3)	24		30
Kinematic Viscosity (centistokes) @ 20°C	0.20	0.29	0.30
Latent Heat of Vapourisation (kJ/kg) @ 20°C	352		368
Specific Heat (kJ/kg/°C) @ 20°C - liquid	2.554		2. 361
Specific Heat (kJ/kg/°C) @ 20°C - vapour	1.047		1. 495
Minimum ignition temperature (°C) in oxygen	470 - 575		380 - 550
Specific Energy (gross) kJ/kg	49.83		49.40

Source: (World Lpg Association, 2015)

From the above table, it is apparent that there are significant differences in the physical properties of butane and propane, most notably boiling point, liquid density, and vapor pressure. The differences in their physical properties mean that butane and propane behave differently under everyday conditions and more especially under extreme conditions. Such differences can be turned to advantages in certain applications. However, differences in boiling point, liquid density, and vapor pressure between butane and propane are particularly important for safety and appliance performance. (World Lpg Association, 2015)

Appliance suppliers and installers should consider differences in the quantity of air required for complete combustion of butane and propane. Failure to do so can affect both consumer safety and satisfaction. (Masami, 2011)

Poor quality control in Lpg refining and production processes can have an indirect bearing on safety as it may lead to hazards further along the distribution chain or at the point of use. Well-intentioned but inexpert attempts to solve Lpg quality problems at the point of use can be risky and are best prevented by appropriate controls during

production. Authorities (EPRA) should ensure that relevant product standards are established and observed.

Because butane and propane have different physical properties, it is important that the composition of Lpg mixtures being distributed in a market be known to participants and kept within specified limits, which are related to product specifications. There are Lpg standards that have international recognition and one of which could be adopted in the absence of a suitable national standard. (Masami, 2011)

Lpg is odorless in its natural state, so a distinctive odor is usually added to warn of its presence. However, not all Lpg is colorized in this way, and additional hazards exist in the storage and distribution of deodorized Lpg. A few applications for Lpg may require a deodorized product, e.g., propellants. Care should be taken when handling Lpg with no odor. When selecting the type of odourant to use, it is important to recognize their particular properties as some are toxic and require careful handling. Attention should also be given to their short life as the odor may fade over time. (Lpg Association, 2015 & Health, and Safety Executive, 2011).

At the beginning of the distribution chain, Lpg is usually stored and handled in sufficient quantity to constitute a major industrial hazard and is regulated accordingly. Further along the distribution chain, Lpg will pass through less skilled hands, but the safety management task remains.

At the point of use, Lpg may be a culprit or an innocent party to an incident arising from deliberate misuse of the product or through a faulty appliance or installation. Such exposures further complicate the management task. (Lpg Association, 2015).

2.1.3 Risks and Potential Hazards from Gas Cylinders

Gas cylinders can be hazardous due to both their physical (size and weight) and chemical characteristics. Hazards from gases are also subject to the chemical properties of each gas. These may be one or more of the following: fire or explosion from the release of flammable gases (Lpg) near ignition sources, spontaneous combustion from oxidizing gases, asphyxiation from non-toxic, non-flammable gases by displacement of oxygen, incorrect storage, leaks, faulty equipment/connections,

physical risks, manual handling, sudden release of gas if cylinder is damaged (torpedo effect), Pressure, and gas density (University of Wollongong, 2015)

The principal potential hazard with Lpg is fire and explosion. This derives from its inherent quality of high flammability and, in extreme cases, may combine with another quality, i.e., pressure, and lead to the BLEVE (Boiling Liquid Expanding Vapour Explosion) phenomenon. There are also hazards .incidental to the various modes of transport for distribution and use.

An additional potential hazard may arise at the point of use if ventilation is inadequate and the products of combustion are not dispersed into the atmosphere. Carbon monoxide may be produced and reach dangerous levels. The intentional inhalation of Lpg vapor (Lpg sniffing) seeking a narcotic effect, can result in injury or, in some cases, death.

Liquid Lpg will cause cold burns if it comes into contact with the skin. Propane, with its low boiling point, is more hazardous in this respect than butane, which, in cold conditions, is slower to vaporize and disperse. The eyes and body must be protected when handling all liquefied products. (University of Wollongong, 2015)

Lpg vapor, being heavier than air, may, in the event of a leak, accumulate in confined spaces and low-lying areas. The means of ventilation and meteorological conditions will influence the movement and dispersion of the Lpg vapor. (UKLpg & Health and Safety Executive, 2016)

Any uncontrolled release of Lpg is inherently hazardous. A liquid Lpg leak is considered more hazardous in that it will expand to vapor by a factor of more than 200. By the fact that Lpg is heavier than air, vapor will tend to lie, or drift, close to the ground with a risk that it will find a source of the ignition while it remains within its flammable limits. (Beheshti et al., 2018).

Liquid Lpg has a high coefficient of volumetric expansion and, therefore, cylinders and tanks should never be filled. They should be filled with an ullage to allow for liquid expansion caused by an increase in temperature. The degree of ullage necessary will depend on the operating conditions, especially the maximum expected operating

temperature. This potential risk is further controlled by a combination of safety devices and procedures and especially by control during product transfer operations. This potential risk explains why cylinders and tanks should only be filled under the supervision of competent persons and why the illegal filling is dangerous. (Concordia University, 2017).

Because of its much higher vapor pressure, tanks and cylinders containing propane need to be stronger than those for butane, and both should be protected against excessive pressure. This potential risk is controlled by safety devices and by segregating the products or, where the Lpg mixture is handled, ensuring that the propane content does not exceed a specified upper limit. In cold weather, a tank storing butane may be subjected to negative pressure and must be capable of withstanding this. (Beheshti et al., 2018).

During the process of distribution, Lpg will normally be transported in one or more modes. There will be hazards associated with the transport mode and with the consequences of traffic accidents and incidents. The risks will vary from country to country and with the transport mode. (Health and Safety Executive, 2016)

2.1.3.1 Pressure hazards

Cylinders contain gases stored under pressure and will have significant stored energy. Any pressure above atmospheric released from a cylinder has the potential to cause injury to personnel or damage to plant or property. Pressure can be released by Inadvertent operation of the outlet valve during handling, deliberate operation of the outlet valve, damage to the valve if cylinder topples or falls, application of heat, mechanical impact, leaking valve, operation of pressure relief devices, unauthorized modification of the cylinder assembly and failure of the cylinder wall, for example, from excessive internal and external corrosion (by reducing wall thickness. (Lpg Association, 2015; WLpgA, 2011).

When compressed moderately at normal temperature, it becomes liquid. When gas is withdrawn, the pressure drops and the liquid reverts to gas. This means that it can be transported and stored as a liquid and burnt as gas. (Alok, 2014).

Care in the handling and use of Lpg will help to minimize the number of incidents, accidents, and their consequences. This is the key driver in the Safety Promotion. The hazard commonly associated with Lpg is an uncontrolled release followed by fire. (Alok, 2014)

2.1.4 Materials for cylinder manufacture

In general, there are three types of gas cylinders:

1. High-Pressure Cylinders – High-pressure cylinders come in a variety of sizes. Some examples of gases supplied in High-pressure cylinders include Nitrogen, Helium, Hydrogen, Oxygen, and Carbon Dioxide.

2. Low-Pressure Cylinders – Low-pressure cylinders come in a variety of sizes. Some examples of gases supplied in the low-pressure cylinder are Lpg and refrigerant gases.

3. Acetylene Cylinders – aggregate filled and acetylene is dissolved in acetone to get sufficient product into the cylinder. (University of Wollongong, 2015)

2.1.4.1 Low carbon steel cylinder manufacture

The cylinders are manufactured either in two pieces or three-piece construction. In two-piece construction, cylinders are fabricated by welding two domed ends directly together. A three-piece cylinder is fabricated by joining two domed ends to a cylindrical body.

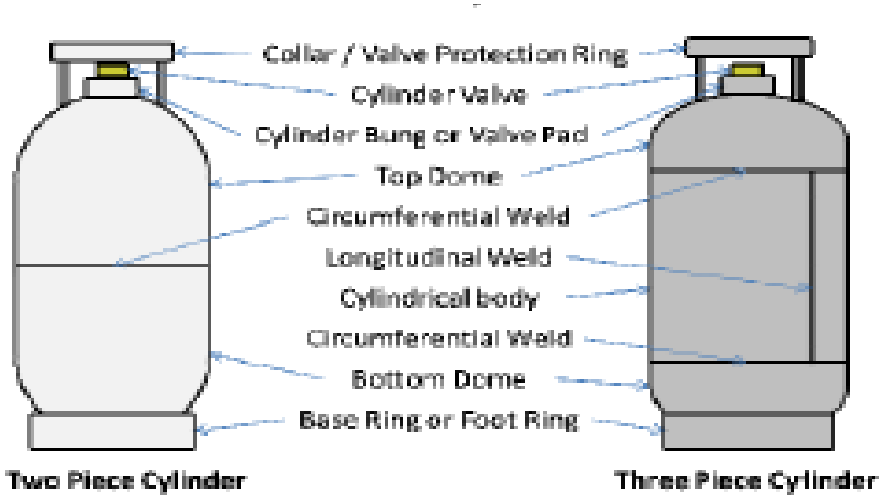


Figure 2.1 Parts of a Liquefied petroleum gas cylinder

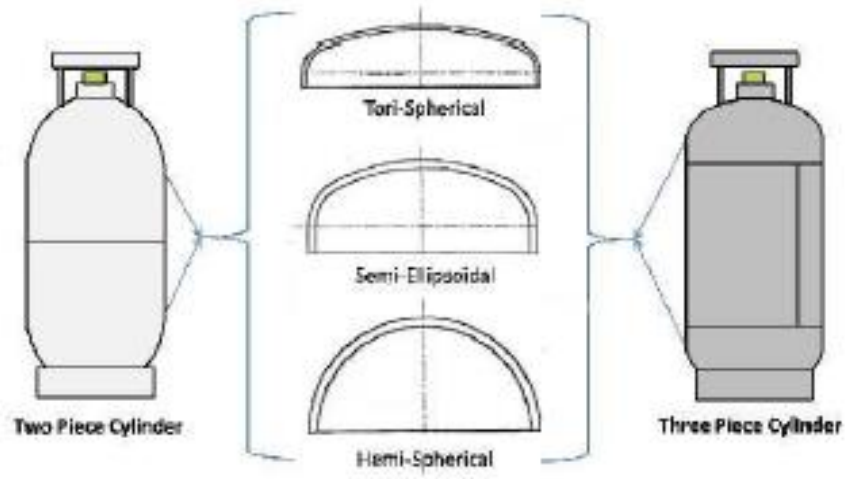


Figure 2.2 Types of domes in two and three-piece cylinder

(Alok, 2014)

2.1.4.2 Basic Safety Principles

Personnel engaged in Lpg operations should receive formal training by competent persons for their normal activities and emergencies. Lpg facilities should have emergency planning and response programs appropriate to the hazards and risks which they represent. These include correct handling procedures to avoid injury. (National Fire Prevention Association, 2014).

Lpg cylinders should never be allowed to become liquid-full. Climatic conditions will influence the degree of ullage required, but it is typical practice to fill to around 80% of the water capacity of the vessel. Further, cylinders should only be filled under the supervision of competent personnel. (National Fire Prevention Association, 2014).

2.1.4.3 Product Classification and Labelling

In practice, the products known collectively as Lpg include n-butane, iso-butane, propane, and propane/propylene. They may be supplied separately or in varying mixtures and degrees of purity. All come within the designation ‘Hazardous Substances’ and are classified ‘Highly flammable.’ Appropriate markings and warning signs should identify Lpg cylinders. (KS ISO 4706-1, 2008).

In the absence of national regulations, the minimum safety information on a cylinder should state the product, the supplier's name or brand, the net fill amount, a flame

symbol, and the word ‘Flammable’ or its local language equivalent. Information should be of sufficient size to be readily legible and in color contrasting with the rest of the cylinder. (University of Queensland, 2011).

2.1.5 Storing Cylinders

Bulk Cylinder

Gas stores should be located outdoors, preferably in a secure cage protected from sunlight. Storage indoors is not recommended unless the building has been designed for that purpose with appropriate fire-rated walls and ventilation. Where gases are stored indoors, additional safety considerations and control measures need to be given consideration. (Newcastle University, 2012).

Lpg is one of the very few common consumer products sold in a metal container that is often costlier than the product itself. In the distribution system, many parties may physically handle the cylinder before it reaches the customer. Once the liquefied petroleum gas cylinder has been sold, the seller has no direct control over its subsequent use. This makes the importance of maintaining the cylinder or container integrity throughout the distribution chain an integral part of customer safety. (Masami, 2011).

Some unscrupulous players elect to fill cylinders owned by others, steal others’ cylinders, and pay little or no attention to proper procedures for filling and handling Lpg and related equipment. Equally important, once the cylinder leaves the direct control of the owner, there is no guarantee as to when or if the cylinder will be returned. Yet, the owner is exposed to the risk that misuse of the cylinder could result in injury to personnel, loss or damage to property, and loss of customer business. Accidents caused by circumstances or people beyond the control of the owner can expose the owner to severe liability claims, damage the reputation of the owner, and damage the reputation of the industry. (UKLpg Association, 2016)

These aspects of the Lpg industry make it of special importance that the market framework within which the Lpg is sold and delivered ensures that cylinders and containers are properly maintained. Maintenance of the cylinder and container is the

responsibility of the owner; proper and safe use is the responsibility of everyone in the distribution chain, including the customer. (World Lpg Association, 2018)

2.1.5.1 General security

All stores containing gas cylinders shall be secure, and access shall be restricted to authorized personnel. The security arrangements shall include appropriate physical and management security controls to prevent unauthorized access, theft, tampering, arson, vandalism, and to effectively monitor the usage of gases, as well as any specific local considerations. Keys for each store shall be kept in a secure location and only issued to authorized persons; a log should be kept where the gas cylinder store is enclosed; a suitable emergency exit may be required depending on the size and layout of the store. All persons handling gas cylinders shall have appropriate security training. (UKLpg Association, 2016)

2.1.5.2 Ventilation

Ventilation is required to ensure that any small leakage of gas is adequately dispersed and will prevent a hazardous atmosphere from being created. An outdoor store with open sides is considered to provide adequate ventilation and is the preferred option.

Where a store may have restricted ventilation due to adjacent buildings or a wall acting as a store boundary; it is necessary to ensure that there is through and thorough ventilation in all areas inside the store. Where the configuration of the store restricts airflow, the installation of high and low-level vents should be considered to ensure a regular change of air.Ventilation openings shall discharge to a safe place in the open air. Warning signs shall be sited at each entrance so that they are visible to personnel before entering the store. (British Compressed Gases Association, 2016)

2.1.5.3 Access

The storage area should be located so that it is readily accessible for cylinder movements with manual handling distances kept to a minimum and clear access maintained at all times for deliveries and the emergency services.

Access to the delivery and storage area is to be kept clear, with no parking allowed, except for the loading and unloading of cylinders. Aisles should be provided to allow safe access to cylinders, to facilitate good housekeeping, stock control, and ease of

handling. They should be a minimum of 1 meter wide. The layout of the storage area should allow for the safe movement of gas cylinder handling trolleys.

Where installed, all designated emergency exits shall open in the direction of escape. They are to provide an unobstructed means of escape and, in operation, shall not obstruct any other escape route. These exits shall be identified properly by signage and maintained in a serviceable condition always. (Concordia University, 2017)

2.1.5.4 Lighting

The area should have adequate lighting to assist in providing a safe work environment, to allow the identification of the cylinder contents, signage, and where necessary to assist with security. Where artificial lighting is used, it shall give suitable color rendering to enable color labeling to be easily recognized by persons with normal color vision. (University of Queensland, 2011)

2.1.5.5 Fire safety requirements

A responsible person shall carry out a fire safety risk assessment on all gas cylinder storage areas to determine the hazard and the risk associated with a fire originating from a gas cylinder and a fire impacting on a gas cylinder(s). The findings from which are to be incorporated into the site fire safety management plan that is to be implemented and maintained. As necessary, advice should be sought from the fire and rescue service. The risk control measures identified shall be incorporated into the construction of the gas cylinder retail shops.

It is good practice, especially where larger quantities of gas cylinders are stored, to invite the local fire and rescue service to the site, so they are familiar with the location in the event of an incident. (National Fire Protection Association, 2017)

Adequate means of providing an alarm in the event of a fire shall be established. Where physical alarms are installed, these should be marked and suitably located, including at all emergency exit points. (Concordia University, 2017)

The fire safety management plan will determine the appropriate fire equipment necessary, including the number and type of fire extinguishers to be provided, and their locations. Where fire extinguishers are required, they should be positioned in

easily visible positions near entrances/exits, at the perimeter of the store and in safe positions. Each gas cylinder store area shall be designated a no-smoking area. (BOC, 2012)

Wherever practicable, the cylinder storage infrastructure (walls, ceiling, floor) shall be constructed of non-combustible or fire-resistant materials. The construction materials will comply with the requirements of BS 476 (27), Parts 20 to 23. If the cylinder store is part of a larger building, it shall be of at least 30 minutes of fire-resisting construction, preferably made of brick or concrete. Where vulnerable populations are housed, then it shall be of 60 minutes fire-resisting construction.

2.1.5.6 Safety signs and warning notices

Individual gas cylinder stores shall have adequate signage to provide warnings and safety information on the hazardous products being stored. Signage shall comply with: The Health and Safety (Safety Signs and Signals) Regulations and BS ISO 7010, graphical symbols. Safety colors and safety signs. Registered safety signs. (Health and Safety executive, 2012).

All signs shall be in the English language. Bilingual/multilingual signs may also be necessary. Signs and pictograms shall be visible from all angles of approach, preferably sited with the center of the sign at the average eye level (between 1.5 and 1.7 m above the ground).

Signs for the following hazards should be displayed: No smoking, No naked lights, No sources of ignition, No access for unauthorized persons, No mobile phones or other electronic devices, No storage of oil, and grease or combustible materials. For flammable gases, these additional signs should be displayed: Flammable gas and, Asphyxiation hazard. (Masami, 2011)

2.1.5.7 General storage requirements

Good natural ventilation is essential, particularly where storage is within a building. Ventilation should be provided at high and low levels. Cylinders should be stored in the open but with some protection from the weather. (Newcastle University, 2012)

Storage should not be below ground level. Storage areas should be readily accessible but secure to prevent access by unauthorized persons. Permanent warning notices should be prominently displayed at the storage areas, identifying the gases stored and prohibiting smoking and the use of naked lights or motor vehicles (except for loading and unloading of cylinders). Designated storage areas should be used solely for the storage of gas cylinders. They should not contain any other products. Cylinders should be stored with their valves uppermost. Protective valve covers should be used when cylinders are not in service. Full cylinders should be stored separately from nominally empty cylinders, and cylinders of different gases should be segregated from each other. Storage arrangements should ensure an adequate turnaround of stock. Nominally empty cylinders should not be stored longer than necessary, and a check should be made to ensure their valves are closed. Gas cylinders should always be securely supported either on trolleys, within racks, or fixed to structural features using a welded steel chain. (Dainty, 2017)

2.1.6 Training

All personnel who are required to handle and store gas cylinders shall receive suitable information and instruction regarding the hazards associated with gas cylinders and the gases being stored, and provided with the necessary skills and knowledge to carry out their job safely. The employer has to ensure their persons have trained adequately and to establish competency. It is recommended that a training program is carried out under a formalized system where an acceptable level of competency must be achieved. Records shall be kept of the training provided, and the competency level achieved. The training program shall make provision for periodic re-training.

All persons engaged in the storage and sale of gas cylinders shall have training commensurate with their responsibilities and should include, but not be necessarily confined to the following subjects: Identification of the cylinder and its contents, Properties and hazards of gases, including pressure, cylinder and valve types, movement of cylinders, including local carriage, stock management, store management and actions to be taken in case of an emergency. (Health and Safety executive, 2012).

2.1.7 Safe handling of gas cylinders

2.1.7.1 Personal protective equipment

All personnel shall wear appropriate personal protective equipment (PPE). The minimum recommended PPE requirements for personnel engaged in the storage and handling of gas cylinders are: protective gloves, safety shoes (boots with metatarsal protection), and safety glasses.

For moving over even floors and only for short distances (<5 m) the 'churning' method may be used. The Cylinders shall not be rolled along the ground as this may damage or open the valve and will also damage identifying labels, marks, and symbols. Valve protection caps are to be fitted before moving a cylinder. When not being moved, all cylinders shall be secured. (British Compressed Gases Association, 2016)

Kaburia, (2016) concludes that, to a great extent, safety issues affect Lpg penetration in the Kenyan market. He further recommends for safety measures to be enhanced in distribution channels as this will not only help maintain good supply standards but also help achieve high levels of efficiency and effectiveness. (Kaburia, 2016)

2.1.8 Key Responsibilities for Principal Participants in Lpg Industry

The principal participants in the Lpg industry - producers, suppliers, marketers, retailers, equipment manufacturers, transporters, and installers - all have responsibilities in the area of safety. They should collaborate to ensure the efficient discharge of their responsibilities. National and local authorities should take advantage of the expertise within the Lpg industry to ensure an informed and uniform approach to good safety practices (World Lpg Association, 2015).

2.1.8.1 Lpg Producer/Supplier/Marketer

The Lpg producer/supplier/marketer may be a producer, importer, a primary marketer, or a distributor appointed by the marketer. It may be a state-owned or private-sector enterprise. Their responsibilities include all components of the distribution chain. The producer/supplier/marketer will be responsible for the quality of Lpg supplied, i.e., for conformity with a declared standard or specification, and quantity.The producer/supplier/marketer should work closely with manufacturers, suppliers, and retailers of Lpg appliances and equipment as part of a coordinated industry approach to good safety practice. (British Compressed Gases Association, 2016)

2.1.8.2 Equipment and Appliance Manufacturer/Supplier

Manufacturers of Lpg equipment and appliances usually distribute them through suppliers who may be sellers of household appliances and who may be Lpg suppliers. Where a manufacturer based in another country sells through an import agent, the agent should fully understand the required safety standards and the safety implications for the users.

Only Lpg compatible appliances should be used with Lpg. It is a key responsibility of the manufacturer/supplier to ensure that Lpg appliances are capable of safe, efficient, and convenient operation with the grade Lpg being sold in the market. (Musami, 2011)

Manufacturers/suppliers should provide clear operating and safety instructions for the user, including compatibility between burner and product (butane, propane, or mixtures). If necessary, connections should be designed to avoid the use of incompatible appliances and products. (Concordia University, 2017)

2.1.8.3 Distributor/Agent/Dealer/Retailer

The distributor/agent/dealer/retailer is a key link in the distribution chain that supplies the customer with products and services. The distribution chain may likely involve several different third party businesses that move the product from the Lpg storage depot, cylinder filling plant or bulk loading facility to the customer. The distributor/agent/retailer/dealer all have a common aim - to move the product safely and efficiently to the end-user, and assist in meeting both the needs of the marketer/supplier and the customer. (British Compressed Gases Association, 2016)

As Lpg moves further down the distribution chain from the depot to the customer, the control over safety by the marketer/supplier becomes weaker. This is the point in the distribution chain where the customer interface occurs, and safety must receive close attention. (World Lpg Association, 2015)

2.1.9 The Role of Government in Lpg Safety Enhancement

The government plays a vital role in the Lpg industry. Two essential areas of government involvement are the elimination of bad practices and providing a competitive business climate.

2.1.9.1 Elimination of Bad Practices

Within the market framework, there is a clear role for a partnership between industry and government. While the industry works to provide sustainable modern energy supply, the government should be aware of, and work to rectify, some of the more egregious practices of unscrupulous operators including: poorly designed and constructed storage areas, inadequately trained staff, allowing unauthorized premises to operate, use of unsafe cylinders, illegal filing of cylinders, unauthorised acquisition, reworking, and repainting of cylinders, underfilling / overfilling of cylinders.

Poorly constructed storage areas can result in unfair competition due to lower capital outlay by unscrupulous operators, and greater safety risk to employees, customers, and the general public. Inadequately trained staff lead to a high-risk environment, and operational errors. Operating unauthorized premises leads to inequitable competition, sub-standard equipment in service, and governments being deprived of legitimate revenue. Illegal filing of cylinders results in no control over the condition of the cylinder, no control over the quality or quantity of the product in the cylinder, and serious risk of damage or injury to those handling including the consumer. Unauthorised acquisition, reworking, and repainting of cylinders results in no control over the cylinder condition, serious risk exposure to those handling the cylinders, and loss of assets of the legitimate owner. (Lpg Regulations, 2019; OSHA, 2007; World Lpg Association, 2015; Concordia University, 2017; Health and Safety Executive, 2012; National Fire Prevention Association, 2014 and KS ISO 4706-1:2008)

2.1.9.2 Provide Competitive Business Climate

Lpg has a unique role for both developing and developed economies. In Kiambu County, the first use is frequently for cooking. Here, Lpg displaces wood, charcoal, and kerosene. For the Lpg industry to fulfill its role, it must operate within a framework of good business practices. It also must rely on the establishment and enforcement of sound governmental practices that will ensure common rules for all participants in the market are equally applied and enforced; clearly defined rights and responsibilities for all participants, offer those with investments an opportunity for financial return on those investments, and lastly, provide a redress for those aggrieved

by bad practices. (Lpg Regulations, 2019; Kenya National Bureau of Statistics, 2013; Kiambu, 2014; World Lpg Association, 2015; & Competition commission, 2017).

For private businesses to bring the benefit of Lpg to those wanting its products and services, there must be a level playing field where the rules are the same for all players. Only then will businesses take the risk of investment, provide jobs, and contribute to the economic welfare of the communities in which it operates. A business climate that favors some over others will ultimately prove a disincentive to the legitimate operators and encourage a drop in industry standards. (Competition Commission, 2017; & Petroleum Act,2019).

2.2 National and International Legal Frameworks

This section outlines the applicable International Standards and relevant Kenyan regulatory framework that set the context within which the study will operate.

2.2.1 Occupational Safety and Health Act of 2007.

The purpose of the Occupational Safety and Health Act 2007 is to provide a legal framework to promote, stimulate, and encourage high standards of safety and health in the workplace.

It is an act of Parliament to provide for the safety, health, and welfare of workers and all persons lawfully present at workplaces, to provide for the establishment of the National Council for Occupational Safety and Health and connected purposes.

The OSHA, 2007, repealed the Factories and Other Places of Work Act, Cap. 514. It has 14 parts and much more elaborate provisions for the health, safety, and welfare of workers. The Act applies to every workplace.

Safety and Health obligations for persons who may come to premises for work and are not employees of that particular workplace. They are reporting any accident, dangerous occurrence, or occupational poisoning caused in the workplace to the area of the Occupational Health and Safety Office. These incidents should be entered in General Register. In case of fatal accident information to the area, Safety and Health Office should be within 24 hrs. And a written notice to the same within 7 days; The duties of manufacturers, designers, importers and suppliers to ensure that all articles and substances for use at workplace are safe and will not cause injury to health and the environment; Duties of self-employed persons; Duties of employed persons;

prohibition of interference or misuse of any appliance, convenience or any other facility provided to secure Safety, Health and Welfare at work by any person (occupier, self-employed person or employed); The administration of the Act is the responsibility of a Director and other appointed and gazetted officials (Occupational Health and Safety Officers); The registration of all workplaces by the Director Directorate of Occupational Health and Safety (DOSHS) forming the basis of his work statistics.

The general penalty for offenses without express penalty is a fine not exceeding 300,000/- or jail term not exceeding 3 months or both fine and term. Should commitment of offense proceed after conviction, a daily fine not exceeding 10,000/- is instituted. A fine not exceeding 1,000,000/- or a jail term not exceeding 12 months instituted on the event of an accident due to the occupier having contravened provisions of the Act. A fine not exceeding 200,000/- or six months jail or both in respect of forgeries, false declaration, conniving, pretense, and lies.

Any person is deemed a worker if lawfully within the precincts of a workplace while work is ongoing.

2.2.1.1 Machinery safety

Part 7 of the Act. Machinery safety (Part 7 of the Act.) covers the following: Safe use of machinery, plant, and equipment; Prime movers and transmission machinery; The maintenance, construction of fencing safeguards; The statutory requirements of various machines, plants, and equipment (hoists and lifts, chains and ropes, cranes, steam receivers and containers, air receivers, cylinders for compressed liquefied and dissolved gases and refrigeration plants).

section 70 clearly states that:

Every cylinder for compressed, liquefied and dissolved gases, and its fittings, shall be so designed as to be suitable for the particular circumstances of their use; and of sufficient strength to sustain the internal pressures to which they will normally be subjected.

Every cylinder for compressed, liquefied and dissolved gases shall conform to a standard specification prescribed under the Standards Act or where a standard is not prescribed, a standard specification approved by the Director and the Kenya Bureau

of Standards and shall be of good construction, sound material, adequate strength and free from patent defect.

Every cylinder, when constructed or sold, shall be covered by the manufacturer's test certificate showing compliance with the safety and health standards specifications, and the certificate shall be obtainable, during the whole life of the cylinder, from the owner of the cylinder.

Every cylinder owner shall keep a cylinder maintenance register in which shall be noted, under the corresponding dates, all tests, internal and external examination, cleanings and repairs undertaken on the cylinder, and the register shall be available for inspection by occupational safety and health officer always.

It shall be the duty of a cylinder owner to ensure that all cylinders belonging to him are examined and tested, and the results of such examinations and tests are entered in the cylinder maintenance register by a person approved by the Director by certificate in writing; before being placed in service for the first time; or before being placed in service after repairs other than changing the neck ring which carried the cap, re-tapping the neck or changing the foot-ring and; at intervals not exceeding two years in the case of cylinders for corrosive gases and five years in the case of cylinders for other gases.

The test that a cylinder other than an acetylene cylinder shall undergo to comply with the provisions of subsection (5) shall comprise a hydraulic pressure test which shall exceed the maximum permissible working pressure; and an internal and external examination per the requirements of the standard specifications.

The following shall be clearly and boldly marked on every cylinder: owner's name; registered number as shown in maintenance register; a clear indication of the gas to be charged; date of type of test undertaken; country and year of manufacture; permissible maximum charging pressure; and standard specification used.

Every cylinder for compressed, liquefied and dissolved gases shall be marked for identification of their contents in color conforming to a standard specification of cylinder color markings.

Markings required shall not be: cut into the metal of the cylinder unless special reinforcement has been provided for that purpose; or placed on the cap.

Every cylinder for liquefied gases shall be clearly and boldly marked with the maximum permissible weight of the charge of gas for which the cylinder is designed; the compressed gases shall be clearly and boldly marked with the maximum permissible weight of the charge of gas for which the cylinder is designed, and the compressed gases shall be clearly and boldly marked with the cubic capacity.

Before being charged, every cylinder shall be carefully examined at the charging station to ensure that it complies with the provisions of this section; and except in the case of acetylene, be completely emptied.

Every cylinder for liquefied gases with a critical temperature exceeding the usual ambient temperature shall not be filled to prevent the generation of dangerous pressure when used at temperatures exceeding this critical temperature and, cylinders for liquefied gases shall be weighted during charging.

2.2.1.2 Chemical safety

Part 9 of the Act. Included under this section is Handling, transportation, and disposal of chemicals and other hazardous substances; Importance of Materials Safety Data Sheets (MSDS); Labelling and marking of chemical substances; Classification of hazardous chemicals and substances; Establishment and adoption of exposure limits on hazardous substances in a workplace; Control of air pollution, noise, and vibrations; Redeployment on medical advice.

2.2.1.3 Safety— General provisions

Part 8 of the act. Included under this section is: vessels containing dangerous liquids; storage of goods, articles, and substances; ladders; ergonomics at the workplace; safe means of access and safe place of employment; fire prevention; precautions in places where dangerous fumes are likely; precautions concerning explosive or inflammable dust or gas; safety precautions in case of fire and evacuation procedures.

2.2.2 The Energy Act (No 1. Of 2019).: Kenya Gazette Supplement No. 29 (Acts No.1)

The Energy Act, 2019 was assented on 12th March 2019, and came into effect on 28 March 2019, repealing the Energy Act, 2006. The Energy Act, 2019, consolidates the laws relating to energy to provide for National and County Government functions; promote renewable energy; promote exploration, recovery, and commercial utilization

of geothermal energy; regulate midstream and downstream petroleum and coal activities, among others. It establishes the Energy and Petroleum Regulatory Authority in place of the Energy Regulatory Commission. It covers the following: Energy policy and integrated energy plan, national energy entities, renewable energy, downstream coal, electrical energy, rights of way, wayleaves, and use of land for energy resources and infrastructure, energy efficiency and conservation, miscellaneous provisions, repeals, savings, and transitional provisions.

2.2.3 Kenya Standards KS 1938-3:2006

The standard is concerned with the code of practice for handling, storage, and distribution of liquefied petroleum gas in domestic, commercial and industrial installations. Part 1 of the standard; Liquefied petroleum gas installations involves gas storage containers of individual capacity not exceeding 500L and a combined water capacity not exceeding 3000L per installation, Part 2 of the standard: Transportation of Lpg in bulk by road, Part 3 of the Standard: Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500L and Part 4 of the Standard concerns the storage and filling sites for re-fillable liquefied petroleum gas (Lpg) containers not exceeding 15 kg.

2.2.4 The Factories and Other Places of Work (Hazardous Substances Rules, 2007)

These Rules shall apply to Every factory, premises, places, process, operation, or work to which the provisions of the Factories and Other Places of Work Act apply and to every employer, occupier or owner, agent, self-employed person or employee. The purpose of the rules is to minimize exposure of persons at the workplace to hazardous or potentially hazardous substances, set exposure standards and minimize the performance of work in hazardous conditions or circumstances

A hazardous substance is defined as any chemical, waste, gas, medicine, drug, plant, animal, or microorganism, which is likely to be injurious to human health or the environment.

Butane and propane are among the hazardous substances mentioned in this legislation. The legislation talks of shared responsibilities by employers, exposure limits, a

amendment of schedules, control measures, personal protective equipment, maintenance and testing of engineering controls, material safety data sheets, disposal of hazardous substances, labeling of containers, training, and information, air monitoring and measurement, duties of competent persons, guidelines on hazardous substances, medical examinations, offenses, and penalties.

2.2.5 The Factories and Other Places of Work (Fire Risk Reduction Rules, 2007)

Key legislation concerning this research. The rules define the different types of fires, i.e., classes A, B, C, and D. Class B fire, which is of importance to this study, is defined as a fire involving flammable or combustible liquids, flammable gases, greases, rubber or plastic material.

The rules further expound on location of installations for highly flammable substances, construction materials, storage of highly flammable substances, marking and labeling, handling of flammable substances, flammable vapors, monitoring of flammable substances, ventilation, hot processes/operations, housekeeping, removal of products and wastes, machinery layout, electrical equipment, fire escape exits, control of spread of smoke, means of evacuation, formation of firefighting teams, training in fire safety, fire drills, assembly points, first aid, means of communication, notices, fire detection systems, firefighting appliances, maintenance testing and inspection of cylinders, selection and distribution of fire extinguishers, fire safety policy, notification of fire occurrence, fire safety audits, duties of fire safety auditors and offenses

2.2.6 KS ISO 4706-1: 2008 Gas Cylinders -Refillable welded steel gas cylinders - Part 1: Test pressure 60 bar and below

The standard gives minimum requirements for certain aspects concerning materials, design, construction, and quality, procedure, and test at the manufacture of refillable welded gas cylinders of a test pressure not greater than 60 bar (1 bar = 100000 Pa) exposed to extreme temperatures (-50^0C to $+65^0$C). It was published in the Kenya Gazette notice No. 8480 of 14th December 2001.

The standard facilitates agreement on the design and manufacture of welded-steel gas cylinders across the country. The requirements are based on knowledge of and experience with materials, design requirements, manufacturing processes, and controls in common use for the manufacture of gas cylinders. It defines various Symbols and terms in Lpg cylinder manufacturing; specifies the material properties in fabrication of gas cylinders, design requirements, construction and quality (quality conformance system, welding qualifications, plates and pressed parts, welded joints, tolerances, non-pressure containing attachments, valve protection, closure of openings, heat treatment), Testing and the acceptance criteria

2.2.7 The Petroleum Act (No 2. Of 2019). The Petroleum (Liquefied Petroleum Gas) Regulations, 2019: Legal Notice No. 100

Liquefied gas regulations, 2019 covers the following: application of the regulations, license application, form and duration of license, license renewal, importation of bulk Lpg, storage of bulk Lpg, acquisition of new cylinders and valves, filling of Lpg, prohibition against unauthorized refilling, damage to cylinders, transport of bulk Lpg, transport of cylinders, wholesale of Lpg in cylinders, retail of Lpg in cylinders, reticulation of Lpg, reporting of accidents, Investigation of accidents, penalties and fines, requirements for application of a new license, application for renewal of a license, Lpg license forms, applicable license fees, offenses, penalties and fines, minimum safety information on Lpg cylinder refill and transitional clauses.

2.3 Previous works relevant to the study

The first case study was carried out on fire and explosion of liquefied petroleum gas tanks at Feyzin, France. The accident brought about an enormous disaster resulting from a small human error. The details of the accident show well the dangers of handling Lpg. (Mitsuo Kobayashi, 2010). Three operators opened two 2 inch valves, which were mounted in series at the bottom of a 1200m^3 propane spherical tank. Due to some problems, the valves did not close, and Lpg escaped. Because Lpg is heavier than air, it spread along the ground as a cloud of vapor to the highway at a distance of 60m and the local road parallel to the highway. The escaped Lpg caught fire by a car passing through the local road and exploded. The fire reached the tank from which the Lpg first leaked, the tank fire caused explosive destruction of the tank vapor phase.

The fire spread to five other Lpg tanks in the same tank yard and damaged other materials that were near. Eighteen persons died, and dozens of persons were injured. These dangerous characteristics of Lpg are the same for general consumption as for industrial use.

The second case report was carried out on a fatal Lpg cylinder blast accident. (Tabin Millo, Fatal LPG cylinder accident, 2014) Accidental explosions in the home are not uncommon, which may be associated with gas leaks. Despite safety guidelines, accidents occur, which are fatal. The injuries in these two cases were mainly of primary impact due to the blast waves caused by the Lpg cylinder blast. The scene showed blood splattered over the wall and the roof and the cylinder standing below with open knob. This suggests that both the victims must have been standing close to the cylinder, one of them handling the cylinder. The bloodstain in the roof suggests the upward direction of the blast wave. The cylinder had a defective valve in the knob, which caused the leak and the subsequent explosion. Liquefied petroleum gas cylinder is one of the common causes of domestic blast accidents. It is, therefore, important to educate the public about the safety precautions in handling the Lpg cylinders and enforce strict guidelines for standards and precautions to be followed by the retailers.

The third study was carried out by Kaburia (2016) on the challenges of liquid petroleum gas penetration in Kenya. In his findings, safety issues had a positive influence on Lpg penetration in the Kenyan Market. The findings were also in line with a study by Akuffo et al., 2008, which indicated that safety problems and associated perceptions are likely barriers to the use of Lpg. The study further concludes that respondents agreed to a great extent (56%) that safety issues affected Lpg penetration in the Kenyan market, 29% agreed to a great extent, 13% agreed to a moderate extent while 2% agreed to a little extent that safety issues affected Lpg penetration in the Kenyan market. This is in agreement with this research that safety awareness to all participants in the Lpg cylinder industry is paramount. Kaburia recommended that appropriate safety measures to be put in place in the various Lpg distribution channels to a great extent as this will not only help maintain good supply standards but also will help achieve high levels of efficiency and effectiveness. This is also in agreement with this research that Lpg cylinder retailers should put in place

appropriate safety measures in their workplaces. To achieve this, awareness of the subject is key. In line with this study, awareness of Lpg retailers on various occupational safety and health issues has assessed and explicitly discussed herein.

The fourth study was carried out in Turkey by (Kapi et al. 2017) on an unusual etiology in cold injury: liquefied petroleum gas. The study presented cases of four patients with cold injuries in the face and upper extremity caused by a pressurized jet stream of liquid gas that escaped out of the valves of the Lpg cylinders. Four male patients presented to the clinic with cold injuries due to direct contact with Lpg. The mean age of the patients was 32.4 years. The patients reportedly attempted to apply pressure on the valve of the Lpg cylinder with their hands to stop the leakage but could not prevent the contact of the jet stream of the gas with the upper extremities and the face, which led to tissue damage. When the patients were questioned about Lpg and its effects, they did not have any knowledge of the possibility of developing a cold injury due to contact with Lpg. This agrees with this study, as 99.3% of the respondents were not aware that Lpg could cause cold burns when it comes into contact with the skin.

No studies investigating the correlation between gender and Lpg related cold injury have been found. However, a predominant of male gender among patients has been observed. Thus, males can be at an increased risk compared with females. The intense damage despite the short exposure time of Lpg is related to the skin contact of the cold liquid gas, which is compressed under high pressure in the cylinder and leaks out with a high acceleration from the cylinder valve. The damage occurs due to the loss of heat from the skin and the underlying tissues within a few seconds as the Lpg is transformed from the liquid form into the volatile gas form without combustion. This rapid transformation shows its effect quickly and causes tissue damage in a short period extending into deep tissue. Therefore, a cold injury could be more severe than other injuries caused due to flame burns.

The sixth case report was carried out in India, Gauhati medical college, and hospital (Raktim Tamuli et al., 2017). Per the inquest report and history given by eyewitnesses and relatives, the incident occurred due to the bursting of an Lpg cylinder while he was working in a local factory. On autopsy, the researchers found carbon particles

over wearing garments and body surfaces with multiple abraded contusions present over the face, neck, and front of the chest and abdomen. A laceration of 10cm x 8cm brain deep was present over the right frontal area of the head with partially missing skull bone fragments and brain tissue along with a punctured laceration of size 0.5 cm x 0.5cm bone-deep which was present over the chin. Laceration of size 12cm x 8cm, muscle deep was also noticed over the front of the chest and abdomen in the midline. The researchers opined that death was due to a coma following a head injury caused by blunt force impact in the blast incident. Abrasions, lacerations, bruises, fractures, penetrating injuries, where the skin is less mobile are the injuries encountered commonly in a blast case.

Awareness of occupational safety and health issues in the gas retail industry is thus important as it makes the retailers pro-active in assessing the possibility of injury/harm in the workplace and adhering to mitigation measures to curb the possibility of causing harm/injury.

CHAPTER THREE

MATERIALS AND METHODS

This chapter outlines and describes the methodology that was adopted for the study. Data was collected from a targeted population, organized, collated, analyzed, interpreted, and presented.

3.1 Study design

The study utilized descriptive and diagnostic research designs. Descriptive research is suitable when one studies things as they are in the field without manipulating variables and gives views and feelings from the respondents (Babbie, 2002.). Descriptive research studies are concerned with describing the characteristics of a particular individual or group, whereas diagnostic research studies determine the frequency with which something occurs or its association with something else. (Kothari, 2004). In descriptive and diagnostic designs, the researcher must define clearly, what he wants to measure and must find adequate methods for measuring it. (Kothari, 2014).

The study designs were employed in the interest of the researcher's aim of providing a picture of the situation on the ground as it naturally happened, viz. liquefied petroleum-gas cylinder retail business, and diagnostic documentation after undertaking the cylinder non-destructive tests and weight measurements.

3.2 Study area and population

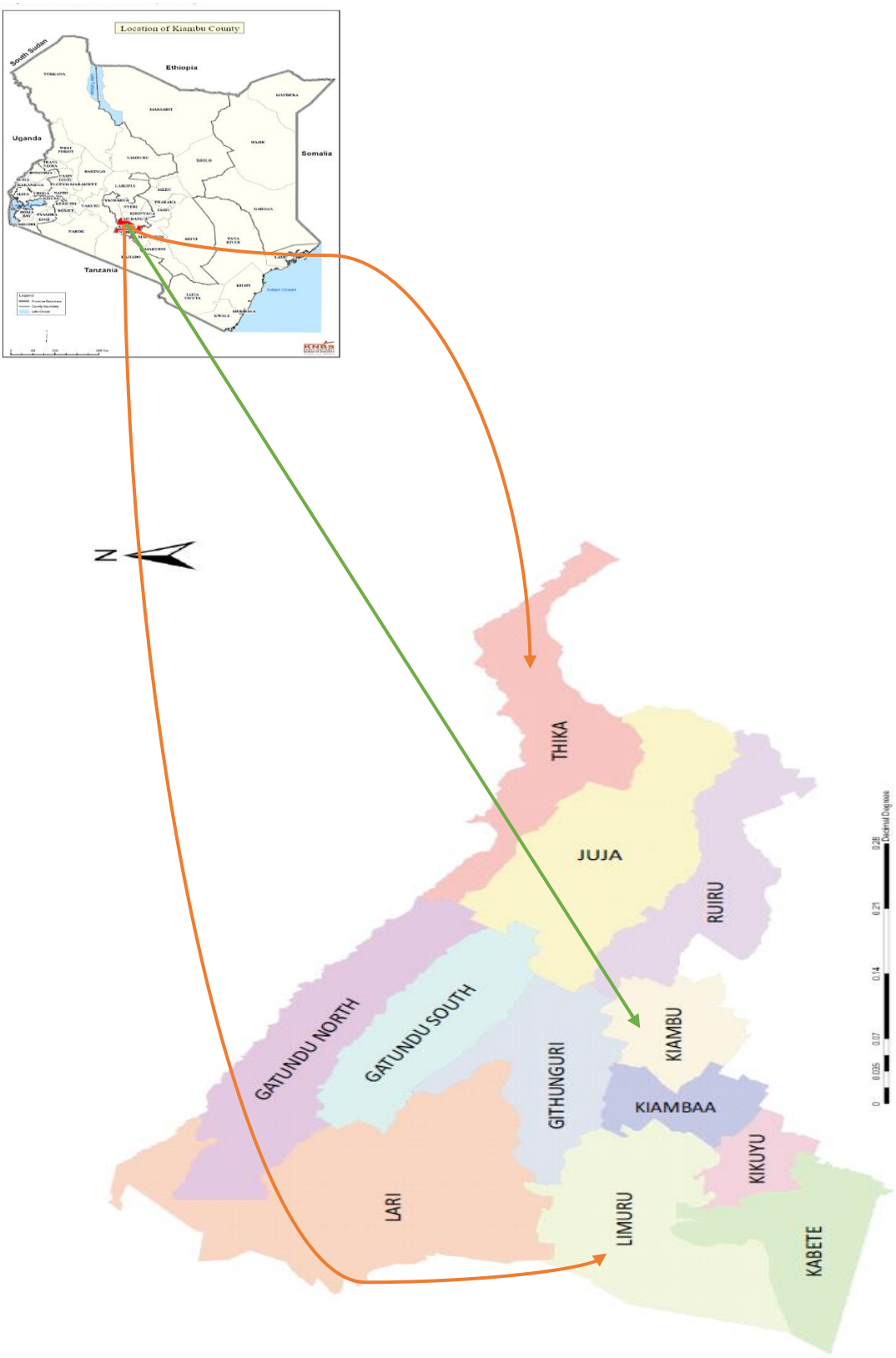
The study area was Kiambu County, which is one of the 47 counties in the Republic of Kenya. It is located in the central region and covers a total area of 2,543.5 Km^2 with 476.3 Km^2 under forest cover and a total population of 2,417,735 according to the 2019 Kenya Population and Housing Census. Kiambu County borders Nairobi and Kajiado Counties to the South, Machakos to the East, Murang'a to the North and North

East, Nyandarua to the North West, and Nakuru to the West (County Government of Kiambu, 2015).

The county has several urban centers, with the largest being Thika Town, which is one of the largest industrial towns in the country. Other urban centers include Kiambu in Kiambu Sub-county, Karuri in Kiambaa sub-county, Kikuyu in Kikuyu sub-county, Juja in Juja Sub County, Limuru in Limuru Sub County, Gatundu in Gatundu South sub-county and Ruiru in Ruiru Sub County. (Kiambu County annual development plan, 2017; County Integrated Development Plan, 2018).

The overall population comprised of 968 Lpg cylinder retailers in Kiambu County. The population of the selected study sites comprised of 400 Lpg cylinder retailers undertaking the Lpg cylinder retail business (CGK Trade Office, 2018). The study sites were arrived at after taking into consideration the budget, time, personnel, and other resource limitations.

Map 3.1: Map showing Kiambu County in Kenya and the study sites



Population figure: 400 (Kiambu C. G., 2014)

3.3 Sampling method

Data were sampled from Lpg cylinder retailers in the county during the data collection period. Stratified purposive sampling was employed.

Stratified purposive sampling focuses on characteristics of particular subgroups of interest, which in turn, cost-effective and time effectively enables the researcher to answer the research questions. The sampling method is also considered more appropriate when a known characteristic is to be studied intensively (Kothari & Garg, 2014; Patton, 2002.).

According to Oliver Paul, (2013) "It is a form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher, based upon a variety of criteria which may include specialist knowledge of the research issue, professional judgment, or capacity and willingness to participate in the research."

In line with Kothari (2004), the overall population was first divided into subgroups/strata that were individually more homogenous than the overall population. The strata classification in this study was under urban centers in the region (Refer to subsection 3.2). Flowing from the above, purposive sampling was then put to use in selecting the study sites from the already established strata. For this study: Thika, Limuru, and Kiambu towns were purposively selected from the population strata, being among the biggest towns in the region.

A known characteristic about the selected study sites is that they are among the highly urbanized regions in Kiambu County (Kiambu County Government's Annual Development Plan, 2018-2019) and therefore a likely indication that most people living within these regions use Lpg as a source of energy for cooking; creating demand for the commodity, and therefore attracting a great deal of Lpg cylinder retailers.

The demand for Lpg in the select study sites has also been witnessed first-hand. It is worth noting that the high population in the select urban centers can be attributed to the proximity of the county to Nairobi as most of the people work in Nairobi and reside in Kiambu County. Besides, industrial development in towns like Thika attracts more labor force. (County Integrated Development Plan, 2018.)

3.4 Sample size determination

The sample of the Lpg cylinder retailers for the study was a well-rounded representation selected from all over the study sites. The sample size was determined by the use of the sample size determination table (Bartlett et al., 2001) attached herewith in appendix 1.

With the data being categorical, a selected margin of error of 0.05, a standard variate value of 1.96 at 95% confidence level and a recommended population proportion of 0.50; then the sample size determination table (appendix 1) gives us the sample size to use for the given population of 200 retailers in Thika town, 100 retailers in Kiambu town and 100 retailers in Limuru town to be 132, 80 and 80 respectively (Table 3.1).

3.4.1 Sample size distribution

The selected sample size was from the population of strata already selected during the sampling period. The sample size distribution is shown in table 3.1 below

Table 3.1 Sample size distribution

Strata	**Population**	**Sample Size**
Thika town	200	132
Kiambu town	100	80
Limuru town	100	80
Total	**400**	**292**

3.5 Research instruments

The measurement tools designed to obtain data from the research subjects were observation (non-participant) by use of a checklist and interview schedules. The checklist and interview schedule are attached herewith in the appendices section. Weight measurements and non-destructive tests were also undertaken on sampled Lpg cylinders. A few activities were captured on camera as evidence observed on a real-time basis as the Lpg cylinder retail business was being undertaken.

3.5.1 Interview Schedule

An interview schedule was prepared and self-administered to the Lpg cylinder business owners -the sole proprietors-. The design of the interview schedule was in two main Sections. Section A consisted of the general information covering areas like Age, gender, education level, Lpg retail experience, and whether EPRA licensed the business.

Section B consisted of three subsections covering the three specific objectives:

Sub-section I aimed at obtaining information from respondents on the level of awareness on occupational safety and health issues in the Lpg cylinder retail business. The section was tailored to answer the first specific objective.

Sub-section II aimed at gathering information on the current OSH practices put in place by the Lpg cylinder retailers. Non-participant observation was employed at this stage and aided the researcher in making informed conclusions. The section was tailored to answer the second specific objective.

Sub-section III was an open-ended question to the respondents and aimed at getting to know the respondents' challenges to the implementation of good occupational safety and health practices in the Lpg cylinder retail business. The section was tailored to answer the third specific objective

3.5.2 Checklist

The observation checklist was developed to supplement the interview schedule. Again, the non-participant observation was employed. The target of the checklist was to check the current practices hence compliance on safety matters concerning provisions of the international and local legal framework in the Lpg retail industry.

3.5.3 Measurements and Non-destructive tests (Leak Test)

Weight measurements and non-destructive tests were also undertaken on sampled Lpg cylinders. In line with the consumer protection act of 2012, and the occupational safety and health act of 2007, Lpg cylinder weight measurements and non-destructive testing

are key practices, as far as safety and the protection of the consumer in the Lpg cylinder retail industry is concerned.

A total of 54 assorted Lpg cylinders sampled from Juja and Thika towns were assessed (30- 6Kg cylinders and 24- 13Kg cylinders). The methodology employed in data collection during this exercise is as per the procedure described below.

3.5.3.1 Leak Test and Measurements Procedure

The test allows for tell-tale gas leak soap bubbles that are indicative of a gas leak.
To make the solution for the gas leak test, the detergent is mixed with water. Dishwashing soap is formulated to make lots of bubbles, so it works better for the soap test for gas leak test.

Apparatus / Equipment

1. Water
2. Dish detergent
3. 2-liter spray bottle
4. 5 No. Kitchen towels
5. 6 & 13Kg Lpg cylinders
6. Weighing balance (that can measure up to 50 Kg)

Procedure

It was ensured that the valve of the cylinder was closed. Thereon, the dish detergent was poured into the spray bottle with water (ratio 1:3). By using the spray bottle, the soapy water solution was applied/sprayed to the entire cylinder assembly, including the cylinder valve. The entire cylinder was then thoroughly inspected. Where there was a leak, bubbles could be seen forming at that exit point, and a smell resembling that of rotten eggs smelled out. The results of the inspection and other comments were then recorded in a form. Thereupon, the cylinder was rinsed with clean water and wiped dry using a kitchen towel. After that, the tare weight and the recommended gross weight marked on the cylinder neck were then recorded. Subsequently, the actual gross weight of the cylinder was measured using a weighing balance and recorded.

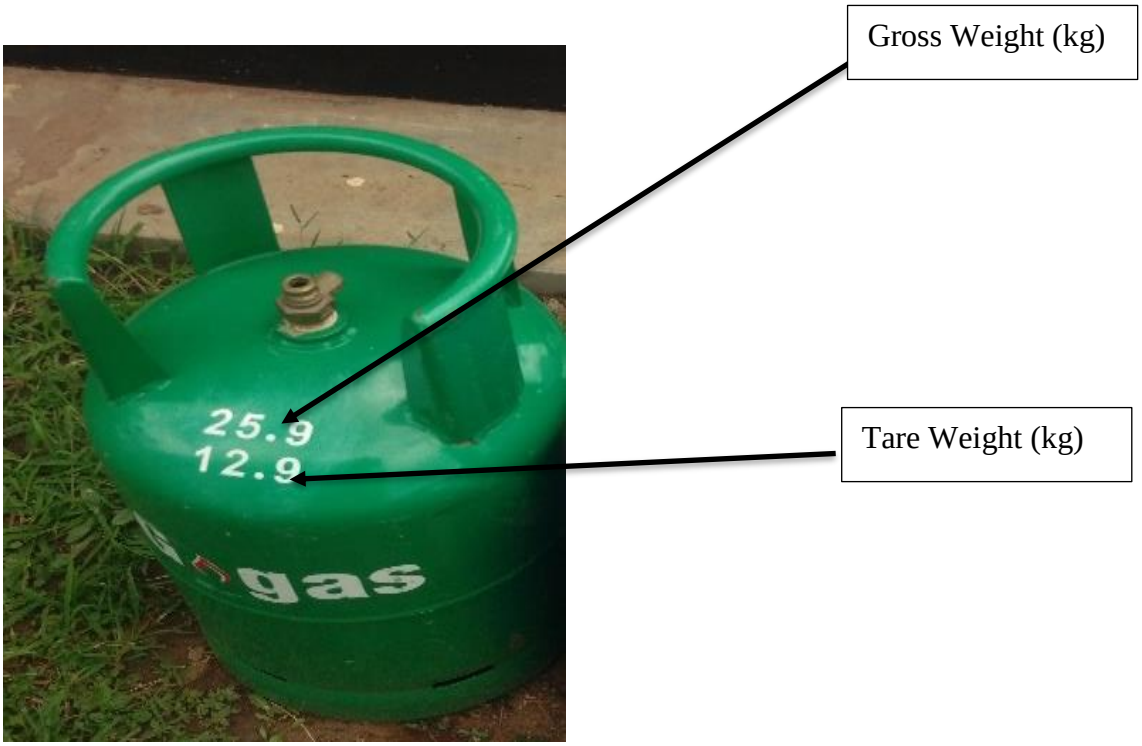


Plate 1: Illustrating cylinder Gross and Tare weight location

Calculations

i. **Lpg weight (Kg)** = [Measured gross cylinder weight – Tare cylinder Weight] Kg

ii. **Lpg cylinder under/overfilling** = [Recommended Lpg Weight – Value in i above] Kg

From the literature reviewed, fill tolerances may be adopted for cylinder fill quantity where permitted by local regulations. A fill tolerance of +/-0.2kg was adopted for this research. (Lpg cylinder filling, 2017)

Leak detection using a soap solution applied manually using a brush or spray to valves and the bung connection, can also be used in Lpg cylinder filling plants operating with small throughputs (Lpg cylinder filling, 2017 & Lpg cylinder Management, 2013).

3.6 Pilot testing

A pre-test was carried out in Kenyatta Road, to measure the validity and reliability of the research instruments. The pilot study targeted a sample size of 5 respondents in which all of them responded to the interview schedules .

3.7 Data processing and analysis

The raw data obtained from the field was coded, classified for ease of identification, checked for errors and omissions, and then summarised for ease in interpretation. The data collected from the field was analyzed using the Statistical Package for Social Sciences (SPSS version 25) software and excel (version 2019). Statistically, the weighted mean was used in answering the research questions.

The response options in the interview schedule were weighted as follows:

Response Options	Point(s)
Don’t Know	1
Disagree	2
Neutral (Neither Agree nor Disagree)	3
Agree	4

The response options in the checklist were weighted as follows:

Response Options	Point (s)
Disagree	1
Agree	2

The results of data analysis were organized and presented in the form of pie charts, bar graphs, tables, among others. A thorough discussion of the results was done and a

report of the research findings and, finally, recommendations drawn from the analysis of the findings made.

3.8 Ethical consideration

All respondents in this study had detailed information about the purpose, aim, and objectives of the study through the interview schedule. The purpose of this was to ensure that all respondents participating were aware and willing to be involved in the study. Copies of the proposal were presented to the IEET Department, JKUAT, for approval and submission to the BPS, JKUAT. Permission to carry out the study was sought from JKUAT and Lpg retailers in the study sites. The confidentiality of the respondents was protected in that no names or personal information as required in the interview schedules/checklists, and measures were taken to ensure no coercion or undue influence was exercised. This ensured that the respondents gave fair responses.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the study. It includes the response rate, demographic characteristics of respondents, and findings on the three research objectives.

4.2 Response rate

The study targeted a sample size of 292 respondents in which the response rate was 100%. This is not a surprising finding as to the method employed in data collection, interview schedules, typically has a high response rate, though expensive and time-consuming (Rubin & Babbie, 2012).

4.2 Demographic characteristics of respondents

4.2.1 Gender distribution of respondents

The gender distribution of respondents was assessed, and results tabulated below.

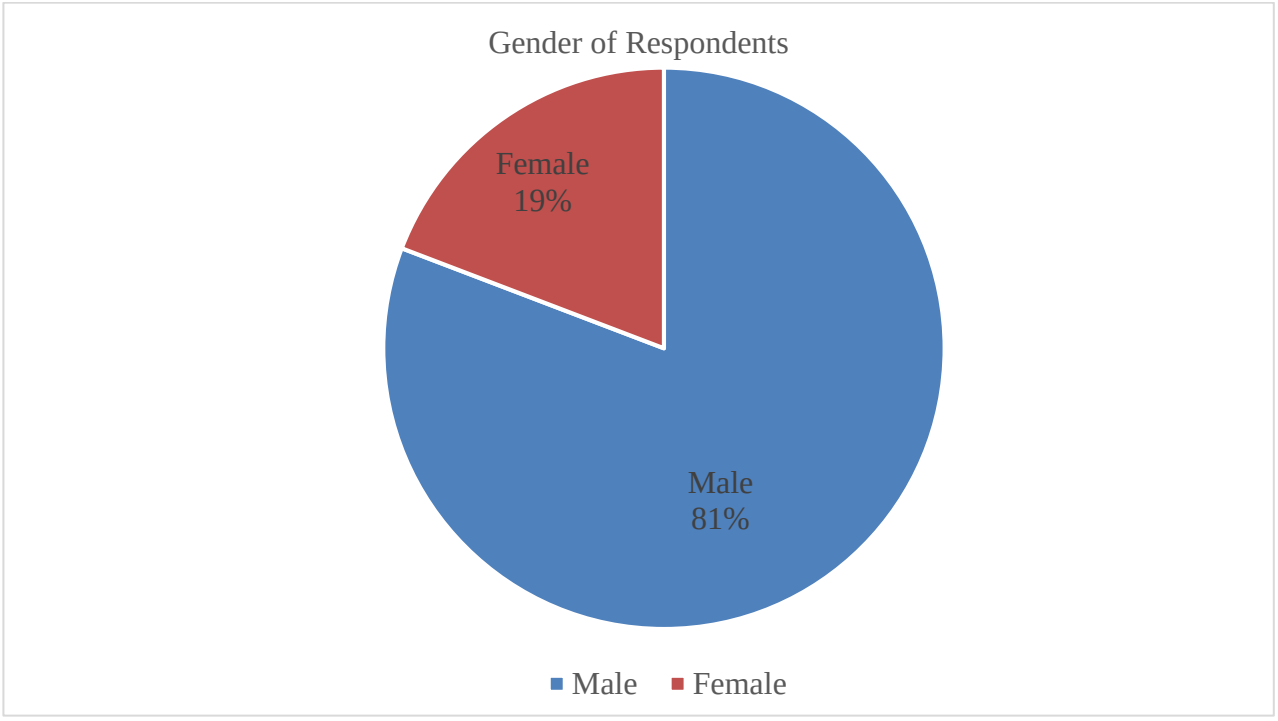


Figure 4.1 Gender distribution of respondents

Referring to figure 4.1, a large proportion of the respondents, 80.8%, were male, whereas the remaining 19.2% were female. For this reason, it is deduced that the Lpg cylinder retail business in Kiambu County is male-dominated. This agrees with OSH (2007) that more men than women work in jobs that expose them to high risks.

4.2.2 Age distribution of respondents

Figure 4.2 below shows the distribution of respondents by their age.

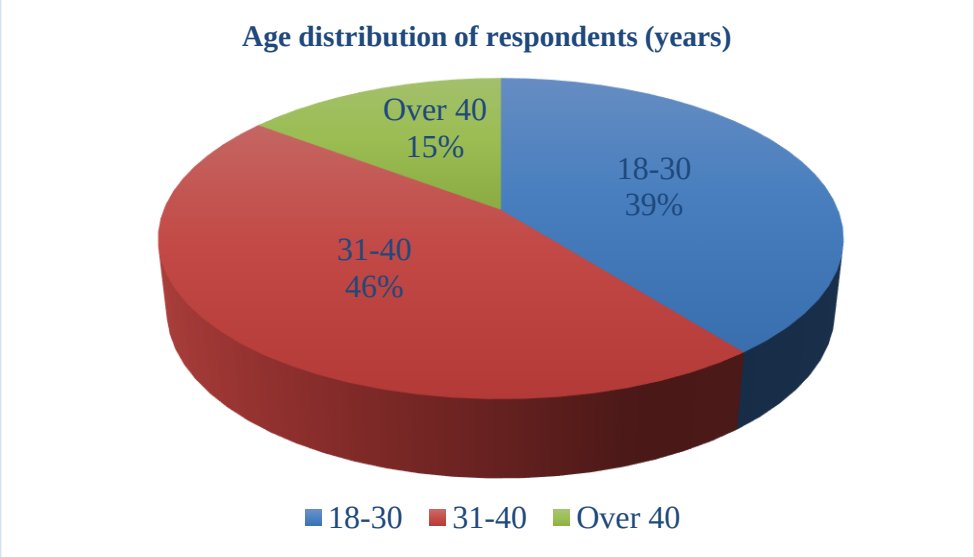


Figure 4.2 Age distribution of respondents

Findings from the study show that the majority of the respondents (46%) were aged between 31 and 40 years. 39% of the respondents were aged between 18 and 30 years. The least represented were respondents aged above 40 years who only made up 15%. The age of the respondents shows that in general, most of the gas cylinder retailers in Kiambu County fall within 18 to 40 years' age bracket. They are still young and energetic. According to Owen (2011), the age of the respondents has a significant influence on responses given in descriptive studies.

4.2.3 Education levels distribution of respondents

The academic achievement of respondents was assessed. Results are shown below

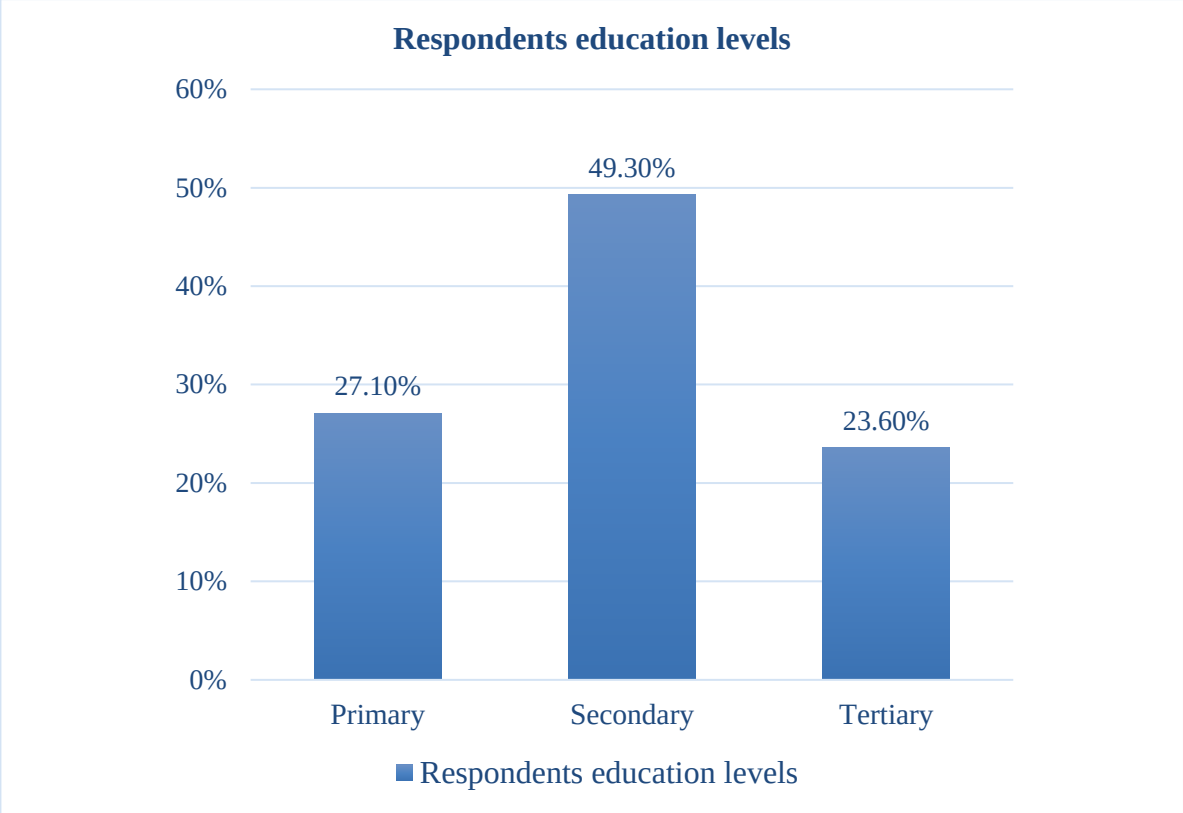


Figure 4.3 Education levels distribution of respondents

Findings in figure 4.3 show that 27.1% of the respondents had attained primary education. The majority of the respondents, 49.3%, had attained up to secondary education, while 23.6% had attained up to tertiary education. However, an interaction with the respondents revealed that reading, writing and understanding English was a major problem.

This variation in education level ensured varied responses, which richly contributed to getting very valuable information for the study. (Schultz et al., 2006).

4.2.4 Distribution of respondents by Lpg retailing experience

Findings in Figure 4.4 shows the Lpg retailing experience of respondents in this study.

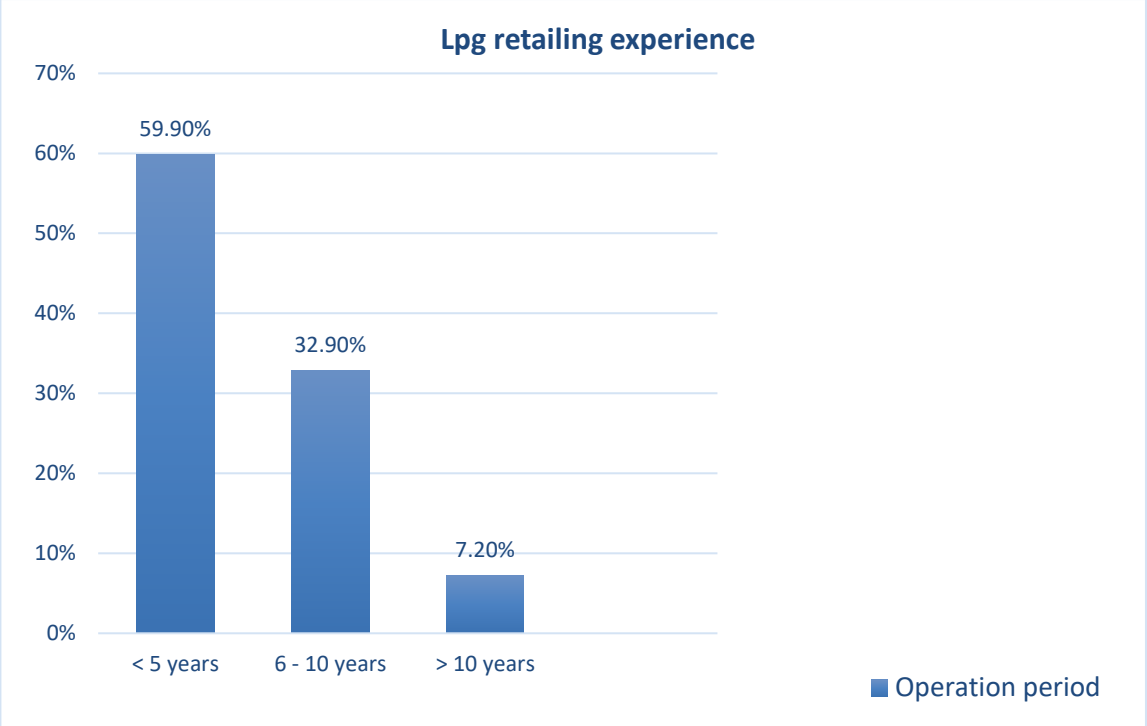


Figure 4.4 Respondents Lpg retailing experience

The study shows that the majority of the respondents (59.9%), had an experience of between 1 and 5 years in the Lpg cylinder retail business. A good number (32.9%) had the experience of between 6 and 10 years. Only 7.2% of the respondents had over ten years' experience in the Lpg cylinder retail business. Lpg cylinder retail is a booming business, and that is why there's plenty of entrants in the past five years. More and more people in Kiambu County are increasingly going for greener and cleaner energy.

Notwithstanding, under the management of health and safety at work Regulations (1999), an employer has the responsibility of ensuring that young and new people employed by them are not exposed to risk due to lack of experience or been unaware of exiting or potential risk and or lack of maturity.

4.3 Level of awareness on occupational safety and health issues

The first specific objective of this study was to assess the respondents' level of awareness of occupational safety and health issues in the Lpg cylinder retail business. Respondents were presented with a predetermined set of questions administered by the researcher from an already prepared interview schedule, and their answers recorded. The findings are analyzed, presented, and discussed in this section.

Table 4.1 Respondents' awareness of occupational safety and health issues.

	Agree (4)	Neutral (3)	Disagree (2)	Don't know (1)	Mean	Standard deviation
I always wear safety shoes at my workplace.	22.3%	-	77.7%	-	2.45	0.833
I always wear safety gloves when handling gas cylinders at my workplace.	18.5%	-	81.5%	-	2.37	0.778
I always wear safety glasses when handling gas cylinders at my workplace.	-	-	99.7%	0.3%	2.00	0.059
I'm aware that safety signs and warning notices should be clearly shown in my workplace.	40.4%	-	43.2%	16.4%	2.64	1.171
A First aid kit is available at my workplace	23.6%	-	76.4%	-	2.47	0.851
There is a fire extinguisher at my workplace.	29.8%	-	69.9%	0.3%	2.59	0.920
I have a health and safety (HSE) policy at my workplace.	8.6%	-	59.6%	31.8%	1.85	0.801
I have been trained on handling gas cylinders.	11.3%	-	88.0%	0.7%	2.22	0.642
I have been trained on fire safety	15.4%	-	81.2%	3.4%	2.27	0.760
There is a Fire safety management Plan at my workplace.	8.6%	-	67.8%	25.7%	1.85	0.720

I know how to use a fire extinguisher	32.2%	-	67.8%	-	2.64	0.936
I have undergone first aid training	26.0%	-	73.3%	0.7%	2.51	0.887
Cylinders should not be transported upright and in a secure position	45.9%	-	38.7%	15.4%	2.32	1.384
I'm aware that gas cylinders can explode when exposed to high temperatures	61.0%	-	16.4%	22.6%	2.99	1.298
Liquefied petroleum gas can cause cold burns when it comes into contact with skin	0.7%	-	72.6%	26.7%	1.75	0.481
In case of a gas leak, switching on lights can cause an explosion/fire	11.6%	4.8%	43.8%	39.7%	1.88	0.949
All injuries and accidents however minor should be reported and recorded	10.6%	-	65.4%	24%	1.97	0.816

Safety awareness implies a state of mind where a person is constantly assessing the possibility of injury or harm, acting to curb the possibility of causing such injury/harm to oneself or other people.

4.3.1 Respondents' awareness of personal protective equipment

From table 4.1 above, 77.7% of the respondents agreed to not wearing safety shoes at their respective workplaces. 81.5% admitted to not wearing safety gloves when handling gas cylinders. 99.7% admitted that they don't wear safety glasses when handling gas cylinders. From the literature reviewed, it is a requirement that all personnel should wear the minimum required personal protective equipment, i.e., protective gloves, safety shoes, and safety glasses.

Personal protective equipment protects the user against health or safety risks at work. Even where engineering controls and safe systems of work have been applied, some hazards in the Lpg cylinder retail industry might remain. This includes injuries to the hands, especially fingers, feet, the eyes, the skin, and the body. It is also important to

make the retailers aware as to why personal protective equipment is needed when to use or replace. The awareness campaign should be spearheaded by the energy and petroleum regulatory authority together with the county government.

4.3.1.1 Association between awareness of personal protective equipment and respondents' demographics

Table 4.2: Association between respondents' demographics and awareness of safety shoes.

Variable	Category	Always wear safety shoes at workplace		
		No	Yes	Chi-Square
Gender	Male	76%	24%	X^2=2.546 , df=1 , p=.111
	Female	86%	14%	
Age	18-30 years	74%	26%	X^2=1.650, df=2, p=.438
	31-40 years	80%	20%	
	> 40 years	81%	19%	
Education level	primary	96%	4%	X^2=31.556 , df=2 , p=<.001
	Secondary	65%	35%	
	Tertiary	84%	16%	
Lpg retailing experience				X^2= 27.656, df=2 , p=<.001
	< 5 years	82%	18%	
	6-10 years	69%	31%	
	> 10 years	43%	57%	

With regard to gender, safety shoe awareness was sort, and the results indicated that female respondents (86%) were less aware of safety shoes as compared to male respondents (76%). This association of awareness on safety shoes and gender of the respondents was not statistically significant at 95% confidence level with χ^2 (df=1) =2.456 since p=.111 was more than the conventional 5% level of significance. Older respondents (>40 years) were less aware of safety shoes at 81%, followed by respondents within 31-40 years age bracket at 80%, and finally respondents within 18-30 years age bracket at 74%. This association of awareness on safety shoes and the age of the respondents was not statistically significant at a 95% confidence level with

χ^2 (df=2) =1.650 since p=.438. Most of the respondents that had only attained up to primary education were less aware of safety shoes (96%). The association of awareness on safety shoes and education level was statistically significant at a 95% confidence level with χ^2 (df=2) =31.556 since p= <.001. Respondents with less than five years' experience were less aware of safety shoes at 82%, followed by respondents with 6-10 years' experience at 69%, and lastly, respondents with over ten years' experience at 43%. The more the years of experience in the Lpg cylinder retail business, the more aware the respondents are on matters about safety shoes. This association of awareness of safety shoes and operation period/experience was statistically significant at a 95% confidence level with χ^2 (df=2) =27.656, since p= <.001.

Table 4.3: Association between respondents' demographics and awareness of safety gloves.

Variable	Category	Always wear safety gloves at the workplace		
		No	Yes	Chi-Square
Gender	Male	78%	22%	X^2=7.932 , df=1 , p=.005
	Female	95%	5%	
Age	18-30 years	77%	23%	
	31-40 years	92%	8%	X^2=21.291 , df=2, p <.001
	> 40 years	63%	37%	
Education level	primary	83%	17%	
	Secondary	84%	16%	X^2=3.464 , df=2 , p=.177
	Tertiary	74%	26%	
Lpg retailing experience	< 5 years	85%	15%	
	6-10 years	76%	24%	X^2=2.997 , df=2 , p=.223
	> 10 years	81%	19%	

Touching on gender, safety gloves awareness was sort, and the results indicated that female respondents (95%) were less aware of safety gloves as compared to male

respondents (78%). This association of awareness on safety gloves and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=1) =7.932 since p=.005 was less than the conventional 5% level of significance. More than 60% of all respondents in the three age categories were not aware of safety gloves. This association of awareness on safety gloves and the age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =21.291 since p=<.001. Education level did not affect the influence the level of awareness on safety gloves as more than 70% of the three education levels (primary, secondary, and tertiary) were not aware of safety gloves. However, the association of awareness of safety gloves and education level was not statistically significant at a 95% confidence level with χ^2 (df=2) =3.464 since p=.177. Operation period/experience did not influence the level of awareness on safety gloves as more than 70% of the respondents in all categories (<5 years, 6-10 years, and >10 years) were not aware of safety gloves. The association of awareness on safety gloves and operation period/experience was not statistically significant at a 95% confidence level with χ^2 (df=2) =2.997, since p= .223.

Table 4.4: Association between respondents' demographics and awareness of safety glasses.

Variable	Category	Always wear safety glasses at the workplace		
		No	Yes	Chi-Square
Gender	Male	100%	0%	
	Female	100%	0%	X^2=0.238 , df=1 , p=.626
Age	18-30 years	99%	1%	
	31-40 years	100%	0%	X^2=1.544, df=2, p=.462
	> 40 years	100%	0%	
Education level	primary	100%	0%	
	Secondary	100%	0%	X^2=2.705 , df=2 , p=.259
	Tertiary	100%	0%	
Lpg retailing experience	< 5 years	100%	0%	

6-10 years	100%	0%	X^2=2.049 , df=2 , p=.359
> 10 years	100%	0%	

Corresponding to gender, safety glasses awareness was sort, and the results indicated that all respondents were not aware of safety glasses. This association of awareness on safety glasses and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =0.238 since p=.626. Age did not influence awareness safety glasses as the majority (over 95%) of the respondents in the three age brackets were not aware of safety glasses. This association of awareness on safety glasses and the age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =1.544 since p=.462. Education level did not influence the level of awareness on safety glasses as all the respondents in the three education levels were not aware of safety glasses. The association of awareness on safety glasses and education level was not statistically significant at a 95% confidence level with χ^2 (df=2) =2.705 since p=.259. The operation period/experience did not influence the level of awareness on safety glasses as all the respondents were not aware of safety glasses. The association of awareness on safety glasses and operation period/experience was not statistically significant at a 95% confidence level with χ^2 (df=2) =2.049, since p= .359.

4.3.2 Respondents' awareness of first aid kits and first aid training

With reference to table 4.1, 76.4% of the respondents did not have first aid kits at their workplaces. 73.3% admitted not to have received any first aid training at all.

First aid kits are necessary so that an Lpg retailer can treat ailments and injuries that happen at the workplace. From the minor ailment to the more serious injury, a first aid kit can help reduce the risk of infection or the severity of the injury. A first aid kit is a must-have item and someone who has been first aid trained to administer the assistance. The kit should be purchased depending on the type of hazards that a workplace might involve, and that is why a risk assessment is also paramount.

It should be mandatory for all Lpg cylinder retailers in Kiambu County to receive basic first aid training and always have a fully equipped first aid kit at the workplace. Periodic monitoring should be undertaken by the energy and petroleum regulatory authority to ensure compliance.

Table 4.5: Association between respondents' demographics and awareness of First aid kits.

Variable	Category	First aid kit available at the workplace		
		No	Yes	Chi-Square
Gender	Male	77%	23%	
	Female	75%	25%	X^2=0.072 , df=1 , p=.788
Age	18-30 years	80%	20%	
	31-40 years	73%	27%	X^2=1.620, df=2 , p=.445
	> 40 years	77%	23%	
Education level	primary	82%	18%	
	Secondary	76%	24%	X^2=3.299 , df=2 , p=.192
	Tertiary	70%	30%	
Lpg retailing experience	< 5 years	84%	16%	
	6-10 years	73%	27%	X^2=32.866 , df=2 , p=<.001
	> 10 years	29%	71%	

In respect of gender, first aid kit awareness was sort, and the results indicated that the majority of the respondents (over 70%), irrespective of gender, were not aware of first aid kits. This association of awareness on first aid kits and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =0.072 since p=.788. Age of the respondents did not influence awareness on first aid kits as the majority of the respondents, over 70%, in the three age categories were not aware of first aid kits. This association of awareness on first aid kits and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =1.620 since

p=<.445. Education level did not influence the level of awareness on first aid kits as more than 69% of the three education levels were not aware of first aid kits. The association of awareness on first aid kits and education level was not statistically significant at a 95% confidence level with χ^2 (df=2) =3.299 since p=.192. Operation period/experience did influence the level of awareness on first aid kits somewhat. Over 70% of the respondents between 0-10 years of experience/operation period were not aware of first aid kits, whereas over 70% of the respondents with more than ten years of experience/operation period were aware of first aid kits. The association of awareness on first aid kits and operation period/experience was statistically significant at a 95% confidence level with χ^2 (df=2) =32.866, since p= <.001.

Table 4.6: Association between respondents' demographics and first aid training.

Variable	Category	Undergone first aid training		
		No	Yes	Chi-Square
Gender	Male	73%	27%	X^2=1.302 , df=2 , p=.522
	Female	79%	21%	
Age	18-30 years	80%	20%	X^2=6.664, df=4, p=.155
	31-40 years	69%	31%	
	> 40 years	74%	26%	
Education level	primary	91%	9%	
	Secondary	65%	35%	X^2=19.389 , df=4 , p=.001
	Tertiary	74%	26%	
Lpg retailing experience	< 5 years	77%	23%	
	6-10 years	73%	27%	X^2=4.084 , df=4 , p=.395
	> 10 years	57%	43%	

From table 4.5, majority of the respondents (over 70%) irrespective of gender had never undergone first aid training and thus unaware of the same. This association of first aid training and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =1.302 since p=.522. Age of the respondents did

not influence awareness on first aid training as the majority of the respondents, over 66%, in the three age categories had never undergone first aid training and thus not aware of the subject. This association of awareness on first aid training and the age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=4) =6.664 since p=.155. Education level influenced awareness of first aid training. Only 9% of the respondents with up to primary education had undergone first aid training. 26% of the respondents with tertiary education had undergone first aid training, while 35% of the respondents with up to secondary education had undergone first aid training. The association of awareness on first aid training and education level was statistically significant at a 95% confidence level with χ^2 (df=4) =19.389 since p=.001. Operation period/experience did influence the level of awareness on first aid kits somewhat. Most of the Respondents with less than 5 years of experience were less aware of first aid training at 77% as compared to the other categories. The association of awareness on first aid training and operation period/experience was not statistically significant at a 95% confidence level with χ^2 (df=4) =4.084, since p= .395.

4.3.3 Respondents' awareness of fire extinguishers

Apropos of table 4.1, 69.9% of the respondents did not have fire extinguishers at their workplaces. Additionally, 67.8% of the respondents agreed they did not know how to operate a fire extinguisher. A fire extinguisher should be available where Lpg cylinders are stored together with emergency response and evacuation plans in the event of a fire.

A fire extinguisher is a major fire suppression control method, and thus, knowing how to use it should be a must for all Lpg cylinder retailers in Kiambu County. The retailers should be aware of the various types of fire extinguishers, how to identify them, when to use them, fuel classifications, how the various types of extinguishers work, and how the extinguisher should be used. The retailers should also know that when preparing to put off the fire, the PASS firefighting method is used, i.e., pull the pin, aim the nozzle, squeeze the handle and lastly, sweep across the base of the fire. From the results, it's worrying that only 32.2% of the gas retailers know how to use a fire extinguisher.

There's a need for Lpg cylinder retailers in Kiambu County to be made aware of the importance of knowing and understanding the fire suppression techniques. A practical firefighting equipment training to demonstrate to the retailers on how to safely deal with an early-stage fire involving Lpg should be mandatory.

Table 4.7: Association between respondents' demographics and awareness of fire suppression.

Variable	Category	Know how to use a fire extinguisher		
		No	Yes	Chi-Square
Gender	Male	65%	35%	
	Female	80%	20%	X^2=4.999 , df=1 , p=.025
Age	18-30 years	71%	29%	
	31-40 years	70%	30%	X^2=4.331, df=2 , p=.115
	> 40 years	77%	23%	
Education level	primary	82%	18%	
	Secondary	55%	45%	X^2=22.090 , df=2 , p=<.001
	Tertiary	78%	22%	
Lpg retailing experience	< 5 years	73%	27%	
	6-10 years	61%	39%	X^2=6.344 , df=2 , p=.042
	> 10 years	52%	48%	

Referring to table 4.7 above, awareness on how to use a fire extinguisher was sort, and the results indicated that the majority of the female respondents (80%) were less aware of how to use a fire extinguisher as compared to males(65%). This association of awareness on how to use a fire extinguisher and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=1) =4.999 since p=.025. Most of the respondents that had over 40 years of age were less aware of how to use a fire extinguisher as compared to the other age brackets. This association of awareness on how to use a fire extinguisher and the age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =4.331 since p=.115.

Education level influenced awareness on how to use a fire extinguisher as most of the respondents that had up to primary education were less aware of how to use a fire extinguisher as compared to the other higher levels of education. The association of awareness on how to use a fire extinguisher and education level was statistically significant at a 95% confidence level with χ^2 (df=2) =22.090 since p=<.001. Most of the respondents with less than five years of experience were less aware of how to use a fire extinguisher (73%) as compared to the other categories. The more the operation period, the more aware the respondents became on how to use a fire extinguisher. The association of awareness on how to use a fire extinguisher and operation period/experience was statistically significant at a 95% confidence level with χ^2 (df=2) =6.344, since p= .042.

Table 4.8: Association between respondents' demographics and awareness of having a fire extinguisher.

Variable	Category	Fire extinguisher available at the workplace		Chi-Square
		No	Yes	
Gender	Male	69%	31%	X^2=0.559 , df=2 , p=.756
	Female	73%	27%	
Age	18-30 years	72%	28%	
	31-40 years	67%	33%	X^2=2.662, df=4, p=.616
	> 40 years	74%	26%	
Education level	primary	76%	24%	
	Secondary	70%	30%	X^2=5.162 , df=4 , p=.271
	Tertiary	64%	36%	
Lpg retailing experience	< 5 years	75%	25%	
	6-10 years	69%	31%	X^2=12.815 , df=4 , p=.012
	> 10 years	38%	62%	

Association between availability of fire extinguishers at the workplace and respondents' demographic was sort, and the results indicated that the majority of the female respondents (73%) did not have a fire extinguisher as compared to males

(69%). This association of availability of a fire extinguisher and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =0.559 since p=.756. Most of the respondents that had over 40 years of age (74%) did not have a fire extinguisher or aware of the same as compared to the other age brackets. This association of awareness of having a fire extinguisher and the age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=4) =2.662 since p=.616. Education level influenced having a fire extinguisher at the workplace as most of the respondents that had up to primary education did not have a fire extinguisher or aware of the same (76%) as compared to the other higher levels of education. The association of availability of fire extinguisher at the workplace and education level was not statistically significant at a 95% confidence level with χ^2 (df=4)=5.162 since p=.271. The operation period influenced having a fire extinguisher at the workplace. Most of the respondents with more than ten years of experience had a fire extinguisher and more aware of the same (62%). As compared to the other categories. The less the years of experience, the less aware the respondents were on the subject. The association of having a fire extinguisher at the workplace and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=4) =12.815, since p= .012.

4.3.4 Respondents' awareness of health and safety policy

With reference to table 4.1, 91.4% of the respondents did not have a health and safety policy at their workplace. A strong health and safety policy will ensure that even in the back of the Lpg retailers' minds that health and safety is important and should always be considered part of everyday business. If something does go wrong, the retailers know how to behave and who to contact without thinking, which will be vital in emergencies. The policy commits the entire organization to maintain a safe workplace and thus encouraging both human and financial resources to help ensure that safety is taken seriously within the workplace.

Health and safety policies and procedures are essential for the workplace because they demonstrate that the business is addressing its health and safety obligations; shows that the business is committed to working within a set of health and safety principles,

clarifies functions and responsibilities in the business, ensures that safe systems of work are recorded, communicated to workers and implemented in a consistent way throughout the business, guides the future actions of workers formally, helps the business to manage workers more effectively by defining acceptable and unacceptable behavior in the workplace and lastly saving time by allowing health and safety matters to be handled quickly through an existing procedure, rather than workers dealing with problems as they occur or responding differently each time the same issues arise.

It should, therefore, be a requirement that every Lpg cylinder retail center have a health and safety policy prepared by an occupational health and safety expert approved by DOSH before issuance of a license to operate. Monitoring of the same should be undertaken by the Energy and petroleum regulatory authority to ensure compliance.

Table 4.9: Association between respondents' demographics and awareness of health and safety policy.

Variable	Category	Health and safety policy available at the workplace		Chi-Square
		No	Yes	
Gender	Male	91%	9%	X^2=8.671 , df=2 , p=.013
	Female	95%	5%	
Age	18-30 years	91%	9%	X^2=7.469, df=4, p=.113
	31-40 years	89%	11%	
	> 40 years	100%	0%	
Education level	primary	96%	4%	X^2=15.478 , df=4 , p=.004
	secondary	85%	15%	
	Tertiary	99%	1%	
Lpg retailing experience	< 5 years	98%	2%	X^2=37.204 , df=4 , p=<.001
	6-10 years	83%	17%	
	> 10 years	71%	29%	

With respect to gender, health, and safety policy awareness was sort and the results indicated that both male and female respondents (over 90%) were not aware of the health and safety policy. This association of awareness of health and safety policy and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =8.671 since p=.013. Older respondents (>40 years) were less aware of the health and safety policy at 100%, followed by 18-30 age bracket at 91% and lastly 31-40 age bracket at 89%. This association between awareness of the health and safety policy and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=4) =7.469 since p=.113. 99% of the respondents with tertiary education were not aware of the safety and health policy; 96% of the respondents with up to primary education were not aware of the health and safety policy. 85% of the respondents with up to secondary education were not aware of the health and safety policy. The association between awareness of the health and safety policy and education level was statistically significant at a 95% confidence level with χ^2 (df=4) =15.478 since p= <.004. Respondents with less than five years' experience were less aware of the health and safety policy at 98%, followed by respondents with 6-10 years' experience at 83%, and lastly, over ten years' experience at 71%. The more the years of experience in the Lpg cylinder retail business, the more the awareness of the health and safety policy improved somewhat. The association of awareness of the health and safety policy and respondents' operation period/experience was statistically significant at a 95% confidence level with χ^2 (df=4) =32.204, since p= <.001.

4.3.5 Respondents' awareness of cylinder handling

In relation to table 4.1, 88.7% of the respondents had not received any training(s) on cylinder handling. All Lpg cylinders retailers should be trained on the safe handling of Lpg cylinders. The retailers should also have in place arrangements for dealing with imminent danger and train persons to implement the arrangements. Besides, the majority (45.9%) of the respondents agreed that it is not a must for Lpg cylinders to be transported in an upright and secure position. 16.4% of the respondents agreed that

cylinders should be transported in an upright and secure position, whereas 15.4% did not know of the same regarding cylinder transportation.

Table 4.10: Association between respondents' demographics and awareness of cylinder handling.

Variable	Category	Trained on cylinder handling		
		No	Yes	Chi-Square
Gender	Male	89%	11%	X^2=1.249 , df=2 , p=.536
	Female	89%	11%	
Age	18-30 years	90%	10%	
	31-40 years	87%	13%	X^2=2.954, df=4, p=.566
	> 40 years	91%	9%	
Education level	primary	97%	3%	
	Secondary	81%	19%	X^2=18.541 , df=4 , p=.001
	Tertiary	95%	5%	
Lpg retailing experience	< 5 years	96%	4%	
	6-10 years	81%	19%	X^2=30.702 , df=4 , p=<.001
	> 10 years	62%	38%	

Associations between awareness of cylinder handling and respondents' demographics was sort, and the results indicated that both male and female respondents (89%) were not trained on cylinder handling. This association of cylinder handling and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =1.249 since p=.536. Most of the respondents that had over 40 years of age (91%) had not received training on cylinder handling. 90% of the respondents within 18-30 years had not received any training on cylinder handling. 87% of the respondents within 31-40 years had not received any training on cylinder handling. This association between awareness of cylinder handling and respondents' age was not statistically significant at a 95% confidence level with χ^2 (df=4) =2.954 since p=.566.

97% of the respondents with primary education were not trained on cylinder handling; 95% of the respondents with up to tertiary education were not trained on cylinder handling. 81% of the respondents with up to secondary education were not trained on cylinder handling. The association of awareness of cylinder handling and education level was statistically significant at a 95% confidence level with χ^2 (df=4)=18.541 since p=<.001. The operation period had an influence awareness of cylinder handling. 96% of the respondents with less than five years of experience did not have any training on cylinder handling; 81 % of the respondents with 6-10 years' experience had no training on cylinder handling. 62% of respondents with more than ten years of experience had not received any training on cylinder handling. The more the years of experience/operation period in the Lpg cylinder retail business, the more the awareness on cylinder handling of the respondents improved. The association of awareness of cylinder handling and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=4) =30.702, since p= .<.001.

4.3.6 Respondents' awareness of liquefied petroleum gas cold burns

99.3% of the respondents were not aware that Lpg could cause cold burns if it encounters the skin. 59.6% of the respondents were not aware that safety signs and warning notices ought to be displayed clearly in the workplace.

Table 4.11: Association between respondents' demographics and awareness of Lpg cold burns.

Variable	Category	Lpg can cause cold burns to the skin		
		No	Yes	Chi-Square
Gender	Male	99%	1%	X^2=1.454 , df=2 , p=.483
	Female	100%	0%	
Age	18-30 years	99%	1%	
	31-40 years	100%	0%	X^2=5.208, df=4, p=.267
	> 40 years	99%	1%	
Education level	primary	100%	0%	
	Secondary	99%	1%	X^2=35.487 , df=4 , p=<.001
	Tertiary	100%	0%	

Lpg retailing experience	< 5 years	100%	0%	
	6-10 years	98%	2%	X^2=5.636 , df=4 , p=.228
	> 10 years	100%	0%	

From table 4.11 above, Lpg cold burns awareness was sort, and the results indicated that both respondents- males at 99% and females at 100% -were not aware that Lpg could cause cold burns when it comes into contact with the skin. This association of awareness on Lpg cold burns and gender of the respondents was not statistically significant at 95% confidence level with χ^2 (df=2) =1.454 since p=.483 was more than the conventional 5% level of significance. 99% of the respondents within 18-30 years of age and over 40 years of age were not aware that Lpg could cause cold burns when it comes into contact with the skin. 100% of the respondents within 31-40 years of age were not aware of the same. There's little awareness with regards to cold burns across all age brackets of Lpg cylinder retailers. This association of awareness of Lpg cold burns and the age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=4) =5.208 since p=.267. Education did not seem to influence the respondents' awareness of Lpg cold burns. Over 98% of all the respondents across all education levels were not aware that Lpg could cause cold burns when it comes into contact with the skin. The association of awareness of Lpg cold burns and education level was statistically significant at a 95% confidence level with χ^2 (df=4) =35.487 since p= <.001. Operation period/ experience did not influence the respondents' awareness of Lpg cold burns as over 97% of respondents across all operation period categories were not aware that Lpg could cause cold burns when it comes into contact with the skin. The association of awareness of Lpg cold burns and operation period was not statistically significant at a 95% confidence level with χ^2 (df=4) =5.636 since p=.228.

4.3.7 Respondents awareness of fire safety

84.6% of the respondents had not received any training whatsoever on fire safety (see Table 4.1). Fire safety training is paramount to any person handling highly flammable

goods. The training makes the Lpg cylinder retailers aware of the sources or phenomena of producing a fire (recognition), measures directed towards avoiding the inception of fire (fire prevention), and the fire fighting and related facilities (fire protection).

The fire caused by Lpg equipment is catastrophic and thus need for the retailers to be trained on fire safety to make them more aware of the subject.

Lpg fire safety pieces of training ensure that workers fully understand the characteristics and hazards that Lpg gases present in the workplace. The workers thus gain knowledge to reduce the risk of a possibly disastrous fire from starting, and they will learn how to both tackle an early-stage fire and how to deal with a dampened gas leak.

Lpg safety training will help the Lpg retailers understand their role concerning workplace fire safety and emergency procedures; an understanding of the properties and characteristics of gases, an understanding of the safe handling of cylinders, knowledge of the principles of combustion and fire spread and an understanding of the emergency first aid treatment of a person affected by Lpg.

This should be done by the energy and petroleum regulatory authority before issuing an operating license.

Table 4.12: Association between respondents' demographics and awareness of fire safety.

Variable	**Category**	**Trained in fire safety.**		
		No	**Yes**	**Chi-Square**
Gender	Male	85%	15%	X^2=2.458 , df=2 , p=.293
	Female	84%	16%	
Age	18-30 years	90%	10%	
	31-40 years	78%	22%	X^2=17.002, df=4, p=.002
	> 40 years	88%	12%	
Education level	primary	95%	5%	
	Secondary	76%	24%	X^2=30.633 , df=4 , p=<.001
	Tertiary	91%	9%	

Lpg retailing experience	< 5 years	95%	5%	
	6-10 years	70%	30%	X^2=44.745 , df=4 , p=<.001
	> 10 years	62%	38%	

Results from table 4.12 indicate that both male and female respondents (Over 83%) were not trained on fire safety. This association of fire safety training and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =2.458 since p=.293. Most of the respondents within 18-30 years of age (90%) had not received any training on fire safety and thus not aware of the subject. 88% of the respondents with over 40 years of age had not received any training on fire safety. 78% of the respondents within 31-40 years had not received any training on fire safety. This association between awareness of fire safety pieces of training and respondents' age was statistically significant at a 95% confidence level with χ^2 (df=4) =17.002 since p=.002.

95% of the respondents with up to primary education were not trained on fire safety; 91% of the respondents with up to tertiary education were not trained on fire safety. 76% of the respondents with up to secondary education had not received any training on fire safety. The association of awareness of fire safety pieces of training and education level was statistically significant at a 95% confidence level with χ^2 (df=4)=30.633 since p=<.001. The operation period had an influence awareness of cylinder handling. 95% of the respondents with less than five years of experience did not have any training on fire safety, 70% of the respondents with 6-10 years' experience had no training on fire safety. 62% of respondents with more than ten years of experience had not received any training on fire safety. The more the years of experience/operation period in the Lpg cylinder retail business, the more the awareness on Lpg fire safety pieces of training of the respondents improved. The association of awareness of Lpg fire safety pieces of training and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=4) =44.745, since p= .<.001.

4.3.8 Respondents' awareness of fire safety management plan.

Relevant to table 4.1, 93.5% of the respondents did not have a fire safety management plan at the workplace. The plan describes the arrangements for managing fire safety effectively to prevent the occurrence of fire, and if a fire breaks out, to protect both property and people.

Awareness with regards to the fire safety management plan by Lpg cylinder retailers in Kiambu county is poor. There is a need to educate the Lpg cylinder retailers on the same. This should be undertaken by the energy and petroleum regulatory authority.

Table 4.13: Association between respondents' demographics and awareness of fire safety management plan.

Variable	Category	Fire safety management plan available at the workplace		
		No	Yes	Chi-Square
Gender	Male	91%	9%	X^2=8.605 , df=2 , p=.014
	Female	93%	7%	
Age	18-30 years	91%	9%	X^2=12.107, df=4, p=.017
	31-40 years	90%	10%	
	> 40 years	95%	5%	
Education level	primary	99%	1%	X^2=25.220 , df=4 , p=<.001
	Secondary	85%	15%	
	Tertiary	96%	4%	
Lpg retailing experience	< 5 years	97%	3%	X^2= 46.018, df=4 , p=<.001
	6-10 years	85%	15%	
	> 10 years	76%	24%	

In connection to gender, awareness of fire management plans and respondents' demographics were sort, and the results indicated that over 90% of the respondents (male and female) were not aware of the fire safety management plan. This association of awareness of fire safety management plan and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =8.605 since p=.014.

Most of the respondents with over 40 years of age (95%) were not aware of the fire safety management plan; 91% of the respondents within 18-30 years of age were not aware of the fire safety management plan. 90% of the respondents within 31-40 were not aware of a fire safety management plan. This association between awareness of fire safety management plan and respondents' age was statistically significant at a 95% confidence level with χ^2 (df=4) =12.107 since p=.017.

Corresponding to table 4.1, 99% of the respondents with up to primary education were not aware of the fire safety management plan; 96% of the respondents with up to tertiary education were not aware of the fire safety management plan whereas 85% of the respondents with up to secondary education were not aware of the same. The association of awareness of fire safety pieces of training and education level was statistically significant at a 95% confidence level with χ^2 (df=4)=25.220 since p=<.001. The operation period had an influence somewhat on awareness of the fire safety management plan. 97% of the respondents with less than 5 years of experience were not aware of the fire safety management plan; 85% of the respondents with 6-10 years' experience were also not aware of the fire safety management plan. 76% of respondents with more than ten years of experience were not aware of the fire safety management plan. The operation period in the Lpg cylinder retail business had a direct relationship with an awareness of the fire safety management plan within respondents. This association of awareness of the fire safety management plan and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=4) =46.018, since p= .<.001.

4.3.9 Respondents' awareness of accident reporting

From table 4.1, Only 10.6% of the respondents agreed that all injuries and accidents, however minor, should be reported to the immediate supervisor and recorded. The majority, 65.4% vehemently disagreed with the statement, while 24% of the respondents had no idea on the subject.

Table 4.14: Association between respondents' demographics and awareness of accident/incident reporting.

Variable	Category	All injuries/accidents/incidents should be reported		
		No	Yes	Chi-Square
Gender	Male	88%	12%	X^2=7.410 , df=2 , p=.025
	Female	96%	4%	
Age	18-30 years	90%	10%	X^2=3.711, df=4, p=.447
	31-40 years	87%	13%	
	> 40 years	95%	5%	
Education level	primary	95%	5%	X^2=5.884 , df=4 , p=.208
	Secondary	86%	14%	
	Tertiary	90%	10%	
Lpg retailing experience	< 5 years	94%	6%	X^2=14.288 , df=4 , p=.006
	6-10 years	82%	18%	
	> 10 years	86%	14%	

Results from table 4.14 indicate that majority of the female respondents (96%) were not in agreement that accidents/incidents at the workplace ought to be reported as compared to their male counterparts at 88%. This association of accident/incident reporting and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =7.410 since p=.025. Most of the respondents that had over 40 years of age (95%) were not aware that accidents/incidents at the workplace ought to be reported and recorded. 90% of respondents within 18-30 years of age were not aware that accidents/incidents ought to be reported and recorded. 87% of respondents within 31-40 years of age were also not aware of the same. This association of awareness of accident/incident reporting and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=4) =3.711 since p=..447. Most of the respondents that had up to primary education (95%) were not aware that accidents/incidents at the workplace ought to be reported. 90% of

respondents with up to tertiary level education and 86% of respondents with up to secondary education were also not aware of the same. The association of awareness of accident/incident reporting and education level was not statistically significant at a 95% confidence level with χ^2 (df=4)=5.884 since p=.208. Most of the respondents with less than five years of experience (94%) were not aware that accidents/incidents at the workplace should be reported and recorded. 86% of the respondents with more than ten years of experience were not aware that accidents/incidents at the workplace ought to be reported and recorded. This is the same for 82% of respondents with 6-10 years of experience who were also not aware of workplace accident/incident reporting. The association of awareness of accident/incident reporting and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=4) =14.288, since p= .006.

4.3.10 Respondents' awareness of liquefied petroleum gas cylinder explosion

In connection to table 4.1, 61% of the respondents agreed that Lpg gas cylinders could explode if exposed to high temperatures. 16.4% of the respondents disagreed with the statement, while 22.6% did not know what to say regarding the subject as they were honestly unaware.

Only 11.6% of the participants agreed that in case of a gas leak, switching on lights can cause an explosion/fire. 43.8% disagreed while with the statement, while 39.7% did not know what to say regarding the subject as they were honestly unaware.

Table 4.15: Association between respondents' demographics and awareness of cylinder explosion.

Variable	Category	Aware that cylinders can explode at high temperatures		
		No	Yes	Chi-Square
Gender	Male	38%	62%	X^2=1.454 , df=2 , p=.483
	Female	45%	55%	
Age	18-30 years	39%	61%	
	31-40 years	35%	65%	X^2=8.851, df=4, p=.065
	> 40 years	51%	49%	
Education level	primary	37%	63%	

	Secondary	31%	69%	X^2=20.235 , df=4 , p=<.001
	Tertiary	59%	41%	
Lpg retailing experience	< 5 years	47%	53%	
	6-10 years	30%	70%	X^2=17.457 , df=4 , p=.002
	> 10 years	10%	90%	

From table 4.15 above, male respondents (62%) were more aware of cylinder explosion at high temperatures as compared to female respondents at 55%. This association of awareness on cylinder explosion and gender of the respondents was not statistically significant at 95% confidence level with χ^2 (df=2) =1.454 since p=.483 was more than the conventional 5% level of significance. Most of the respondents within 31-40 years of age (65%) were more aware of cylinder explosion at high temperatures, followed by respondents within 18-30 years of age at 61%. Only 49% of respondents with over 40 years of age were aware that cylinders could explode at high temperatures. This association of awareness of cylinder explosion at high temperatures and respondents' age was not statistically significant at a 95% confidence level with χ^2 (df=4) =8.851 since p=.065. Most of the respondents with up to secondary education (69%) were aware of cylinder explosion at high temperatures, followed by respondents with up to primary education (63%). Only 41% of respondents with up to tertiary education level were aware of cylinder explosion at high temperatures. This association of awareness of cylinder explosion at high temperatures and respondents' education level was statistically significant at a 95% confidence level with χ^2 (df=4) =20.235 since p= <.001. The majority of respondents with more than ten years of experience (90%) were more aware that cylinders can explode at high temperatures, followed by respondents 6-10 years of experience at 70 %, and lastly, respondents with less than five years of experience at 53%. There is a direct relationship between operation period and awareness on cylinder explosion at high temperatures. The association of awareness of cylinder explosion at high temperatures with operation period/experience was statistically significant at a 95% confidence level with χ^2 (df=4) =17.457, since p= .002.

Table 4.16: Association between respondents' demographics and awareness of cylinder explosion.

Variable	Category	In the case of Lpg leak, switching on lights can cause an explosion		
		No	Yes	Chi-Square
Gender	Male	87%	13%	X^2=6.384 , df=3 , p=.094
	Female	93%	7%	
Age	18-30 years	83%	17%	
	31-40 years	91%	9%	X^2=24.302, df=6, p=<.001
	> 40 years	93%	7%	
Education level	primary	90%	10%	
	Secondary	87%	13%	X^2=26.835 , df=6 , p=<.001
	Tertiary	90%	10%	
Lpg retailing experience	< 5 years	91%	9%	
	6-10 years	82%	18%	X^2=34.872 , df=6 , p=<.001
	> 10 years	90%	10%	

Results from table 4.16 show that both male and female respondents (Over 85%) were not aware that in case of Lpg leak, switching on lights can cause an explosion. This association of cylinder explosion and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=3) =6.384 since p=.094. Most of the respondents with over 40 years of age (93%) were not aware that in the case of the Lpg lean explosion. Switching on lights can cause an explosion. 91% of respondents within 31-40 years of age were also not aware of the same. 83% of the respondents within 18-30 years of age were not aware that in case of an Lpg leak, switching on lights can cause an explosion. This association between awareness of cylinder explosion and respondents' age was statistically significant at a 95% confidence level with χ^2 (df=6) =24.302 since p=<.001.

90% of the respondents with up to primary and tertiary education levels were not aware that in case of a gas leak, switching on lights can cause an explosion. 87% of respondents with up to secondary education were also not aware that in case of a gas

leak, switching on lights can cause an explosion. The association of awareness of cylinder explosion and education level was statistically significant at a 95% confidence level with χ^2 (df=6)=26.835 since p=<.001. 91% of the respondents with less than five years of experience were not aware that in case of a gas leak, switching on lights could cause an explosion. 90% of respondents with more than ten years of experience and 82% of respondents with 6-10 years of experience were not aware that in case of a gas leak, switching on lights could cause an explosion. The association of awareness of cylinder explosion and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=6) =34.872 since p= .<.001.

From the literature reviewed, it can be confirmed from this study that the application of safety expertise becomes progressively challenging as Lpg is moved along the distribution chain away from the direct control of the primary supplier. A very important consideration is that all cylinder retail centers should have adequate signage to provide warnings and safety information on the hazardous products being stored.

Additionally, Lpg retailers should receive suitable information and instruction regarding the hazards associated with gas cylinders, the gas being stored, and provided with the necessary skills and knowledge to carry out their job safely. The employer must ensure his/her workers are adequately trained and to establish competency. Training records should be preserved and available upon request.

In summary, from the data collected and analyzed, the majority of the Lpg cylinder retailers in Kiambu County, 77%, are not aware of the occupational safety and health issues in the Lpg cylinder retail business.

4.4 Current Occupational safety and health practices

The second specific objective aimed at investigating the current occupational safety and health practices liquefied petroleum-gas cylinder retail business in Kiambu County. This was achieved through observation and the use of a checklist. The

observations were made under natural conditions and findings presented in figure 4.5 below.

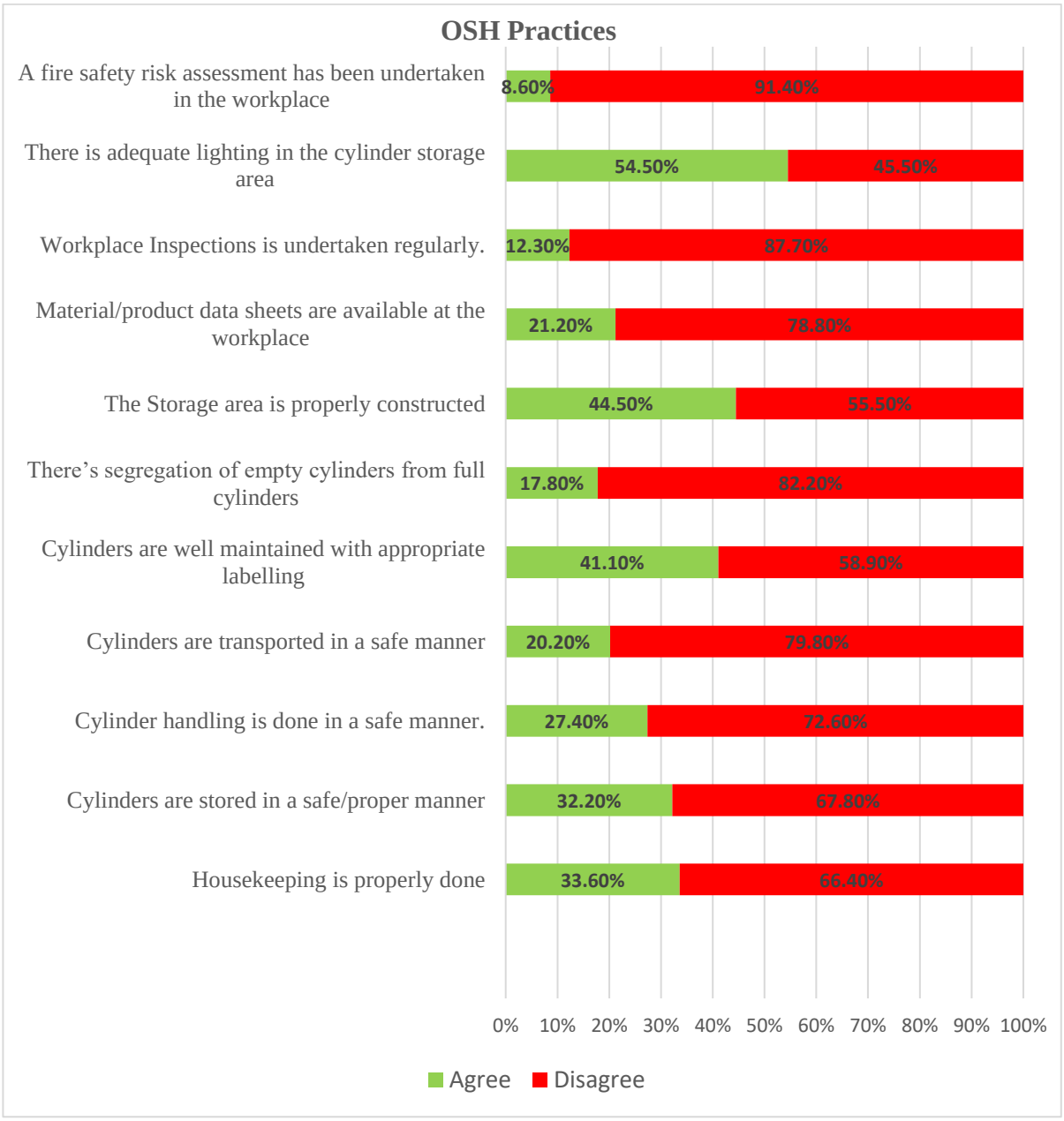


Figure 4.5 Current occupational safety and health practices in Lpg cylinder retail business

4.4.1 Housekeeping

From the collected and analyzed data, housekeeping was not done properly in 66.4% of the sites visited (see figure 4.5). Inadequate housekeeping results in untidy facilities, increased risk of fire, accidents, incidents or obstruction, damage to business image/brand. This can be prevented by clearly stated procedures, regular audits and inspections, and assessment of critical assets.

Keeping the workplace clean and tidy encourages a tidier work ethic and helps eliminate unwanted items that could fuel a fire, create an obstruction, or cause potential injury. Clean and tidy workplaces also improve the efficiency of operations.

Table 4.17: Association between respondents' demographics and housekeeping.

Variable	Category	Housekeeping properly has done.		
		No	Yes	Chi-Square
Gender	Male	69%	31%	X^2=3.816 , df=1 , p=.051
	Female	55%	45%	
Age	18-30 years	68%	32%	
	31-40 years	71%	29%	X^2=7.268, df=2, p=.026
	> 40 years	49%	51%	
Education level	primary	66%	34%	
	Secondary	63%	37%	X^2=3.479 , df=2 , p=.176
	Tertiary	75%	25%	
Lpg retailing experience	< 5 years	74%	26%	
	6-10 years	59%	41%	X^2=17.303 , df=2 , p=<.001
	> 10 years	66%	34%	

Association between gender and housekeeping was assessed, and the results indicated that housekeeping was not properly done in most workplaces with male respondents (69%) as compared to female respondents (55%). This association of housekeeping and gender of the respondents was not statistically significant at 95% confidence level with χ^2 (df=1) =3.816 since p=.051 was less than the conventional 5% level of

significance. Housekeeping was not done properly across all age categories. Housekeeping was not done properly by the majority of respondents within 31-40 years of age (71%), followed by respondents within 18-30 years at 68%, and lastly, respondents with over 40 years of age at 48%. This association of housekeeping and age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =7.268 since p=.026. The majority of respondents did not properly do housekeeping with up to tertiary education (75%), followed by respondents with up to primary education (66%), and lastly, respondents with up to secondary education at 63%. This association of housekeeping and education level of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =3.479 since p=.176. Housekeeping was not done properly by the majority of respondents with less than five years of experience in the gas retail business (74%), followed by respondents with over ten years of experience (66%), and lastly respondents with 6-10 years of experience at 59%. This association of housekeeping and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =17.303 since p=<.001.

Plate 2: Depicting poor housekeeping.

As per plate 2, the trolleys ought to have been placed elsewhere, so as not to obstruct the Lpg cylinder cage (accessibility), which consequently improves the efficiency of operations and eliminates the obstructions that may cause potential injury.

4.4.2 Cylinder handling and storage

According to figure 4.5, cylinder storage was not satisfactory in 67.8% of the sites visited. Cylinder handling was poor in 78.8% of the sites visited. Care in the handling of Lpg cylinders helps minimize the number of incidents, accidents, and their consequences. This is a key driver in safety promotion in the Lpg cylinder retail business.

Table 4.18: Association between respondents' demographics and cylinder storage.

Variable	Category	Cylinder storage in a safe manner		
		No	Yes	Chi-Square
Gender	Male	67%	33%	X^2=0.107 , df=1 , p=.744
	Female	70%	30%	
Age	18-30 years	64%	36%	
	31-40 years	78%	22%	X^2=16.755 , df=2, p=<.001
	> 40 years	47%	53%	
Education level	primary	66%	34%	
	Secondary	66%	34%	X^2=1.543 , df=2 , p=.462
	Tertiary	74%	26%	
Lpg retailing experience	< 5 years	79%	21%	
	6-10 years	51%	49%	X^2=27.110 , df=2 , p=<.001
	> 10 years	48%	52%	

Association between gender and cylinder storage was assessed, and the results indicated that cylinder storage was not properly undertaken in most workplaces with female respondents (70%) as compared to male respondents (67%). This association of cylinder storage and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =0.107 since p=.744. Most respondents did not properly undertake cylinder storage within 31-40 years of age (78%), followed by respondents within 18-30 years at 64%. Conversely, cylinder storage was undertaken safely by 53% of respondents with over 40 years of age. This association of cylinder storage and age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =16.755 since p=<.001. The majority of respondents did not properly do cylinder storage with up to tertiary education (74%), followed by both respondents with up to primary education and up to secondary education (66%). This association of cylinder storage and education level of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =1.543 since p=.462. Cylinder storage was not done properly by the majority of respondents with less than five years of experience in the gas retail business (79%), followed by respondents with

6-10 years of experience (51%). On the other hand, cylinder storage was done properly by 52% of respondents with over ten years of experience. This association of cylinder storage and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =27.110 since p=<.001.

Table 4.19: Association between respondents' demographics and cylinder handling.

Variable	Category	Cylinder handling in a safe manner		
		No	Yes	Chi-Square
Gender	Male	69%	31%	X^2=7.731 , df=1 , p=.005
	Female	88%	12%	
Age	18-30 years	59%	41%	
	31-40 years	81%	19%	X^2=17.471, df=2, p=<.001
	> 40 years	84%	16%	
Education level	primary	58%	42%	
	Secondary	74%	26%	X^2=14.193 , df=2 , p=.001
	Tertiary	86%	14%	
Lpg retailing experience	< 5 years	81%	19%	
	6-10 years	56%	44%	X^2=19.459 , df=2 , p=<.001
	> 10 years	76%	24%	

Association between gender and cylinder handling was assessed, and the results indicated that cylinders were not handled safely in most workplaces with female respondents (88%) as compared to male respondents (69%). This association of cylinder handling and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=1) =7.731 since p=.005. Cylinder handling was not undertaken in a safe manner age categories. Cylinder handling was not done safely by the majority of respondents with over 40 years of age (84%), followed by respondents within 31-40 years of age at 81%, and lastly respondents within 18-30 years of age at 59%. This association of cylinder handling and age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =17.471 since p=<.001. Cylinder

handling was not done safely by the majority of respondents with up to tertiary education (86%); followed by respondents with up to secondary education (74%), and lastly, respondents with up to primary education at 58%. This association of cylinder handling and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =14.193 since p=<.001. Cylinder handling was not done safely by the majority of respondents with less than five years of experience in the gas retail business (81%), followed by respondents with over ten years of experience (76%), and lastly respondents with 6-10 years of experience at 56%. This association of cylinder handling and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =19.459 since p=<.001.

Plate 3: Depicting improper cylinder storage

From the literature reviewed (Subsection2.1.5.7), cylinders should be stored with their valves uppermost.

4.4.3 Cylinder transportation

In line with figure 4.5; In 79.8% of the sites visited, transportation of cylinders was not done safely.

Table 4.20: Association between respondents' demographics and cylinder transportation.

Variable	Category	Cylinders transported in a safe manner		
		No	Yes	Chi-Square
Gender	Male	77%	23%	X^2=5.465 , df=1 , p=.019
	Female	91%	9%	
Age	18-30 years	79%	21%	
	31-40 years	80%	20%	X^2=0.100, df=2, p=.951
	> 40 years	81%	19%	
Education level	primary	80%	20%	
	Secondary	73%	27%	X^2=13.110 , df=2 , p=.001
	Tertiary	94%	6%	
Lpg retailing experience	< 5 years	89%	11%	
	6-10 years	66%	34%	X^2=23.685 , df=2 , p=<.001
	> 10 years	67%	33%	

Association between gender and cylinder transportation was assessed, and the results indicated that cylinders were not transported safely in most workplaces with female respondents (91%) as compared to male respondents (77%). This association of cylinder transportation and gender of the respondents was statistically significant at a 95% confidence level with χ^2 (df=1) =5.465 since p=.019. Cylinder transportation was not undertaken in a safe manner of age categories. Cylinder transportation was not done safely by the majority of respondents with over 40 years of age (81%), followed by respondents within 31-40 years of age at 80%, and lastly, respondents within 18-30 years of age at 79%. This association of cylinder transportation and age of the respondents was not statistically significant at a 95% confidence level with χ^2

(df=2) =0.100 since p=<.951. Cylinder transportation was not done safely by majority of respondents with up to tertiary education (86%); followed by respondents with up to tertiary education (94%); followed by respondents with up to primary education (80%) and lastly respondents with up to secondary education at 73%. This association of cylinder transportation and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =13.110 since p=.001. Cylinder transportation was not done safely by the majority of respondents with less than five years of experience in the gas retail business (89%), followed by respondents with over 10 years of experience (67%); and lastly respondents with 6-10 years of experience at 66%. This association of cylinder transportation and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =23.685 since p=<.001.

4.4.4 Cylinder maintenance and labeling

In congruence with figure 4.5, In 58.9% of the sites visited, cylinders weren't well maintained, and appropriate labeling wasn't done as required.

Table 4.21: Association between respondents' demographics and Cylinder maintenance and labeling.

Variable	Category	Cylinders well maintained/appropriate labeling		
		No	Yes	Chi-Square
Gender	Male	57%	43%	X^2=2.294 , df=1 , p=.130
	Female	68%	32%	
Age	18-30 years	56%	44%	
	31-40 years	63%	37%	X^2=2.159, df=2 , p=.340
	> 40 years	54%	46%	
Education level	primary	68%	32%	
	Secondary	50%	50%	X^2=9.348 , df=2 , p=.009
	Tertiary	67%	33%	
Lpg retailing experience	< 5 years	68%	32%	
	6-10 years	43%	57%	X^2=16.410 , df=2 , p=<.001

> 10 years	57%	43%

Association between gender and cylinder maintenance/labeling was assessed, and the results indicated that cylinders were not maintained/labeled properly in most workplaces with female respondents (68%) as compared to male respondents (57%). This association of cylinder maintenance/labeling and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =2.294 since p=.130. Cylinder maintenance/labeling was not undertaken properly across all age categories. Cylinder maintenance/labeling was not done properly by the majority of respondents within 31-40 years of age (63%), followed by respondents within 18-30 years of age at 56%, and lastly, respondents with over 40 years of age at 54%. This association of cylinder maintenance/labeling and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =2.159 since p=.340. Cylinder maintenance/labeling was not done appropriately by the majority of respondents with up to primary education (68%), followed by respondents with up to tertiary education (67%). On the other hand, cylinder maintenance/labeling was properly done by 50% of respondents with up to secondary education. This association of cylinder maintenance/labeling and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =9.348 since p=.009. Cylinder maintenance/labeling was done properly by the majority of respondents with less than five years of experience in the gas retail business (68%), followed by respondents with over ten years of experience (57%).On the other hand, cylinder maintenance/labeling was properly done by respondents with 6-10 years of experience at 57%. This association of cylinder maintenance/labeling and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =16.410 since p=<.001.

4.4.5 Cylinder segregation

In agreement with figure 4.5; in 82.2% of the sites visited, there was no segregation of empty cylinders from full cylinders.

Table 4.22: Association between respondents' demographics and cylinder segregation.

Variable	Category	Segregation of empty and full cylinders		
		No	Yes	Chi-Square
Gender	Male	83%	17%	X^2=0.159 , df=1 , p=.690
	Female	80%	20%	
Age	18-30 years	84%	16%	
	31-40 years	81%	19%	X^2=0.215, df=2, p=.898
	> 40 years	81%	19%	
Education level	primary	99%	1%	
	Secondary	75%	25%	X^2=20.587 , df=2 , p=<.001
	Tertiary	78%	22%	
Lpg retailing experience	< 5 years	82%	18%	
	6-10 years	84%	16%	X^2=1.976 , df=2 , p=.372
	> 10 years	71%	29%	

Association between gender and cylinder segregation was assessed, and the results indicated that segregation of empty and full cylinders was not undertaken in most workplaces with male respondents (83%) followed by female respondents at 80%. This association of cylinder segregation and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =0.159 since p=.690. The majority of respondents did not undertake cylinder segregation within 18-30 years of age (84%), followed by respondents within 31-40 years of age and over 40 years of age, both at 81%. This association of cylinder segregation and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =0.215 since p=.898. The majority of respondents did not undertake cylinder segregation with up to primary education (99%), followed by respondents with up to tertiary education (78%), and lastly, respondents with up to secondary education at 75%. This association of cylinder segregation and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =20.587 since

p=<.001. Cylinder segregation was undertaken by the majority of respondents with 6-10 years of experience (84%), followed by respondents with less than five years of experience (82%), and lastly, respondents with over ten years of experience at 71%. This association of cylinder segregation and operation period/experience of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =1.976 since p=<.372.

4.4.6 Storage area construction

In 55% of the sites visited, the storage areas were not constructed properly.

Table 4.23: Association between respondents' demographics and storage area construction.

Variable	Category	Storage area properly constructed		
		No	Yes	Chi-Square
Gender	Male	54%	46%	X^2=0.769 , df=1 , p=.381
	Female	61%	39%	
Age	18-30 years	55%	45%	
	31-40 years	63%	37%	X^2=10.225, df=2, p=.006
	> 40 years	35%	65%	
Education level	primary	60%	40%	
	Secondary	47%	53%	X^2=8.951 , df=2 , p=.011
	Tertiary	68%	32%	
Lpg retailing experience	< 5 years	63%	37%	
	6-10 years	44%	56%	X^2=11.179 , df=2 , p=.004
	> 10 years	43%	57%	

Association between respondents' demographics and cylinder storage area construction was assessed, and the results indicated that; the storage area was not properly constructed in most workplaces with female respondents (61%) as compared to male respondents (54%). This association of storage area construction and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =0.769 since p=.381. Most respondents did not properly construct the cylinder

storage area within 31-40 years of age (63%), followed by respondents within 18-30 years at 55%. Conversely, the storage area was constructed properly by 65% of respondents with over 40 years of age. This association of cylinder storage area construction and age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =10.225 since p=.006. The majority of respondents did not properly construct the storage with up to tertiary education (68%), followed by respondents with up to primary education at 60%. On the other hand, the storage area was properly constructed by 53% of the respondents with up to secondary education. This association of cylinder storage area construction and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =8.951 since p=.011. The storage area was not properly constructed by the majority of respondents with less than five years of experience in the gas cylinder retail business (53%). 57% of respondents with over ten years of experience in the Lpg cylinder retail had constructed their cylinder storage areas properly. 56% of respondents with 6-10 years of experience had also constructed their Lpg cylinder storage areas properly. This association of cylinder storage area construction and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =11.179 since p=.004.

4.4.7 Material data sheets

From the analyzed data presented in figure 4.5, 78.8% of the study sites did not have product data sheets of the gas cylinders they were retailing to consumers.

Table 4.24: Association between respondents' demographics and material datasheets.

Variable	Category	MDS Available		
		No	Yes	Chi-Square
Gender	Male	77%	23%	X^2=1.999 , df=1 , p=.157
	Female	86%	14%	
Age	18-30 years	72%	28%	
	31-40 years	85%	15%	X^2=6.282, df=2, p=.043

	> 40 years	77%	23%	
Education level	primary	80%	20%	
	Secondary	73%	27%	X^2=8.065 , df=2 , p=.018
	Tertiary	90%	10%	
Lpg retailing experience	< 5 years	87%	13%	
	6-10 years	71%	29%	X^2=27.655 , df=2 , p=<.001
	> 10 years	43%	57%	

Association between respondents' demographics and availability of material data sheets was assessed. The results indicated that material data sheets were not available in most workplaces with female respondents (86%) as compared to male respondents (77%). This association of availability of material data sheets and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =1.999 since p=.157. Material data sheets were not available in most workplaces with respondents within 31-40 years of age (85%), followed by respondents with over 40 years of age at 77%, and lastly followed closely by 72% respondents within 18-30 years of age. This association of availability of material data sheets and the age of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =6.282 since p=.043. Material data sheets were not available in most workplaces with respondents with up to tertiary education (90%), followed by respondents with up to primary education at 80%, and lastly, respondents with up to secondary education at 73%. This association of availability of material data sheets and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =8.065 since p=.018. 87% of respondents with less than five years of experience; and 71% of respondents with 6-10 years of experience did not have material data sheets at the workplace. On the other hand, 57% of respondents with over ten years of experience in the Lpg cylinder retail business had material data sheets at the workplace. This association of availability of material data sheets and operation

period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =27.655 since p=<.001.

4.4.8 Workplace Inspections

In consonance with data analyzed and presented in figure 4.5; It is worth noting that in 87.7% of the sites visited, workplace inspections had never been undertaken at all. Workplace-fire safety risk assessments had also not been undertaken in 95.5% of the sites visited.

Table 4.25: Association between respondents' demographics and workplace inspections.

Variable	Category	Inspections are undertaken regularly		
		No	Yes	Chi-Square
Gender	Male	88%	12%	X^2=0.002 , df=1 , p=.965
	Female	87%	13%	
Age	18-30 years	84%	16%	
	31-40 years	89%	11%	X^2=2.474, df=2, p=.290
	> 40 years	93%	7%	
Education level	primary	96%	4%	
	Secondary	81%	19%	X^2=11.655 , df=2 , p=.003
	Tertiary	91%	9%	
Lpg retailing experience	< 5 years	94%	6%	
	6-10 years	82%	18%	X^2=27.761 , df=2 , p=<.001
	> 10 years	57%	43%	

Association between respondents' demographics and workplace inspections was assessed. The results indicated that inspections were not undertaken regularly in most workplaces with male respondents (88%) followed closely by female respondents at 87%. This association of inspections and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =0.002 since p=.965. Inspections were not regularly in most workplaces with respondents with over 40 years of age (93%), followed by respondents within 31-40 years of age at 89%,

followed closely by 84% respondents within 18-30 years of age. This association of inspections and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =2.474 since p=.290. Inspections were not undertaken regularly in most workplaces with respondents with up to primary education (96%), followed closely by respondents with up to tertiary education at 91%, and finally respondents with up to secondary education at 81%. This association of workplace inspections and education level of the respondents was statistically significant at 95% confidence level with χ^2 (df=2) =11.655 since p=.003. Inspections were not regularly undertaken in most workplaces with respondents with less than five years of experience (94%), followed by respondents with 6-10 years of experience at 82%, and finally respondents with over ten years of experience at 57%. This association of workplace inspections and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =27.761 since p= <.001.

4.4.9 Lighting

From the data analyzed and presented in figure 4.5, 45.5% of the sites visited did not have adequate lighting.

Table 4.26: Association between respondents' demographics and lighting.

Variable	Category	Adequate lighting		
		No	Yes	Chi-Square
Gender	Male	43%	57%	X^2=3.756 , df=1 , p=.053
	Female	57%	43%	
Age	18-30 years	40%	60%	
	31-40 years	52%	48%	X^2=3.572, df=2, p=.168
	> 40 years	42%	58%	
Education level	primary	56%	44%	
	Secondary	38%	62%	X^2=6.806 , df=2 , p=.033
	Tertiary	49%	51%	

Lpg retailing experience	< 5 years	50%	50%	X^2=6.168, df=2 , p=.046
	6-10 years	42%	58%	
	> 10 years	24%	76%	

The association between respondents' demographics and adequacy of lighting at the workplace was assessed. The results indicated that lighting was not adequate in most workplaces with female respondents (57%). On the other hand, lighting was adequate in 57% of workplaces with male respondents. This association of lighting and gender of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=1) =3.756 since p=.053. Lighting was not adequate in most workplaces with respondents within 31-40 years of age (52%).

On the other hand, 60% of workplaces with respondents within 18-30 years of age (60%) had adequate lighting, followed closely by respondents with over 40 years of age at 58%. This association of adequacy of lighting and age of the respondents was not statistically significant at a 95% confidence level with χ^2 (df=2) =3.572 since p=.168. Lighting was not adequate in most workplaces, with respondents with up to primary education (56%). On the other hand, 62% of workplaces with respondents with up to secondary education had adequate lighting, followed by respondents with up to tertiary education at 51%. This association of adequacy of lighting and education level of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =6.806 since p=.033. The operation period in the Lpg cylinder retail business had a direct relationship with the adequacy of lighting at the workplace. 76% of workplaces with respondents with over ten years of experience had adequate lighting, followed by respondents with 6-10 years of experience at 58% and finally respondents with less than five years of experience at 50%. This association of adequacy of lighting and operation period/experience of the respondents was statistically significant at a 95% confidence level with χ^2 (df=2) =6.168 since p= .046.

4.4.10 Cylinder Branding

Lpg cylinders were also inspected if branded or not and findings presented in figure 4.6 below

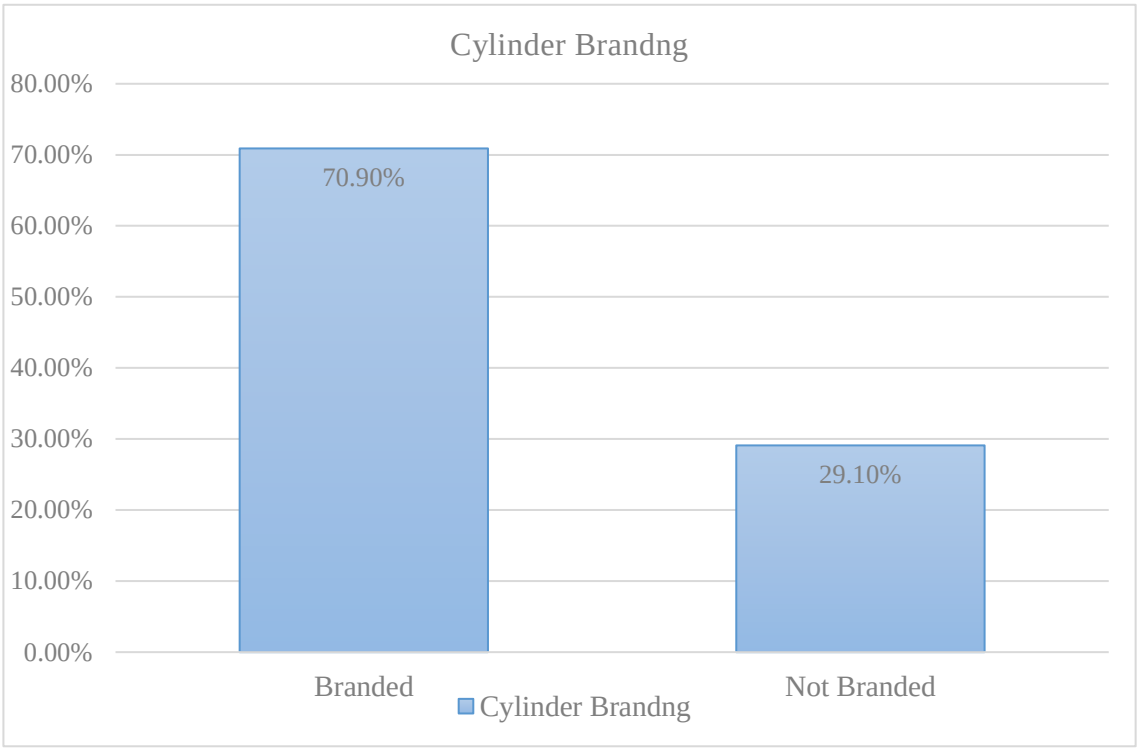


Figure 4.6 Cylinder branding

In accordance with figure 4.6 above, most of the Lpg cylinders,70.9%, were branded. On the other hand, 29.1% of the Lpg cylinders were not branded. This is alarming as far as Lpg safety is concerned. The unbranded Lpg cylinders may be a likely indication of illegal gas filling as no registered supplier/wholesaler will circulate their gas in the market in an unbranded cylinder.

4.4.11 EPRA Licensing

The sites visited were also inspected if they had been licensed by the Energy and petroleum regulatory authority. Findings are presented in figure 4.7 below

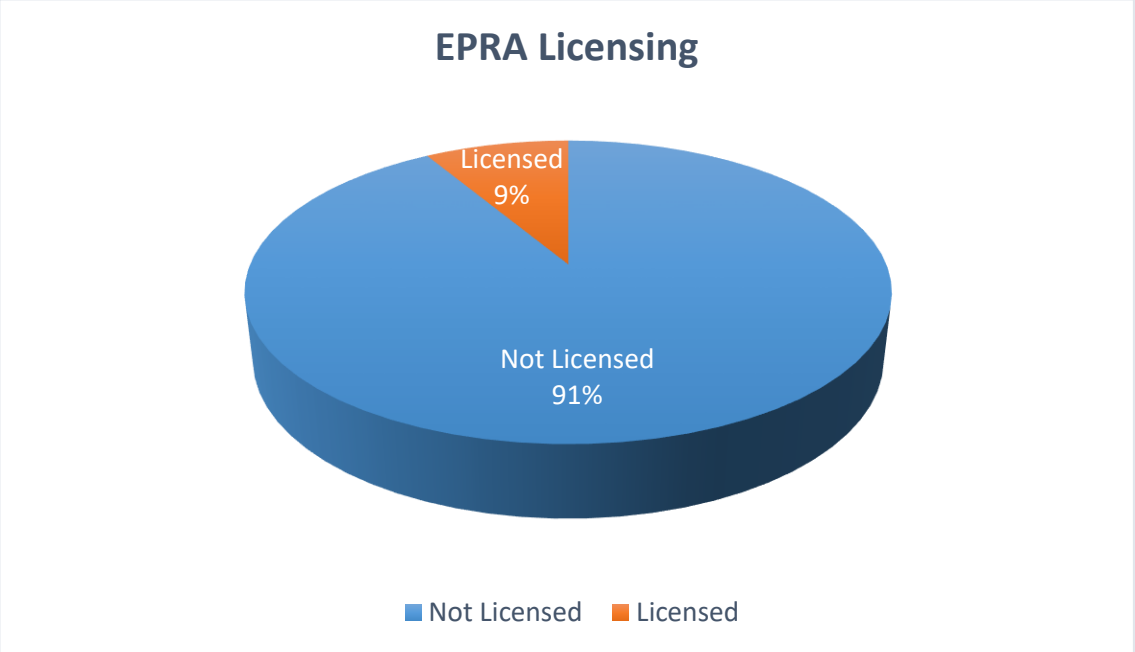


Figure 4.7 EPRA Licensing

As attested by figure 4.7 above, the majority of the sites visited, 91%, were not licensed by EPRA. EPRA licensed only 9% of the sites visited.

4.4.12 Lpg cylinder filling and Non-destructive testing

Weight measurements and non-destructive tests were undertaken as per the methodology in chapter 3, section 3.5.3, subsection 3.5.3.1. The results are presented in table 5.1 and 5.2 below.

Table 5.1: 6Kg Lpg cylinder measurements & leak test.

Cylinder Code	Site	Tare Weight (Kg)	Measured Gross Weight (Kg)	Lpg Weight (Kg)	Leak test		Conforms	Reason
					Leak	No leak		
6C1	Thika	8.6	14.9	6.3	No	Yes	No	OF
6C2	Thika	7.8	14.0	6.2	No	Yes	Yes	N/A
6C3	Thika	8.0	14.1	6.1	No	Yes	Yes	N/A
6C4	Thika	8.5	14.8	6.3	No	Yes	No	OF
6C5	Thika	8.0	14.3	6.3	No	Yes	No	OF
6C6	Thika	8.4	14.6	6.2	No	Yes	Yes	OF
6C7	Thika	8.3	14.7	6.4	No	Yes	No	OF
6C8	Thika	8.0	14.1	6.1	Yes	No	No	L
6C9	Thika	8.3	14.1	5.8	No	Yes	Yes	N/A
6C10	Thika	8.2	14.0	5.8	No	Yes	Yes	N/A
6C11	Thika	8.1	13.8	5.7	No	Yes	No	UF
6C12	Thika	8.5	14.6	6.1	No	Yes	Yes	N/A
6C13	Thika	8.6	14.6	6.0	No	Yes	Yes	N/A
6C14	Thika	9.2	15.4	6.2	No	Yes	Yes	N/A
6C15	Thika	8.5	14.4	5.9	No	Yes	Yes	N/A
6C16	Juja	8.5	14.1	5.6	No	Yes	No	UF
6C17	Juja	8.7	13.9	5.2	Yes	No	No	L/UF
6C18	Juja	8.5	13.9	5.4	Yes	No	No	L/UF
6C19	Juja	8.2	13.8	5.6	No	Yes	No	UF
6C20	Juja	8.9	14.8	5.9	No	Yes	Yes	N/A
6C21	Juja	8.0	14.2	6.2	No	Yes	Yes	N/A
6C22	Juja	8.2	14.5	6.3	No	Yes	No	OF
6C23	Juja	8.7	14.8	6.1	Yes	No	No	L
6C24	Juja	8.3	14.3	6.0	No	Yes	Yes	N/A
6C25	Juja	8.0	14.4	6.4	No	Yes	No	OF
6C26	Juja	8.5	14.7	6.2	No	Yes	Yes	N/A
6C27	Juja	8.7	13.8	5.1	Yes	No	No	L
6C28	Juja	9.2	15.0	5.8	No	Yes	Yes	N/A

6C29	Juja	8.4	14.6	6.2	No	Yes	Yes	N/A
6C30	Juja	8.3	14.2	5.9	No	Yes	Yes	N/A
Mean		**8.4**	**14.4**	**6.0**				
SD		**0.33415**	**0.3995**	**0.33235**				

LEGEND

N/A Not Applicable
UF Underfilled
L Leakage
OF Overfilled

Tolerance: +-0.2Kg

Being academic research, names, and details of the cylinder brand owners and respondents were withheld for the protection of the dignity of the subjects, respect for anonymity, and confidentiality of the respondents who cooperated all through the data collection period.

4.4.12.1 6Kg cylinder conformity based on leak test and weight measurements

From Table 5.1, it was found out that for the 6kg cylinders, the Lpg measured weight ranged between 5.1 Kg to 6.1Kg with a mean of 6.0Kg and a standard deviation of 0.3323. 16.7% of the cylinders were found to be leaking from the valve, therefore not conforming. Leakages from the valve area, however minor, maybe a likely indication of tampering with the valves during illegal gas refilling. 40% of the cylinders were not conforming for cylinder filling.

Table 5.2: 13Kg Lpg cylinder measurements & leak test.

Cylinder Code	Site	Tare Weight (Kg)	Measured Gross Weight (Kg)	Lpg Weight (Kg)	Leak test		Conforms	Reason
					Leak	No leak		
13C1	Thika	18.0	30.8	12.8	No	Yes	Yes	N/A
13C2	Thika	12.8	25.5	12.7	No	Yes	No	UF
13C3	Thika	11.9	24.8	12.9	No	Yes	Yes	N/A
13C4	Thika	12.7	25.7	13.0	No	Yes	Yes	N/A
13C5	Thika	13.5	26.7	13.2	No	Yes	Yes	N/A
13C6	Thika	13.0	26.2	13.2	No	Yes	Yes	N/A
13C7	Thika	11.9	25.1	13.2	No	Yes	Yes	N/A
13C8	Thika	12.0	25.4	13.4	Yes	No	No	L
13C9	Thika	12.5	25.4	12.9	No	Yes	Yes	N/A
13C10	Thika	12.9	26.0	13.1	No	Yes	Yes	N/A
13C11	Thika	11.9	24.7	12.8	No	Yes	Yes	N/A
13C12	Thika	13.4	26.4	13.0	No	Yes	Yes	N/A
13C13	Juja	13.0	26.1	13.1	No	Yes	Yes	N/A
13C14	Juja	12.7	25.4	12.7	No	Yes	No	UF
13C15	Juja	13.9	26.7	12.8	No	Yes	Yes	N/A
13C16	Juja	14.0	26.6	12.6	No	Yes	No	U/F
13C17	Juja	12.7	26.0	13.3	Yes	No	No	L
13C18	Juja	11.3	23.8	12.5	No	Yes	Yes	N/A
13C19	Juja	12.0	24.6	12.6	No	Yes	No	UF
13C20	Juja	12.1	24.9	12.8	No	Yes	Yes	N/A
13C21	Juja	12.2	25.1	12.9	No	Yes	Yes	N/A
13C22	Juja	14.3	27.5	13.2	No	Yes	Yes	N/A
13C23	Juja	13.5	26.7	13.2	No	Yes	Yes	N/A
13C24	Juja	11.9	25.0	13.1	No	Yes	Yes	N/A
Mean		**12.9**	**25.9**	**13.0**				
SD		**1.30319**	**1.32539**	**0.23965**				

LEGEND

N/A Not Applicable
UF Underfilled
L Leakage
OF Overfilled

Tolerance: +-0.2Kg

4.4.12.2 13Kg cylinder conformity based on leak test and weight measurements

With reference to Table 5.2, it was found out that for the 13kg cylinders, the Lpg measured weight ranged between 12.5Kg to 13.4 Kg with a mean of 13.0 Kg and a standard deviation of 0.2396, an indication that most values in the data collected were close to the mean of the data set, on average. 8.3% of the cylinders did not conform with respect to the leak test as they were found to be leaking from the valve.12.5% of the cylinders were not conforming with respect to cylinder filling.

Overfilling of cylinders is unlikely to be done deliberately and a likely indication of faulty or poorly calibrated filling equipment. Overfilling of cylinders can cause problems, as it would reduce the ullage expansion space. Overfilled cylinders left out in the sun or subjected to excessive heat put severe stress on the cylinder, causing the relief valve to discharge, and this distorts the cylinder hydraulic pressure. Underfilling of cylinders can be a deliberate act and is disadvantageous to consumers as they don't get value for their money. In line with the consumer protection act of 2012, the customer should receive all the product purchased (World Lpg Association, 2015)

4.4.12.3 Overall Lpg cylinder conformity

Along with figure 4.8, it can be ascertained that 29.17% of the 13Kg Lpg cylinders and 46.67% of the 6Kg Lpg cylinders were not conforming, based on the weight measurements and non-destructive testing.

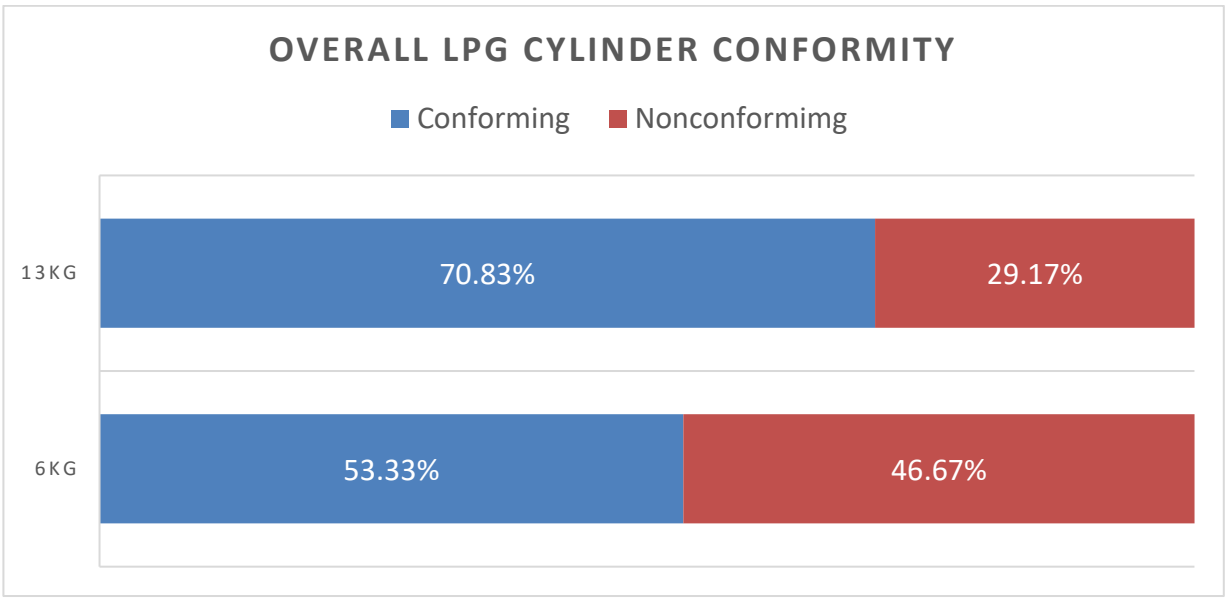


Figure 4.8: Overall Lpg cylinder conformity

From the literature reviewed, Care in handling Lpg cylinders helps minimize the number of incidents, accidents, and their consequences, and this is a key driver in safety promotion. But from data collected and analyzed, this is not respected at all in Kiambu county.

Lighting is also a very important component. Adequate lighting assists in providing a safe working environment. Safety risk assessment helps determine the anticipated hazards and risks associated with a fire originating from a gas cylinder or a fire impacting on a gas cylinder. It also helps in formulating adequate means of providing an alarm in the event of a fire, and other control measures required. Good natural ventilation is important, but also, cylinders stored in the open should have protection from the weather. Storage areas should be readily accessible but also secure to prevent access by unauthorized persons.

Regarding the Liquefied Petroleum Gas regulations of 2019 and KS ISO 4706-1:2008, the minimum safety information should state the product in the cylinder, the supplier's brand/name, the net fill amount and a flame symbol. The information should be sufficient in size to be readily legible and in color contrasting with the rest of the cylinder. However, this was not the case during the data collection phase.

An example of the many cases observed has been highlighted in the plate below

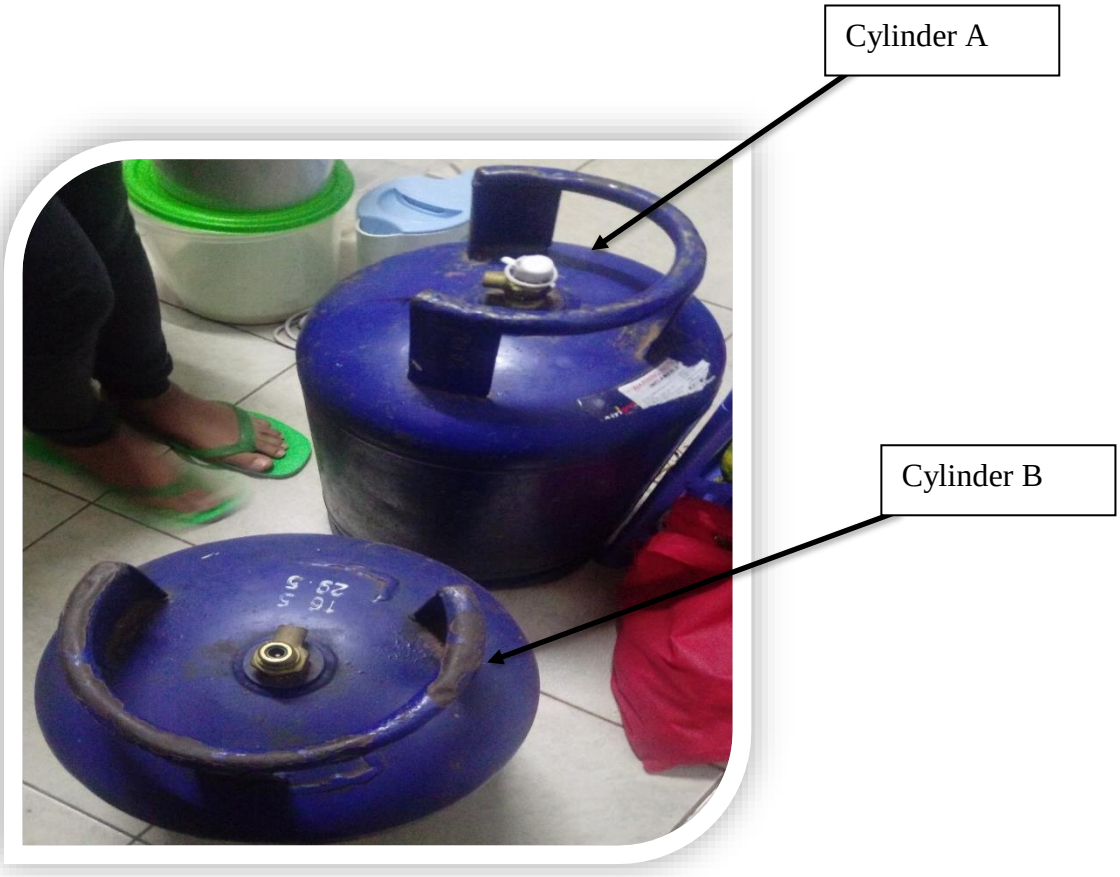


Plate 4: Depicting condition of retailed cylinders

Cylinder A: Has a valve cap and branded with the minimum safety information, states the product in the cylinder, the supplier, and the brand name. However, the cylinder doesn't have the tare or gross weight stamped on the neck. It is difficult for the consumer to judge whether they are getting the correct amount of the product they have paid for. This is one of the many examples that depict egregious practices in the Lpg retail business and a likely indication of illegal Lpg cylinder activities.

Cylinder B: Has the tare and gross weight stamped on the cylinder neck. However, the cylinder lacks the brand name and the supplier, the cylinder contents, and the minimum safety information. The cylinder also lacks a valve cap

In summary, the majority of the Lpg cylinder retailers, 71%, don't employ safe occupational safety and health practices in their operations.

4.4.13 Role of the Government in Lpg Safety Enhancement

Key roles of the governmentin lpg safety enhancement are the elimination of bad practices and providing a competitive business climate (Refer to Subsection 2.1.9 in Chapter 2). While the Lpg retailers in Kiambu county work hard to provide sustainable modern energy to the residents, the government ought to be aware and work to rectify some of the egregious practices in the industry. This includes: poorly designed and constructed storage facilities, inadequate training of retailers, operating in unauthorized premises, use of unsafe cylinders, illegal filling of cylinders, unauthorized acquisition, reworking and repainting of cylinders, and general cylinder maintenance.

The provision of competitive business climate by government entails establishment and enforcement of sound governmental practices to ensure common rules for all participants in the market are equally applied and enforced. This has been effected through the enactment of the Petroleum (Liquefied Petroleum Gas) Regulations, 2019: Legal notice No.100.

The body responsible for the elimination of bad practices and providing a competitive business climate is the Energy and petroleum regulatory authority (EPRA) previously known as ERC. EPRA'S environmental health and safety section provides leadership on the commission's environmental health and safety mandate. Section 11 (g) of the Energy Act, 2019 mandates the Authority to formulate, set, enforce and review environmental, health, safety, and quality standards for the energy sector in coordination with other statutory authorities. EPRA's Environment, health, and safety (EHS) section works in collaboration/consultation with statutory authorities, e.g., NEMA and DOSH and its main functions include formulation, enforcement, and review of EHS and quality standards for the energy sector; monitoring energy sector EHS compliance, enforcing EHS and quality standards for the energy sector, investigating accidents and incidents, checking EHS compliance for license or permit application and requesting and analyzing Licensee EHS performance records.

Surprisingly; the study established that the relevant agency does not actively undertake its mandated roles as far as Lpg cylinder safety in Kiambu county is concerned. This

includes: routine inspections to check for compliance, fire safety risk assessments, sensitization of retailers (on the importance of safety in the Lpg retail industry, cylinder handling and storage, importance of PPE's and emergency preparedness, importance of reporting incidents and accidents to the authority however minor). This may be due to understaffing and underfunding.

4.5 Challenges to good occupational safety and health practices

The third objective sought to explore the challenges to good occupational safety and health practices in the Lpg cylinder retail business in Kiambu County. This was done by asking the Lpg retailers an open-ended question as to why they did not observe recommended OSH practices. Majority of the responses revolved around three major areas. The responses were tabulated, ranked, and findings presented in figure 4.8 below.

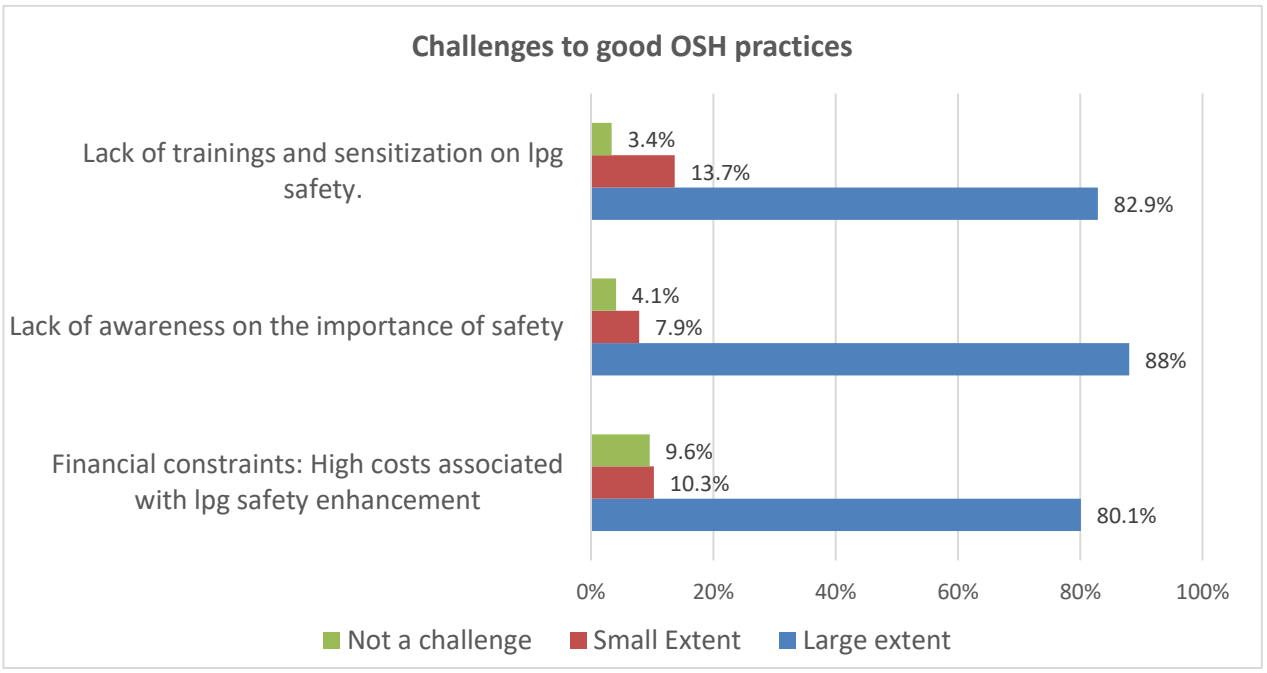


Figure 4.9 Challenges to good occupational safety and health practices

Altogether, failure to comply with safety and health requirements came down to cost (high costs associated with Lpg safety enhancement), lack of awareness on the importance of safety, and lack of pieces of training and sensitization on Lpg cylinder safety.

The majority of gas retailers stated that complying with various requirements such as PPE's, safety pieces of training had a cost implication which they did not want to incur.

Below are some of the responses from the respondents.

Enhancing safety is very expensive and will reduce our profits to a great degree

I have never heard of these things you are telling me. But I think it is an important area.

I don't see how this will help me. It is not important in this business.

I have never been trained or received any sensitization/awareness on these issues. I wish I were trained or made aware of these issues.

4.6 Additional data from EPRA

Additional data was obtained from EPRA. The data was requested on August 2020, and received on September 2020 (to be used for academic purposes). This included a summary of Lpg accidents in Kenya for the financial year 2019/2020, and registered Lpg retailers, per County, as at August 2020.

The total number of accidents for the financial year 2019/2020 were 10, whereby 50% of this accidents occurred in Nairobi County. Root causes of the accidents were: leakages of Lpg cylinders leading to fire, poor end use due to inadequate knowledge, poor technician training leading to poor installation hence an explosion, external heat application leading to a BLEVE scenario, manufacturer's default-defective bung weld, and negligence in fixing the Lpg burner while in proximity to a burning stove.

As at August 2020, the authority had managed to register 6,367 pg retailers in the whole country; with Nairobi County having the highest number of registered retailers (1,396), followed by Kiambu County (968). It's worth nothing that some Counties only have one registered Lpg retailer each. This counties are: Tana River, Lamu, and Mandera Counties. Other Countier with less than ten registered Lpg retailers include: Wajir County (4), Marsabit County (6), West Pokot County (3), Samburu County (7),

Elgeyo-Marakwet County (5), and Baringo County (8). All the information received from EPRA is included in the appendix section.

4.7 Data From Related Studies

From the first case study on fire and explosion of Lpg at Feyzin, France. The accident was brought about by human error whereby the operators did not close the Lpg tank valves properly. Lpg then escaped and spread along the ground. The escaped Lpg was ignited by a car passing through the local road and exploded. Further, the fire reached the 1200m^3 tank from which the Lpg first leaked. The tank exploded and the fire spread to five other tanks in the same yard and property worth millions destroyed. Eighteen people died and dozens injured. This is the same scenario that happened in Bomet and Nyandarua Counties. The root cause of the Bomet accident was the accumulation of Lpg vapour leading to a fire. In Nyandarua County, the accident happened due to external heat application leading to a BLEVE scenario. From the research, 61% of the respondents agreed that Lpg could explode if exposed to high temperatures. 16.4% of the respondents disagreed with the statement, while 22.6% did not know what to say regarding the subject as they were honestly unaware. In terms of gender, male respondents (62%) were more aware of cylinder explosion at high temperatures as compared to female respondents at 55%. The association of awareness on cylinder explosion and gender of the respondents was not statistically significant at 95% confidence level with X^2 (df=2) =1.454 since p=.483 was more than the conventional 5% level of significance. The association of awareness of cylinder explosion at high temperatures and respondents' age was not statistically significant at a 95% confidence level with X^2 (df=4) =8.851 since p=.065. Most of the respondents with up to secondary education (69%) were aware of cylinder explosion at high temperatures, followed by respondents with up to primary education (63%). Only 41% of respondents with up to tertiary education level were aware of cylinder explosion at high temperatures. This association of awareness of cylinder explosion at high temperatures and respondents' education level was statistically significant at a 95% confidence level with X^2 (df=4) =20.235 since p= <.001. Most respondents with more than ten years of experience (90%) were more aware that cylinders can explode at high temperatures, followed by respondents 6-10 years of experience at 70 %, and lastly,

respondents with less than five years of experience at 53%. There is a direct relationship between operation period and awareness on cylinder explosion at high temperatures. The association of awareness of cylinder explosion at high temperatures with operation period/experience was statistically significant at a 95% confidence level with X^2 (df=4) =17.457, since p= .002.

The case study was on a fatal Lpg cylinder blast accident in India. The cylinder had a defective valve, which caused a leak and the subsequent explosion that killed two people. The same scenario happened in Nairobi and Nakuru Counties. In Nairobi County, the root causes of the accidents were: Manufacturer's Default-Defective bung weld and leakage of Lpg from a cylinder leading to a fire. In Nakuru County, the root cause of the accident was the manufacturer's default- defective ball valve. The injuries in these cases were mainly of primary impact due to the blast waves caused by the Lpg cylinder blast. From the analyzed data on the non-destructive cylinder tests conducted, 16.7% of the 6Kg cylinders were found to be leaking from the valve whereas 8.3% of the sampled 13kg cylinders were also found to be leaking from the valve. Leakages from the valve may be due to the manufacturer's default or a likely indication of illegal gas refilling activities (thus tampering with the valve).

The third study carried out by Kaburia R (May 2015) on challenges of Lpg penetration in Kenya. In his findings, safety issues had a positive influence on Lpg penetration in the Kenyan market(P=0.03). The findings were also in line with a study by Akuffo et al, 2008, which indicated that safety safety problems and associated perceptions are likely barriers to the use of Lpg. The study further concludes that respondents agreed to a great extent (56%) that safety issues affected Lpg penetration in the Kenyan market. 29% agreed to a little extent that safety issues affected Lpg penetration in Kenya, 13% agreed to a moderate extent, while 2% agreed to a little extent that safety issues affected Lpg penetration in the Kenyan market. This is also in agreement with this study that safety awareness to all participants in the Lpg cylinder industry is paramount. Kaburia further recommended that appropriate safety measures to be put in place in the various distribution channels to a great extent as this will not only help maintain good supply standards but also will help achieve high levels of efficiency and effectiveness. This is also in agreement with this study that Lpg retailers should

put in place appropriate safety measures in their workplaces. The appropriate safety measures include but not limited to: proper housekeeping, proper cylinder handling and maintenance, proper cylinder transportation, appropriate labelling and cylinder maintenance, cylinder segregation, proper storage area construction, routine workplace inspections, adequate lighting and EPRA licensing. To achieve this, awareness of the subject is key. From this research, failure to comply with safety and health requirements came down to high costs associated with Lpg safety enhancement, lack of awareness on the importance of safety, and lack of pieces of training and sensitization on Lpg safety.

The fourth study was carried out in Turkey (Kapi et al. 2017) on an unusual etiology in cold injury. When the affected persons were questioned about Lpg and its effects, they did not have any knowledge of the possibility of developing cold injuries due to contact with Lpg. This is in agreement with this study as 99.3% of the respondents were not aware that Lpg can cause cold burns when it comes into contact with the skin. From the fourth study, no studies investigating the correlation between gender and Lpg related cold injury were found. However, a predominant of male gender among patients was observed. Thus, males can be at an increased risk compared to females. However, from this research, In terms of gender, Lpg cold burns awareness was sort, and the results indicated that both respondents- males at 99% and females at 100% -were not aware that Lpg could cause cold burns when it comes into contact with the skin. This association of awareness on Lpg cold burns and gender of the respondents was not statistically significant at 95% confidence level with X^2 (df=2) =1.454 since p=.483 was more than the conventional 5% level of significance. 99% of the respondents within 18-30 years of age and over 40 years of age were not aware that Lpg could cause cold burns when it comes into contact with the skin. 100% of the respondents within 31-40 years of age were not aware of the same. There's little awareness with regards to cold burns across all age brackets of Lpg cylinder retailers. This association of awareness of Lpg cold burns and the age of the respondents was not statistically significant at a 95% confidence level with X^2 (df=4) =5.208 since p=.267. Education did not seem to influence the respondents' awareness of Lpg cold burns. The association of awareness of Lpg cold burns and education level was

statistically significant at a 95% confidence level with X^2 (df=4) =35.487 since p= <.001. Operation period/ experience did not influence the respondents' awareness of Lpg cold burns as over 97% of respondents across all operation period categories were not aware that Lpg could cause cold burns when it comes into contact with the skin. The association of awareness of Lpg cold burns and operation period was not statistically significant at a 95% confidence level with X^2 (df=4) =5.636 since p=.228.

4.8 Limitation of the Study

Due to financial constraints, the researcher was not able to undertake the cylinder measurements and non destructive testing on all the study sites. The data was only collected in Thika and Juja towns. Additionally, most of the Lpg cylinder retailers were also adamant with allowing the researcher to undertake the non destructive tests and weight measurements for the cylinders. They were uncooperative and at some instances chased the researcher away, with threats.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

This chapter covers the conclusion and the recommendation of the research study based on the research findings from the collected data.

5.1 Conclusion

This study aimed to assess the occupational safety and health issues in the liquefied petroleum gas retail business in Kiambu County, Kenya. Three specific objectives guided the study: assessing the level of awareness by retailers on occupational safety and health issues in Lpg business, investigating the current occupational safety and health practices in Lpg retail business, and exploring the challenges to good occupational safety and health practices in Lpg retail business.

Undeniably, there's little observance of safety and health measures in the Lpg cylinder retail business. The majority of the retailers are not aware of the hazards they are exposed to in the Lpg retail business, therefore not able to prevent and control or act in a way to curb these hazards. The study has captured the situation as it is on the ground, for the relevant authorities to act upon.

The study established that 77% of the Lpg retailers were not aware of the occupational safety and health issues in the Lpg retail business. It was therefore concluded that the level of awareness on OSH among cylinder retailers was inadequate. It was further established that 71% of the Lpg retailers did not employ safe occupational safety and health practices in their Lpg retail operations. For the 6Kg cylinders: 16.7% were found to be leaking from the valve whereas 40% did not conform to cylinder filling requirements. For the 13Kg cylinders: 8.3% were found to be leaking from the valve whereas 12.4% did not conform to cylinder filling requirements. Leakages from the valve may be a likely indication of illegal gas refilling. Overfilling of cylinders is a likely indication of faulty or poorly calibrated filling equipment. Underfillling of cylinders is likely to be a deliberate act, that is disadvantageous to the consumers, as they don't get value for their money.

The main challenges that hindered compliance with occupational safety and health requirements were lack of awareness on the importance of safety in the Lpg retail

business, lack of pieces of training and sensitization on Lpg safety, and the high costs associated with Lpg safety enhancement. The majority of respondents reported that complying with various OSH requirements had cost implications, which they did not want to incur.

A cost analysis on the minimum amount required for minimum Lpg safety enhancement in a retail center consisting of a sole proprietor and two assistants came down to Ksh 20,000 on average.

It should be the role of the government to provide a competitive business climate and also eliminate bad practices in the Lpg cyinder retail industry.

5.2 Recommendation

From this study, the researcher recommends the following:

i. Energy and petroleum regulatory authority should keep an up to date online register of licensed Lpg retailers, which is accessible to the public. The authority should also undertake routine inspections and monitoring in all Lpg retail centers.
ii. Lpg suppliers in partnership with the County governments should raise public awareness about Lpg cylinder safety; through safety tailored campaigns on local television/radio stations, print media, and social media platforms.
iii. Each Lpg retailer should develop clear safety policy guidelines that will help ease the understanding of the safety requirements and consequently improve compliance.
iv. Technological breakthroughs to be embraced in Lpg cylinder safety enhancement.

5.3 Areas of further research

The researcher recommends that further research be done on:

i. The viability of centralized retail centers with bulk supply Lpg that can be piped to consumers
ii. Cylinder validation as an aspect of Lpg containment safety

REFERENCES

Akinyi, J. (2008). *Demand for Lpg in Kenya*. (MA thesis). Nairobi: University of Nairobi.

Alli, B. (2008). *Fundamental principles of occupational health and safety*. Geneva: International Labour Organization.

Alok,T. (2014). *Design and Analysis of Lpg Cylinder*. *International Journal of Engineering & Applied Sciences (IJEAS)*, 17-31.

Antonette, D., & Narasimha, V. (2004). *International Energy Initiative Report on the use of Lpg as a domestic cooking fuel option in India*. New Delhi,Krishna .

Association of world Lpg. (2015). *Guidelines for Good Safety Practices in the Lpg Industry.* Neuily-Sur-Seine: United Nations Environment Programme.

Babbie, E. (2002).*Survey research methods*, Belmont, CA: Wadsworth.

Bartlett, J., Kotrlik, J., Higgins, C. (2001).*Organizational Research: Determining Appropriate Sample Size in Survey Research*. Information Technology, Learning, and Perfomance Journal, 1(19), Spring

Beheshti, M., Dehghan, S., Hajizadeh, R., Jafari, S., & Koohpaei, A. (2018). *Modelling the Consequences of Explosion, Fire and Gas Leakage in Domestic Cylinders Containing Lpg.* Annals of Medical & Health Sciences Research. 2018; 8: 83-88

BOC. (2012). *Guidelines for gas cylinder safety.* Australia

Concordia University. (2017). *Environmental Health and Safety, Compressed gas safety manual.* Montreal: Canada

Cochran, W. (1963). *Sampling Techniques*, (2nd Ed). New York: John Wiley and Sons.

Competition Commision of South Africa. (2017). *Market Inquiry Into The Lpg Sector.* Pretoria: Government Gazette.

County Government Of Kiambu. (2015). *County Integrated Development Plan, 2013 – 2017.* Kiambu: County Government Of Kiambu.

County Government of Kiambu. (2015). *Kiambu Agriculture, Livestock & Fisheries 2013-2017 Strategic Plan.* Kiambu: County Government of Kiambu.

County Government Of Kiambu. (2018). *County Integrated Development Plan, 2018 – 2022.* Kiambu: County Government Of Kiambu.

County Government of Kiambu. (2016). *Department of finance and economic planning. Annual development plan 2017/2018.* Kiambu: County Government of Kiambu.

County Government of Kiambu. (2018). *County Annual Development Plan 2018/2019.* Kiambu: County Government of Kiambu.

Dainty, S. (2017). *Storage, use and handling of gas cylinders guidance 202.* OHSS.

Government of Kenya. (2007). *Factories and other places of Work. Fire risk reduction rules.*

Nairobi, Kenya: Government Printer

Government of Kenya. (2012). *Consumer Protection Act No. 46 of 2012*. Nairobi: Government Printer.

Guetterman, C. (2015). *Descriptions of Sampling Practices Within Five Approaches to Qualitative Research in Education and the Health Sciences*. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *16*(2), Art. 25. Retrieved from http://nbn-resolving.de/urn:nbn:de:0114-fqs1502256.

Hammeeda, A. (2016). *Assessment of the use of liquefied petroleum gas as cooking energy source among rural households in Badagry area of Lagos Sstate.* American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 16-28.

Health and Safety Executive. (2011). *Safe use of liquefied petroleum gas at small commercial and industrial bulk installations.* Sudbury: Health and safety Executive.

Health and Safety Executive. (2012). *The safe use of gas cylinders.* Sudbury: Health and Safety Executive.

Health and Safety Executive. (2016). *Liquefied Petroleum Gas- industrial and commercial users awareness of their legal responsibilities.* Health and Safety Executive.

Joan, E. (2008). *Demand For Liquefied Petroleum Gas (Lpg) In Kenya: 1971 - 2005.* Nairobi: University of Nairobi.

Kaburia, R. (2016). *Challenges Of Liquid Petroleum Gas Penetration In Kenya. International Journal of Business, Social Sciences and Education,* 161-180.

Kariithi, S., C.Mburu., & R. Kinyua. (2017). *Awareness of occupational safety and health issues in Roadway maintenance works in Nyeri County, Kenya.* International journal of innovative research and development, October 2017 10(6).

Kenya National Bureau of Statistics. (2013). *Exploring Kenya's Inequality. Pulling apart or pulling together ? Kiambu County.* Nairobi: Kenya National Bureau of Statistics.

Kenya National Bureau of Statistics. (2017). *Economic Survey 2017. Kenya National Bureau of Statistics.* Nairobi: Kenya National Bureau of Statistics. ISBN:978-9966-102-00-3

Kenya National Bureau of statistics, (2019). *Kenya population and housing census: volume 1, November 2019.* Nairobi: Kenya National Bureau of Statistics. ISBN:978-9966-102-09-6

Kothari, C. (2004). *Research Methodology (Methods and Techniques).* New Delhi: New Age International Publishers.

Kothari, C. & Garg. G. (2014). *Research Methodology, (Third Edition).* New Delhi: New Age International Publishers.

Maureen, H. (2017). *Lessons learned from Lpg/LNG accidents.* Joint research centre. European commission's in-house society service.

Masami, K. (2011). *The role of liquefied petroleum gas in reducing energy poverty.* The world bank.

MacNealy & Mary Sue. (1999). *Strategies for Empirical Research in Writing*. New York: Longman.

Ministry of Environment and Forestry. (2018). *Taskforce report on forest resources management and logging activities in Kenya.* Nairobi.

Ministry of forestry and wildlife. (2013). *Analysis of drivers and underlying causes of forest cover change in various forest types of Kenya*. Nairobi: Ruri Consultants.

Mitsuo, K. (2010). *Fire and explosion of Lpg tanks at Feyzin, France.* Tokyo: Graduate School of New Frontier Sciences, University of Tokyo.

Mugenda, O. & Mugenda, A. (2012). *Research methods: Quantitative and qualitative approaches (*2nd. Rev Ed). Nairobi: Act Press.

Mutai, B. (2000). *How to Write Quality Research Proposals: A Complete and Simplified Guide.* Edinburg: Thelley.

National Fire Prevention Association, (2014). *Standard for the storage and handling of liquefied petroleum gases.* Quincy, MA, USA: NFPA.

NFPA 58. (2017). *Liquefied Petroleum Gas Code.* Quincy, USA: NFPA.

Newcastle University. (2012). *Guidance for those who use and store gas cylinders.* England: Newcastle University.

Njogu, N. (2012). *Challenges facing the implementation of liqueified petroleum gas supply chain strategies in Kenya.* Nairobi: University Of Nairobi.

Occupational Safety and Health Act (2007). Nairobi: Government Press.

Oliver, P.(2013). *Purposive sampling (Ed.).* The SAGE dictionary of Social Research Methods. Retrieved from http://srmo.sagepub.com/view/the-sage-dictionary-of-social-research-methods/n162.xml, accessed on September 11, 2018.

OSHAcademy. (2017). *Course 900 study guide. Oil and gas safety management*: Geige safety group.

Patton, M. (2002). *Qualitative research and Evaluation methods (3rd Edition).* Thousand Oaks, CA: Sage Publications.

Phani, K., Raj, T., & Lemoff, C. (2006). *Fire safety analysis manual for LP-Gas storage facilities.* Propane Education and Research Council

Rai, N. & Thapa, B. (2016). *A study on purposive sampling method in research.* Nepal: Kathmandu School of Law.

Rimando, M., Brace, M., Namageyo, A., Parr, T., Sealy, D., Davis, T., Martinez, L., & Christiana, R. (2015). *Data Collection Challenges and Recommendations for Early Career Researchers. The Qualitative Report*,*20*(12),2025-2036. Retrieved from https://nsuworks.nova.edu/tqr/vol20/iss12/8

Rubin, A. & Babbie, R. (2012). *Brooks/Cole empowerment series: Essential research methods for social work.* Cengage Learning. ISBN:9781133709640

Tabin, M. (2014). *Fatal Lpg cylinder accident. Journal of Indian Academic Forensic Medicine, 31(1),* 54-59.

Tabin, M. (2014). *Fatal Lpg cylinder blast accident – a case report.* New Delhi: Journal of Indian academic Forensic medicine.

UKLpg., HSE. (2016). *Trade association for the Lpg industry in the UK. Safety changes in the industrial and commercial use of Lpg: 2009-2015.* UkLpg. HSE.

University of Queensland. (2011). *Guidelines for working safely with gases. OHS Guidelines.* Brisbane: University of Queensland.

University of Wollongong. (2015). *Storage and Handling of Gas Cylinders Guidelines.* Australia: University of Wollongong.

Wambugu, F., Mburu, C., & Gatebe, E. (2015). *Assessment of fire safety preparedness at Jomo Kenyatta International Airport Nairobi, Kenya.* Nairobi: Journal of Agriculture Science and Technology.

Weights and Measures Act. (2012). Nairobi: National Council for Law Reporting with the Authority of the Attorney General.

World Lpg Association. (2008). *Guidelines for Good Business Practices in the LP Gas Industry.* Neuilly-Sur-Seine: World LP Gas.

World Lpg Association. (2013). *Good industry practices for Lpg cylinder Management.* WLpgA

World Lpg Association. (2015). *Guidelines for good safety practices in the Lpg industry.* WLpgA, International chamber of commerce.

World Lpg Association. (2017). *Guidelines for Lpg cylinder filling*. WLPGA

Yvonne, A. (2013). *Energy Poverty and Lpg in Kenya* (MA thesis). Nairobi: University of Nairobi.

APPENDICES

Appendix I: Table for determining the minimum required sample size for a given population size for continuous and categorical data (Bartlett et al., 2001)

Population size	Sample size					
	Continuous data (margin of error=.03)			Categorical data (margin of error=.05)		
	alpha=.10 t=1.65	alpha=.05 t=1.96	alpha=.01 t=2.58	p=.50 t=1.65	p=.50 t=1.96	p=.50 t=2.58
100	46	55	68	74	80	87
200	59	75	102	116	132	154
300	65	85	123	143	169	207
400	69	92	137	162	196	250
500	72	96	147	176	218	286
600	73	100	155	187	235	316
700	75	102	161	196	249	341
800	76	104	166	203	260	363
900	76	105	170	209	270	382
1,000	77	106	173	213	278	399
1,500	79	110	183	230	306	461
2,000	83	112	189	239	323	499
4,000	83	119	198	254	351	570
6,000	83	119	209	259	362	598
8,000	83	119	209	262	367	613
10,000	83	119	209	264	370	623

NOTE: The margins of error used in the table were .03 for continuous data and .05 for categorical data. Researchers may use this table if the margin of error shown is appropriate for their study; however, the appropriate sample size must be calculated if these error rates are not appropriate. Table developed by Bartlett, Kotrlik, & Higgins.

Appendix II: Interview schedule used for data collection.

An interview schedule for the assessment of occupational safety and health issues in Lpg cylinder retail business in Kiambu County.

The information you provide will be treated in strict confidence and will not be shown to other individuals. Participation is voluntary, and your views are important and welcome.

Section A: General

1. Age (years): 18-30 { } 30-40 { } over 40 { }.
2. Gender: Male { } Female { }
3. Education level: Primary { } Secondary { } Tertiary { }
   other, specify_____
4. How long have you been in the Lpg retail business ?
   Less than 5 years { } 6-10 years { } Over 10 years { }
5. EPRA Licencing: Licensed { } Not Licensed{ }

Section B:

I. Retailers' responses on awareness on occupational safety and health issues.

OSH Aspect	***Agree***	***Neutral***	***Disagree***	***Don't know***
I always wear safety shoes at my workplace.				
I always wear safety gloves when handling gas cylinders at my workplace.				
I always wear safety glasses when handling gas cylinders at my workplace.				
I'm aware that safety signs and warning notices should be clearly shown at my workplace.				
A First aid kit is available at my workplace				
There is a fire extinguisher at my workplace.				
I have a health and safety (HSE) policy at my workplace.				
I have been trained on handling gas cylinders.				

OSH Aspect	*Agree*	*Neutral*	*Disagree*	*Don't know*
I have been trained on fire safety				
There is a Fire safety management Plan at my workplace.				
I know how to use a fire extinguisher				
I have undergone first aid training				
Cylinders should not be transported upright and in a secure position				
I'm aware that gas cylinders can explode when exposed to high temperatures				
Liquefied petroleum gas can cause cold burns when it comes into contact with skin				
In case of a gas leak, switching on lights can cause an explosion/fire				
All injuries and accidents however minor should be reported and recorded				

II. Responses on current occupational safety and health practices. (Observation)

	Agree	*Disagree*
Housekeeping is properly done		
Cylinders are stored in a safe/proper manner		
Cylinder handling is done in a safe manner.		
Cylinders are transported in a safe manner		
Cylinders are well maintained with appropriate labelling		
There's segregation of empty cylinders from full cylinders		
The Storage area is properly constructed		
Material/product data sheets are available at the workplace		
Workplace Inspections is undertaken regularly.		
There is adequate lighting in the cylinder storage area		
A fire safety risk assessment has been undertaken in the workplace		

III. Retailer's responses on challenges to good occupational safety and health practices.

Challenge	**Large extent**	**Small Extent**	**Not a challenge**
Financial constraints: High costs associated with Lpg safety enhancement			
Ignorance by retailers/staff on Lpg safety issues			
Lack of awareness on the importance of safety			
Resistance to implementation of good safety practices at the workplace			
Lack of trainings and sensitization on Lpg safety.			

Other,……
……
……
……
……
……
……
……..

Appendix III: A Checklist for Assessment of occupational health and safety issues in Lpg cylinder retail business in Kiambu County

OSH Aspect	**Yes**	**No**	**Comment**
No ignition sources near gas cylinders (ignition sources controlled)			
Designated storage areas solely for storage of gas cylinders			
Cylinders stored in upright position and secured			
Fire safety management plan in place			
HSE policy in place			
All personnel wear appropriate PPE (protective gloves { }, safety shoes { } safety glasses { }			
Proper signage and warning notices in place			
Fire extinguishers (correct type) in place.			
First aid kit available			
Empty cylinders segregated from full cylinders			
Cylinders are Branded			

Appendix IV: Select photos during data collection

Good practice: Proper cylinder storage and signages

Bad practice: Poor cylinder storage (Cylinders stored horizontally, instead of upright position)

Good practice: Retail center with business permit, ERC licensing, fire clearance certificate, and approved cylinder brands to be sold.

Cylinder non-destructive testing

Cylinder weight measurements

Appendix V: Good cylinder practices summary

Issue/Bad Practice	Risks	Remedy
(a) Illegal acquisition and re-branding of cylinders A variant of (b) where cylinders are repainted with the identification mark/brand of another company, and subsequently marketed under this brand. This often occurs across international borders, or by transporting cylinders to a region in which the original owner does not operate.	▪ Legitimate operators lose effective control over the condition of their cylinders. Pirate fillers have no incentive to adequately maintain stolen cylinders bearing the identification mark of the cylinder owner. Product Quality or quantity difficult to identify. ▪ Serious damage and injury from badly maintained cylinders. ▪ Injury and damage compensation claims difficult to process since it will be impossible to identify the original filler with certainty. ▪ Industry reputation threatened, customer less willing to use gas.	▪ Permanently identifying ownership on the cylinder. ▪ Tighter controls at country borders. ▪ Regular monitoring and inspection throughout distribution chain. ▪ Cooperating and assisting regulatory authorities in enforcing regulations and identifying non compliance.
(b) Illegal filling (decanting) of cylinders One of the more destructive practices in the LPG business is the illegal filling (or pirate filling) of cylinders in the distribution chain. Cylinders belonging to one company are used without permission by another company and refilled. This practice sometimes involves cylinders that have been scrapped as no longer safe for use and is therefore particularly dangerous.	▪ Legitimate operators lose effective control over the condition of their cylinders. Pirate fillers have no incentive to adequately maintain stolen cylinders bearing the identification mark of the cylinder owner. This also applies to product quality or quantity since customers will find it difficult to identify who the filler actually was. ▪ Serious damage and injury from badly maintained cylinders ▪ Injury and damage compensation claims difficult to process since it will be impossible to identify the original filler with certainty ▪ Industry reputation threatened, customers less willing to use gas.	▪ Industry and government to clearly identify cylinder ownership, be vigilant against cylinder thefts, support legal action in case of malpractice. ▪ Enforce industry/state regulations relating to maintenance of cylinders and tanks, identify non compliance operators, and establish mechanism for enforcement. ▪ Governments/local communities assist householders with refundable deposits ▪ Licensing of new LPG operators, regular inspection of facilities ▪ Designs making it difficult to illegally fill (e.g. self sealing valves/security seals) ▪ Customer awareness programmes of risks and consequences of pirate filling ▪ Destroying beyond repair when scrapping cylinders
(c) Re-use of scrapped cylinders Using cylinders that have been scrapped (usually due to their no longer being safe for use)	▪ Cylinders that are known to be unsafe enter the market ▪ Accidents occur but it is difficult to determine liability	▪ Destroying beyond repair when scrapping cylinders
(d) Under filling of cylinders Customers expect a full cylinder of LPG. Under filling or filling when impurities are in the cylinder	▪ Customers are cheated ▪ If due to poor operation/management at the filling plant, overfilling may be likely with potentially disastrous consequences in the event of vessel rupture	▪ Monitoring, calibration of equipment and audit of the distribution chain ▪ Regular drainage of storage tanks to avoid a build up of 'heavy ends' ▪ Regular training on proper filling procedures in filling plants
(e) Filling of cylinders at autogas service stations Depending on relative pricing in the market, there may be an incentive for customers to purchase LPG at an autogas service station rather than from an authorised LPG dealer, e.g. by filling an empty cylinder. Relative pricing in some markets may encourage the reverse, e.g. the use of domestic LPG cylinders in vehicles. This practice can also be hazardous but is not discussed in detail here.	▪ The filling connection will not necessarily be suitable for LPG cylinders and there is a risk of leakage ▪ Cylinders will have bypassed the normal inspection, repair, requalification procedures at the filling plant. As they degrade with normal use the probability of accidents due to faulty cylinders will increase ▪ The cylinders will not necessarily be suitable for autogas use, largely Propane, whereas the cylinder maybe rated for Butane	▪ Licensing regime for autogas sites to include safe equipment checks and rules ensuring only suitable autogas tanks are filled. ▪ Industry/authority cooperation in ensuring rules are followed and enforced ▪ Strict rules with station operator banning illegal practices ▪ Customer awareness and education programmes ▪ Frequent audits and monitoring ▪ Specific autogas LPG dispenser nozzles

Source: World Lpg association, 2015

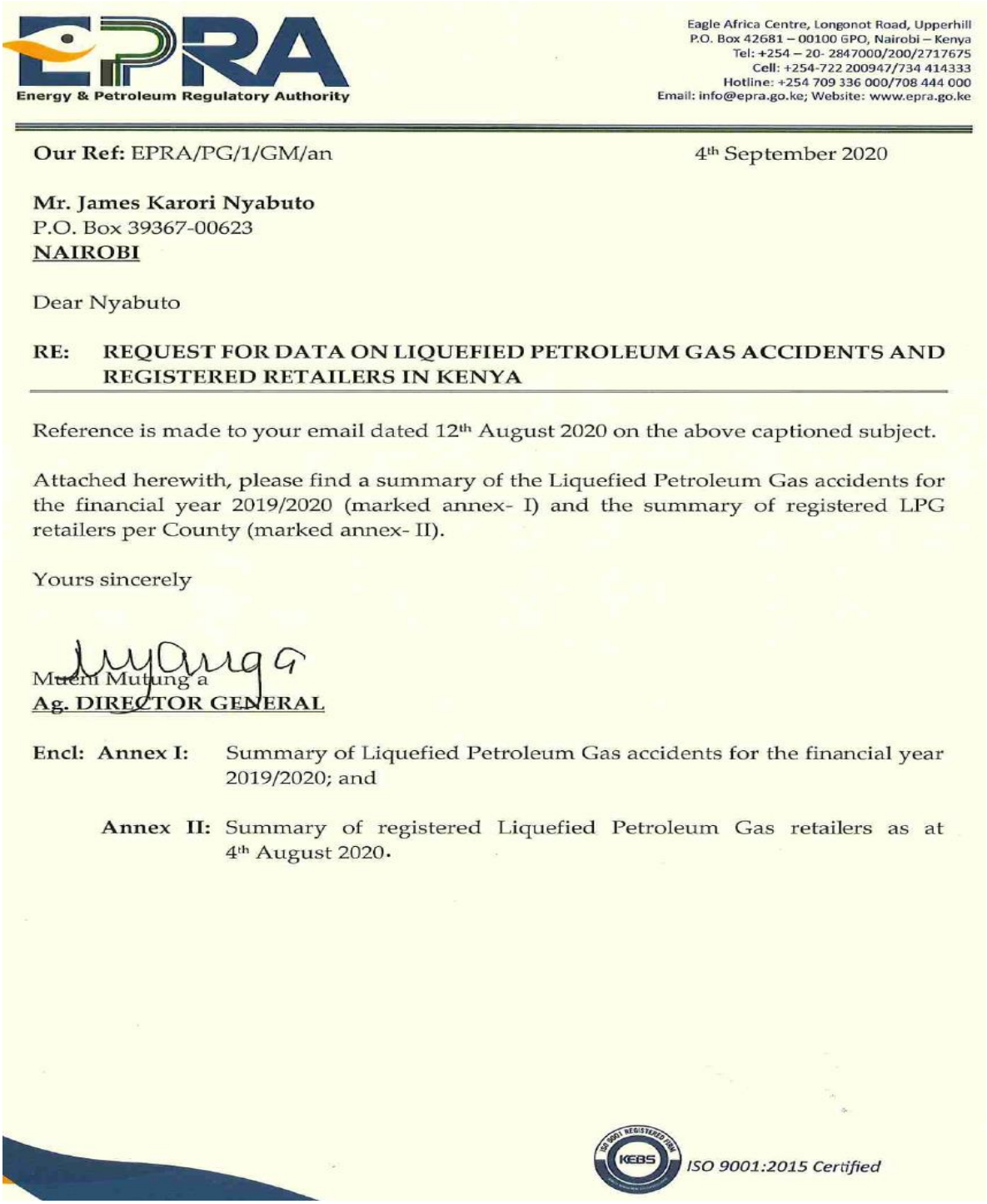
Appendix VI: Minimum PPE required, fire extinguisher & signage cost requirement

Assessment of occupational safety and health issues in liquefied petroleum gas retail busines in Kiambu County.	JAMES KARORI		Date : 26/11/2019
	MINIMUM PPE REQUIRED, FIRE EXTINGUISHER & SIGNAGE COST ANALYSIS TABLE		

Institution	JKUAT	Created By:	James Karori	MSc.OSH
Faculty	IEET	Date	26/11/2019	

Bid Summary			1st supplier : Specialised h/w		2nd supplier : Unipro ltd		3rd supplier : Oriental General	
Description	Unit	Quantity	Unit price	Amount	Unit price	Amount		
Safety Goggles	u	3	200.00	600.00	325.00	975.00	150.00	450.00
Safety Gloves (protective gloves against mechanical risks)	u	3	475.00	1425.00	690.00	2070.00	300.00	300.00
Safety boot	u	3	2100.00	6300.00	3,500.00	10500.00	2,800.00	8,400.00
6Kg Class B Fire extinguisher (from Nairobi safety shop*)	u	2	3800.00	7600.00	3,800.00	7600.00	3,800.00	7,600.00
Safety Signage (minimum)		1	2500.00	2500.00	2,500.00	2500.00	2,500.00	2,500.00
								-
								-
	TOTAL			18,425.00		23,645.00		19,250.00

Appendix VII: Additional Data from the Regulating Agency



EPRA
Energy & Petroleum Regulatory Authority

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Email: info@epra.go.ke; Website: www.epra.go.ke

Our Ref: EPRA/PG/1/GM/an

4th September 2020

Mr. James Karori Nyabuto
P.O. Box 39367-00623
NAIROBI

Dear Nyabuto

RE: REQUEST FOR DATA ON LIQUEFIED PETROLEUM GAS ACCIDENTS AND REGISTERED RETAILERS IN KENYA

Reference is made to your email dated 12th August 2020 on the above captioned subject.

Attached herewith, please find a summary of the Liquefied Petroleum Gas accidents for the financial year 2019/2020 (marked annex- I) and the summary of registered LPG retailers per County (marked annex- II).

Yours sincerely

Mureri Mutung'a
Ag. DIRECTOR GENERAL

Encl: Annex I: Summary of Liquefied Petroleum Gas accidents for the financial year 2019/2020; and

Annex II: Summary of registered Liquefied Petroleum Gas retailers as at 4th August 2020.

KEBS ISO 9001:2015 Certified

ANNEX I: SUMMARY OF LIQUEFIED PETROLEUM GAS ACCIDENTS FOR THE FINANCIAL YEAR 2019/2020.

LIQUEFIED PETROLEUM GAS ACCIDENTS SUMMARY FOR THE FINANCIAL YEAR 2019/2020			
NO	COUNTY	LPG ACCIDENTS AND INCIDENTS	ROOT CAUSE
1	Nyandarua County	1	External heat application leading to a BLEVE scenario
2	Bomet County	1	Accumulation of LPG vapour leading to a fire
3	Nairobi County	5	Leakage of LPG from a cylinder leading to a fire
			Leakage of LPG from a cylinder leading to a fire
			Poor End use due to inadequate knowledge
			Manufacturer's Default-Defective Bung weld
			Poor technician training leading to poor installation hence an explosion.
4	Nakuru County	1	Manufacturer's Default-Defective Ball valve
5	Kirinyaga County	2	Suspected arson.
			Negligence in fixing the LPG burner while in proximity to a burning stove
	TOTAL	10	

ANNEX II: SUMMARY OF REGISTERED LIQUEFIED PETROLEUM GAS RETAILERS AS AT 4TH AUGUST 2020.

REGISTERED LIQUEFIED PETROLEUM GAS RETAILERS PER COUNTY		
No	**County**	**No. of Registered Retailers**
1	Mombasa County	312
2	Kwale County	16
3	Kilifi County	145
4	Tana River County	1
5	Lamu County	1
6	Taita Taveta County	39
7	Garissa County	10
8	Wajir County	4
9	Mandera County	1
10	Marsabit County	6
11	Isiolo County	12
12	Meru County	107
13	Tharaka-Nithi County	17
14	Embu County	56
15	Kitui County	89
16	Machakos County	316
17	Makueni County	134
18	Nyandarua County	116
19	Nyeri County	112
20	Kirinyaga County	116
21	Murang'a County	251
22	Kiambu County	968
23	Turkana County	14
24	West Pokot County	3
25	Samburu County	7
26	Trans-Nzoia County	57
27	Uasin Gishu County	190
28	Elgeyo-Marakwet County	5
29	Nandi County	34
30	Baringo County	8
31	Laikipia County	22
32	Nakuru County	405
33	Narok County	25
34	Kajiado County	276

No	County	No. of Registered Retailers
35	Kericho County	74
36	Bomet County	22
37	Kakamega County	137
38	Vihiga County	57
39	Bungoma County	227
40	Busia County	81
41	Siaya County	82
42	Kisumu County	144
43	Homa Bay County	103
44	Migori County	74
45	Kisii County	68
46	Nyamira County	27
47	Nairobi County	1,396
	TOTAL	**6,367**

Appendix VIII: Select Research Publication

International Journal of Scientific and Research Publications, Volume 10, Issue 4, April 2020 19
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Awareness of Occupational Safety and Health Issues in Liquefied Petroleum Gas Business in Kiambu County, Kenya.

James Karori Nyabuto*, Charles Mburu, PhD*, Margaret Gichuhi, PhD*

* Institute of Energy and Environmental Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya.

DOI: 10.29322/IJSRP.10.04.2020.p10003
http://dx.doi.org/10.29322/IJSRP.10.04.2020.p10003

Abstract- Liquefied petroleum gas cylinder accidents are catastrophic; thus, safety enhancement in this trade is indispensable. The aim of this research was to ascertain the level of awareness of occupational safety and health issues in Lpg retail business among retailers in Kiambu County. Interview schedules were administered to 292 Lpg retailers during the data collection period. Subsequently, the data collected was analysed using SPSS ver.25. Descriptive and inferential statistical analyses were effectuated and presented in form of charts, bar graphs, and tables. The targeted outcome of this study was that the results will provide important information that is the first step necessary to ensure that safety and health -which is a legal requirement- in the Lpg retail business is implemented for the well-being of all stakeholders. The study established that 77% of the respondents were not aware of the occupational safety and health issues in the Lpg cylinder retail business. The association of awareness of how to use a fire extinguisher and gender of the respondents was statistically significant at 95% confidence level with X^2 (df=1) =4.999, since p=0.025. The association of awareness of the health and safety policy and respondents' experience was statistically significant at 95% confidence level with X^2 (df=4) =32.204, since p= <0.001. The study recommends that Lpg suppliers in partnership with EPRA and the county governments should raise public awareness about Lpg cylinder safety; through safety tailored campaigns on local television/radio stations, print media, and social media platforms.

Index Terms- Liquefied petroleum gas cylinders, Retailers, OSH Awareness, Safety culture.

I. INTRODUCTION

Occupational safety and health is the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace, which could compromise the health and well-being of employees and the occupier, considering the possible impact on the surrounding neighbourhoods and the prevailing environment. (Alli, 2008).

Liquefied petroleum gas (Lpg) is produced as a by-product of the oil and gas refinery process or obtained during the natural gas production process. In Kenya, Lpg is sold to consumers in pressurized cylinders. Lpg is predominantly used as a thermal fuel; burns cleanly, posing no water or ground pollution hazards and releases few Sulphur emissions. The normal ingredients of Lpg are propane and butane. (Competition Commission of South Africa, 2017).

Lpg cylinder accidents are catastrophic. Lpg is conceivably hazardous if mishandled, and therefore promotion of good safety practices in its retail is key. (Beheshti, et al., 2018). There's therefore need for simple practical advice on eliminating or reducing the risks associated with Lpg cylinder retailing in Kiambu County.

This research aimed at finding out the level of awareness of occupational safety and health issues in Lpg retail business in Kiambu County. This will provide important information that is the first step necessary to ensure that safety and health, in the Lpg retail business, which is a legal requirement is implemented for the well-being of all stakeholders.

II. MATERIALS AND METHODS

2.1. Study design

The study utilized descriptive research design. Descriptive research is suitable when studying things or variables as they are in the field without manipulating them, and gives views and feelings from the respondents (Babbie, 2002.). The study design was employed in the interest of the researcher's aim of providing a picture of the situation on the ground as it naturally happened viz. Lpg cylinder retailing.

2.2. Study area and population

The study area was Kiambu County, which is one of the 47 counties in the Republic of Kenya. It is in the central region and covers a total area of 2,543.5 Km^2 with 476.3 Km^2 under forest cover. (County Government Of Kiambu, 2015). The county has various urban centres: Thika town being the largest. Other urban centres include: Kiambu, Juja, Kikuyu, Karuri, Limuru, Gatundu, and Ruiru. (Kiambu County annual development plan, 2017). The study population comprised of 400 Lpg cylinder retailers undertaking the Lpg cylinder retail business, sampled from the selected study sites during the data collection period. (November, 2018 to February, 2019).

2.3 Sampling method

Stratified purposive sampling was employed. Stratified purposive sampling focuses on characteristics of subgroups of interest. (Kothari & Garg, 2014; Patton, 2002.). In line with Kothari, (2004)., the overall population was first divided into subgroups that were individually more homogenous than the overall population. The strata classification was by virtue of urban centres in the region. Then; Thika, Limuru and Kiambu towns were purposively selected from the population strata. A known characteristic about the selected study sites is that they are among the biggest and highly urbanized regions in Kiambu County (Kiambu County annual development plan, 2018 & County Integrated Development Plan, 2018).

2.4 Sample size determination

The sample of the Lpg cylinder retailers was a well-rounded representation selected from all over the study sites. From the population in 2.2 above, the sample size was determined by use of the sample size determination table, (Bartlett et. Al, 2001). With the data being categorical, a selected margin of error of 0.05, a standard variate value of 1.96 at 95% confidence level and a recommended population proportion of 0.50; the sample size determination table gives the sample size to use for the given population of 200 retailers in Thika town, 100 retailers in Kiambu town and 100 retailers in Limuru town to be 132, 80 and 80 respectively.

2.5. Research instruments

The measurement tools designed to obtain data from the research subjects were observation and interview schedules. Response options in the interview schedule were weighted as follows: 1 =don't know,2 =disagree, 3 =Neutral, and 4 =Agree. Data collected from the respondents was on socio-demographic characteristics and OSH awareness.

2.6. Pilot testing

A pre-test was carried out in Kenyatta Road, to measure the validity and reliability of the research instruments. The pilot study targeted a sample size of 5 respondents in which all of them responded to the interview schedules.

2.7. Data processing and analysis

Data from the study sites were coded, classified, checked for errors, omissions, and then summarised. The data were then analysed using the Statistical Package for Social Sciences (SPSS version 25.0) software and excel (version 2019). The results were organized and presented in form of tables, bar graphs, pie charts.

2.8 Ethical consideration

Permission to carry out the study was sought from the Institution (Jomo Kenyatta University of Agriculture and Technology), and the Lpg cylinder retailers. Confidentiality of the respondents was protected in that no names or personal information was required in the interview schedules, and measures were taken to ensure no undue influence or coercion was exercised.

III. Results and Discussion

3.1. Response rate

The study targeted a sample size of 292 respondents in which the response rate was 100%. Interview schedules, typically have a high response rate, though expensive and time consuming (Rubin & Babbie, 2012).

3.2. Demographic characteristics of respondents

3.2.1 Gender distribution of respondents

A large proportion of the respondents, 81%, were male whereas the remaining 19% were female. For this reason, it is deduced that Lpg cylinder retail business in Kiambu County is male dominated. This agrees with OSH (2007) that more men than women work in jobs that expose them to high risks.

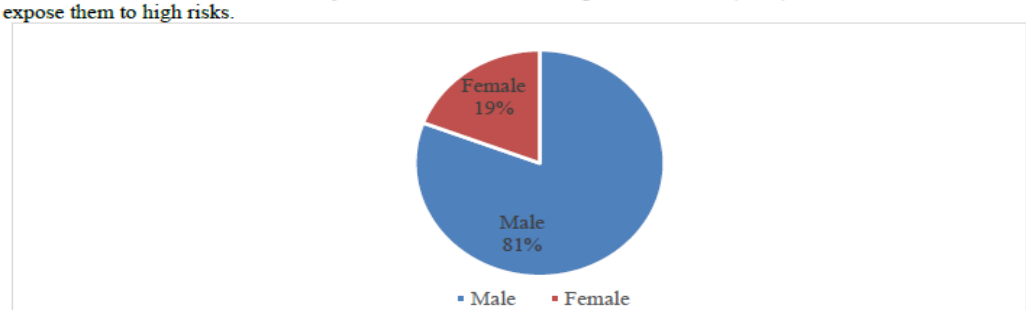

Figure 1: Gender distribution of respondents

3.2.2 Age distribution of respondents

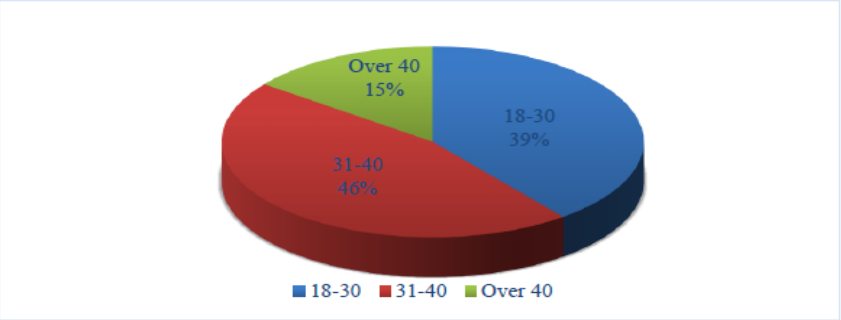

Figure 2: Age distribution of respondents

A greater part of the respondents, 46%, were aged between 31 and 40 years. 39% of the respondents were aged between 18 and 30 years. The least represented were respondents aged above 40 years who only made up 15%.

3.2.3 Education levels distribution of respondents

27.1% of the respondents had attained up to primary education. A greater number of the respondents, 49.3%, had attained up to secondary education, while 23.6% had attained up to tertiary education. The variation in education level ensured varied responses which richly contributed to getting valuable information for the study. (Schultz et al., 2006).

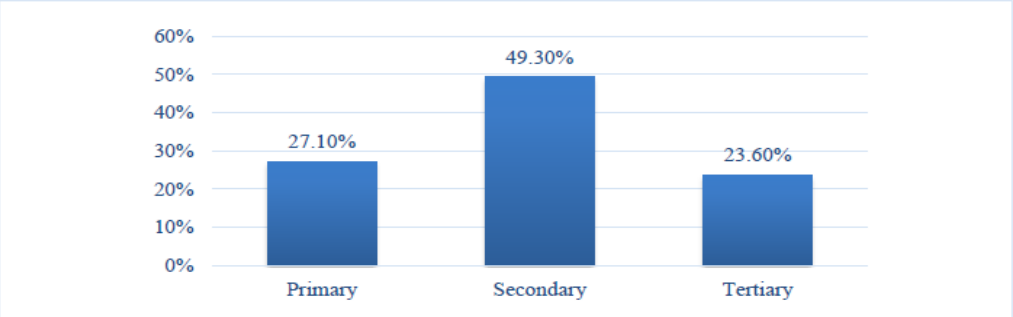

Figure 3: Education levels distribution of respondents

3.2.4 Distribution of respondents by Lpg retailing experience

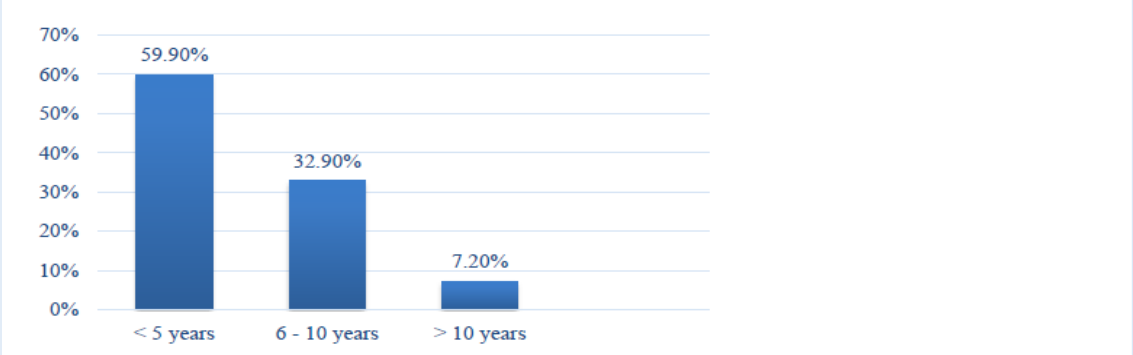

Figure 4: Lpg retailing experience of respondents

More than half of the respondents (59.9%), had an experience of between 1 and 5 years in the Lpg cylinder retail business. A good number (32.9%) had an experience of between 6 and 10 years. Only 7.2% of the respondents had over 10 years' experience in the Lpg cylinder retail business.

3.3 Level of awareness on occupational safety and health issues

The study sought to assess the level of awareness of occupational safety and health issues in Lpg cylinder retail business. Respondents were presented with a predetermined set of questions, from an already prepared interview schedule, and their answers recorded. The findings are presented below.

Table 1: Respondents' awareness of occupational safety and health issues.

OSH Awareness Aspect	Agree	Neutral	Disagree	Don't know	Mean	Standard Deviation
I always wear safety shoes at my workplace.	22.3%	-	77.7%	-	2.45	0.833
I always wear safety gloves when handling gas cylinders at my workplace.	18.5%	-	81.5%	-	2.37	0.778
I always wear safety glasses when handling gas cylinders at my workplace.	-	-	99.7%	0.3%	2.00	0.059

OSH Awareness Aspect	Agree	Neutral	Disagree	Don't know	Mean	Standard Deviation
I'm aware that safety signs and warning notices should be clearly shown at my workplace.	40.4%	-	43.2%	16.4%	2.64	1.171
A First aid kit is available at my workplace	23.6%	-	76.4%	-	2.47	0.851
There is a fire extinguisher at my workplace.	29.8%	-	69.9%	0.3%	2.59	0.920
I have a health and safety (HSE) policy at my workplace.	8.6%	-	59.6%	31.8%	1.85	0.801
I have been trained on handling gas cylinders.	11.3%	-	88.0%	0.7%	2.22	0.642
I have been trained on fire safety	15.4%	-	81.2%	3.4%	2.27	0.760
There is a Fire safety management Plan at my workplace.	8.6%	-	67.8%	25.7%	1.85	0.720
I know how to use a fire extinguisher	32.2%	-	67.8%	-	2.64	0.936
I have undergone first aid training	26.0%	-	73.3%	0.7%	2.51	0.887
Cylinders should not be transported upright and in a secure position	45.9%	-	38.7%	15.4%	2.32	1.384
I'm aware that gas cylinders can explode when exposed to high temperatures	61.0%	-	16.4%	22.6%	2.99	1.298
Liquefied petroleum gas can cause cold burns when it comes into contact with skin	0.7%	-	72.6%	26.7%	1.75	0.481
In case of a gas leak, switching on lights can cause an explosion/fire	11.6%	4.8%	43.8%	39.7%	1.88	0.949
All injuries and accidents however minor should be reported and recorded	10.6%	-	65.4%	24%	1.97	0.816

Table 2. Association between respondents' demographics and first aid training.

Variable	Category	Undergone first aid training		
		No	Yes	Chi-Square
Gender	Male	73%	27%	X^2=1.302, df=2, p=0.522
	Female	79%	21%	

Age	18-30 years	80%	20%	X^2=6.664, df=4, p=0.155
	31-40 years	69%	31%	
	> 40 years	74%	26%	
Education level	primary	91%	9%	
	Secondary	65%	35%	X^2=19.389, df=4, p=0.001
	Tertiary	74%	26%	
Lpg retailing experience	< 5 years	77%	23%	
	6-10 years	73%	27%	X^2=4.084, df=4 , p=0.395
	> 10 years	57%	43%	

Table 3. Association between respondents' demographics and awareness of fire suppression

Variable	Category	Know how to use a fire extinguisher		
		No	Yes	Chi-Square
Gender	Male	65%	35%	
	Female	80%	20%	X^2=4.999, df=1, p=0.025
Age	18-30 years	71%	29%	
	31-40 years	70%	30%	X^2=4.331, df=2, p=0.115
	> 40 years	77%	23%	
Education level	primary	82%	18%	

	Secondary	55%	45%	X^2=22.090, df=2, p=<0.001
	Tertiary	78%	22%	
Lpg retailing experience	< 5 years	73%	27%	
	6-10 years	61%	39%	X^2=6.344, df=2, p=0.042
	> 10 years	52%	48%	

Table 4. Association between respondents' demographics and awareness of health and safety policy.

Variable	Category	Health and safety policy available at workplace		
		No	Yes	Chi-Square
Gender	Male	91%	9%	X^2=8.671, df=2, p=0.013
	Female	95%	5%	
Age	18-30 years	91%	9%	
	31-40 years	89%	11%	X^2=7.469, df=4, p=0.113
	> 40 years	100%	0%	
Education level	primary	96%	4%	
	secondary	85%	15%	X^2=15.478, df=4, p=0.004
	Tertiary	99%	1%	
Lpg retailing experience	< 5 years	98%	2%	

	6-10 years	83%	17%	X^2=37.204, df=4, p=<0.001
	> 10 years	71%	29%	

Table 5. Association between respondents' demographics and awareness of cylinder handling

Variable	Category	Trained on cylinder handling		
		No	Yes	Chi-Square
Gender	Male	89%	11%	X^2=1.249, df=2, p=0.536
	Female	89%	11%	
Age	18-30 years	90%	10%	
	31-40 years	87%	13%	X^2=2.954, df=4, p=0.566
	> 40 years	91%	9%	
Education level	primary	97%	3%	
	Secondary	81%	19%	X^2=18.54, df=4, p=0.001
	Tertiary	95%	5%	
Lpg retailing experience	< 5 years	96%	4%	
	6-10 years	81%	19%	X^2=30.702, df=4, p=<0.001
	> 10 years	62%	38%	

Table 6. Association between respondents' demographics and awareness of Lpg cold burns

Variable	Category	Lpg can cause cold burns to skin		
		No	Yes	Chi-Square
Gender	Male	99%	1%	X^2=1.454, df=2, p=0.483
	Female	100%	0%	
Age	18-30 years	99%	1%	
	31-40 years	100%	0%	X^2=5.208, df=4, p=0.267
	> 40 years	99%	1%	
Education level	primary	100%	0%	
	Secondary	99%	1%	X^2=35.487, df=4, p=<0.001
	Tertiary	100%	0%	
Lpg retailing experience	< 5 years	100%	0%	
	6-10 years	98%	2%	X^2=5.636, df=4, p=0.228
	> 10 years	100%	0%	

Table 7. Association between respondents' demographics and awareness of fire safety.

Variable	Category	Trained on fire safety.		
		No	Yes	Chi-Square
Gender	Male	85%	15%	X^2=2.458, df=2 , p=0.293
	Female	84%	16%	
Age	18-30 years	90%	10%	
	31-40 years	78%	22%	X^2=17.002, df=4, p=0.002
	> 40 years	88%	12%	
Education level	primary	95%	5%	
	Secondary	76%	24%	X^2=30.633, df=4 , p=<0.001
	Tertiary	91%	9%	
Lpg retailing experience	< 5 years	95%	5%	
	6-10 years	70%	30%	X^2=44.745, df=4 , p=<0.001
	> 10 years	62%	38%	

Table 8. Association between respondents' demographics and awareness of accident/incident reporting.

Variable	Category	All injuries/accidents/incidents should be reported		
		No	Yes	Chi-Square
Gender	Male	88%	12%	X^2=7.410 , df=2 , p=0.025
	Female	96%	4%	
Age	18-30 years	90%	10%	
	31-40 years	87%	13%	X^2=3.711, df=4, p=0.447
	> 40 years	95%	5%	
Education level	primary	95%	5%	
	Secondary	86%	14%	X^2=5.884 , df=4 , p=0.208
	Tertiary	90%	10%	
Lpg retailing experience	< 5 years	94%	6%	
	6-10 years	82%	18%	X^2=14.288, df=4 , p=0.006
	> 10 years	86%	14%	

Table 9: Association between respondents' demographics and awareness of cylinder explosion

Variable	Category	cylinders can explode at high temperatures		
		No	Yes	Chi-Square
Gender	Male	38%	62%	X^2=1.454, df=2, p=0.483
	Female	45%	55%	
Age	18-30 years	39%	61%	
	31-40 years	35%	65%	X^2=8.851, df=4, p=0.065
	> 40 years	51%	49%	
Education level	primary	37%	63%	
	Secondary	31%	69%	X^2=20.235, df=4, p=<0.001
	Tertiary	59%	41%	
Lpg retailing experience	< 5 years	47%	53%	
	6-10 years	30%	70%	X^2=17.457, df=4 , p=0.002
	> 10 years	10%	90%	

IV. DISCUSSION AND CONCLUSION

It can be confirmed from this study that the application of safety command becomes more and more taxing as Lpg cylinders are moved away from the direct control of the wholesaler/supplier. A very important consideration is that all cylinder retail shops should have sufficient signage to give warnings and safety information on the hazardous products (Lpg cylinders) being stored. The employer must make sure that his/her employees are adequately trained, on Lpg safety, and should establish competency. Training records should be preserved and available upon request.

Majority of the Lpg retailors are not aware of the hazards they are exposed to, therefore unable to prevent and control this hazards. The study established that 77% of the retailers were not aware of the occupational safety and health issues in the Lpg retail business. The author concludes that the level of OSH awareness among Lpg retailers is inadequate.

The study further recommends that Lpg suppliers, in partnership with EPRA and the county governments should raise public awareness about Lpg cylinder safety; through safety tailored campaigns on local television/radio stations, print media, and social media platforms. Technological breakthroughs should also be embraced in Lpg cylinder safety enhancement in Kenya.

REFERENCES

[1] Alli, B. (2008). Fundamental principles of occupational health and safety. Geneva: International Labour Organization.
[2] Babbie, E. (2002). Survey research methods. Belmont, CA: Wadsworth.
[3] Bartlett, J., Kotrlik, J., Higgins, C. (2001). Organizational research: determining appropriate sample size in survey research. Information Technology, Learning, and Perfomance Journal, Vol. 19, No. 1, Spring
[4] Beheshti, M., Dehghan, S., Hajizadeh, R., Jafari, S., & Koohpaei, A. (2018). Modelling the consequences of explosion, fire and gas leakage in domestic cylinders containing Lpg. Annals of Medical & Health Sciences Research. 2018; 8: 83-88
[5] Competition Commision of South Africa, www.compcom.co.za, (2017). Market inquiry into the Lpg sector. Pretoria: Government Gazette.
[6] County Government of Kiambu. (2015). County Integrated Development Plan, 2013 – 2017. Kiambu: CGK.
[7] County Government of Kiambu. (2018). County Integrated Development Plan, 2018 – 2022. Kiambu: CGK.
[8] County Government of Kiambu. (2018). County Annual Development Plan 2018/2019. Kiambu: CGK.
[9] Kariithi, S, C.Mburu, & R. Kinyua. (2017). Awareness of occupational safety and health issues in Roadway maintenance works in Nyeri County, Kenya. International journal of innovative research and development, October 2017 Vol 6 Issue 10.
[10] Kothari, C. (2004). Research Methodology (Methods and Techniques). New Delhi: New Age International Publishers.
[11] Kothari, C.R & Garg Gaurav. (2014). Research Methodology, Third Edition. New Delhi: New Age International Publishers.
[12] Occupational Safety and Health Act (2007). Nairobi: Government Press.
[13] Rubin, A. & Babbie, R. (2012). Brooks/Cole empowerment series: Essential research methods for social work. Cengage Learning. ISBN:9781133709640.

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