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## Assessment of the Safety Handling of Domestic Liquefied Petroleum Gas (LPG) Cylinders using a Suburb of Afienya Township as a Case Study

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### ABSTRACT

**Purpose:** LPG is increasingly becoming the preferred choice of household fuel in most parts of the world including Ghana. However, the unsafe handling of LPG cylinders used to store the gas could lead to various safety issues. This research, therefore, assessed the safety state of domestic LPG cylinders using a suburb of Afienya Township in the Greater Accra Region.

**Methodology:** Questionnaires were distributed among 148 domestic LPG users to sample their views on domestic LPG cylinder safety knowledge. Applying the technique of triangulation, both closed and open-ended questions were used to sample views. Statistically, both qualitative and quantitative analyses were performed on the data. The data was categorized and tabulated to address the purpose of the study.

**Findings:** From the survey, it was discovered that 59.50% had virtually no idea or safety knowledge of LPG usage it was noted that 48.65% respondents transport LPG cylinders horizontally which is an unsafe practice of handling filled cylinders as it could lead to the excitement of the gas to cause an explosion. Also, 81.76% detect leakage by smell which is also not a safe and efficient way of detecting leakages. It was also a practice of 19.59% of respondents to overfill the cylinders and 53.38% preferred keeping their cylinders within the open space in their kitchen. However, 75.00% showed a good form of leakage rectification practiced through consultation. In summary, the general safety knowledge and handling of domestic LPG cylinders in Afienya is unsatisfactory.

**Recommendations:** It is therefore recommended that the government of Ghana should strengthen and enforce existing legislation and standards that govern the LPG value chain to ensure both public and consumer safety. Again, there should be continuous education to improve on safety standards for handling domestic LPG usage.

**Keywords:** *LPG, Cylinder, Safety, Handling, Leakage.*

## 1.0 Introduction

Liquefied Petroleum Gas (LPG) is a liquefied flammable mixture of hydrocarbon gases such as propane and butane. LPG is increasingly becoming the preferred choice of fuel in most parts of the world including Ghana due to its relative affordability, efficiency, and environmental friendliness of gas (Asamoah *et al.*, 2012). Global consumption of LPG occurs at the household level (49%), followed using LPG as feedstock in the petrochemical industry (21.6%), other industrial uses (11.8%), direct consumption in refineries and the agricultural sector make up 2% and other sectors (e.g., Autogas) add up to an aggregated 9.3% of total consumption (Anon, 2022d). LPG burns relatively cleanly with less to no soot with very negligible Sulphur emissions. Its mixtures with air between the percentages between 2% Lower Explosive Limit (LEL) and 10% Upper Explosive Limit (UEL) could ignite and explode causing injuries, claiming lives, and destroying properties (Kwaw, 2014; Beheshti *et al.*, 2018).

### 1.1 Some Safety Protocols

Due to the dangers associated with the use of the gas, there are recommended standards or protocols that one must follow to ensure the safe use of the gas. For domestic purposes, LPG is recommended to be stored in high pressured bottles or cylinders to accommodate the stored pressure in the gas. These cylinders are mostly made of low-carbon steel and less with aluminum and fibre materials (Anon, 2022a; Velmurugan *et al.*, 2019). These cylinders should always be kept in an upright position, securely and in a well-ventilated area under a shade to keep the temperature of the gas low. These cylinders must be stored outside the kitchen or away from ignition sources. The higher the temperature, the higher the pressure buildup within the cylinder. They must not be kept in enclosed units and or basements to avoid the accumulation of leaked gas to reach the ignition limit. The cylinders should not be subjected to any mechanical shock that could cause damage to their valves or pressure relief devices. They should not be dropped, dragged, slid, or used as rollers for moving material or other equipment. The cylinders should have caps to protect the valve on the top of the cylinder from damage if it is knocked over and if gas is accidentally released through the valve, the cap will vent the gas out of both sides, minimising the likelihood that the cylinder will topple. Cylinder caps should not be removed until the cylinder is secured in place and ready for use (Asamoah, *et al.*, 2012; Velmurugan *et al.*, 2019; Anon, 2022b; Anon 2022f).

The serviceable age of cylinders depends on various external factors such as atmospheric conditions, usage and cylinder rotation, wear and tear due to impacts, rusting, etc. LPG cylinders, thus, do not have a fixed expiry date but have a statutory testing date which is generally to be done after every 5 years. The cylinders are tested for safe usability and are stamped with a new test due date (Anon, 2022c). However, some countries have set expiration dates for some cylinders. For Nigeria, the lifespan of cylinders used to store LPG is pegged at 15 years, a maximum of 30 to 40 years for LPG trailers, and 25 years for smaller LPG tanks (Alike, 2014).

The test due date, an alphanumeric code, is marked on one of three side collars (shroud) of the

cylinder. It starts with alphabets A, B, C or D followed by 2 digits. A quarter of a year is represented by each letter. The letter A stands for the January-March, B stands for April-June, C stands for July-September and D stands for the October-December. The two digits indicate the year till it is valid. If a cylinder has the number A-25, it must be pulled out for obligatory tests in the first quarter of 2025 (Anon, 2022c).

In Ghana, LPG has become an integral component of the domestic energy mix. According to the Ghana Living Standards Survey (GLSS6), 22.3% of households in Ghana use bottled LPG for cooking in 2013; the capital (Accra) recording 52.7%, urban and rural population recording 35.8% and 5.5% respectively (Nyarko, 2014b). This is estimated to increase to 40% nationwide in 2030 (Anon, 2020). However, Government, through its Sustainable Energy for All (SE4All) in promoting clean household cooking fuel is determined to expand LPG access to 50% (Anon, 2020).

Unfortunately, the use of LPG riskier compared to other means of energy because of the tremendous pressure contained inside the cylinder. All compressed gases are potentially hazardous; as low-pressure cylinders can even be deadly. By propelling a cylinder, a quick release of pressure can inflict injury. Compressed gas cylinders are cumbersome to transport. Sprains, strains, falls, bruising, broken bones and other injuries could occur if cylinders are handled incorrectly (Anon, 2022b). Ghana has recorded various gas explosions at domestic and commercial levels. Gas filling stations having claimed over two hundred and fifty (250) lives from 2007 to 2017 aside related injuries (Anon, 2019). A report by the Reconstructive Plastic Surgery and Burns Centre stated that, LPG explosions accounted for 33% of all burns-cases and 44% of burns-related deaths cases annually (Nyarko, 2014b). These casualties contravene Sustainable Developments Goals 3, 7, 9, 11 and 13.

The perennial LPG handling and the safe state of the LPG cylinders in Ghana is therefore an uncomfortable experience that needs urgent attention. Therefore, the study sought to investigate the safe handling of domestic LPG cylinders using a suburb of Afienua Township as a case study to assist stakeholders in their policy decisions in the sector.

## **2.0 Materials and Methods**

Both structured interview and questionnaire were developed and employed in this study. This was administered to 148 domestic LPG users in Afienua. The population of Afienua Township is estimated to be 4,064 with 908 households and 533 houses according to the 2010 population and housing census. According to the 2014 Ghana Living Standards Survey (GLSS6) report, on average, 23.3% of urban areas including Afienua use LPG as the source of fuel (Nyarko, 2014a; Nyarko, 2014b). As a precaution for detailed and unbiased responses, both closed and open-ended questions formed part of the questionnaires. No single source of data has a complete advantage over the others and also various sources of data collection are highly complementary. The combination of different methodologies to examine the same phenomenon is known as triangulation. Through triangulation, a researcher can improve the accuracy of results by collecting data through different methods or even collecting different kinds of data on the subject matter of

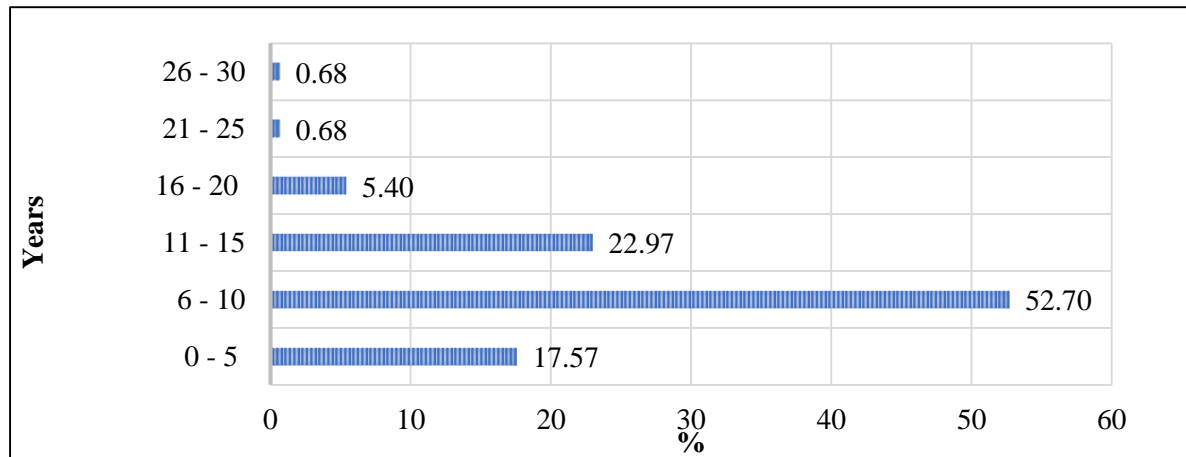
the research (Amorin *et al.*, 2018; Yin, 2008). To collect the data, a research team was organized. Statistically, both qualitative and quantitative analyses were used in the study. The data were categorized and tallied to meet the objectives of the study. Both primary and secondary data were employed in this study. Primary data was obtained from the domestic LPG users in Afienya whereas secondary data was obtained from existing work published in this study. The data were categorized and tabulated to address the purpose of the study.

### 3.0 Results and Discussions

Information gathered included knowledge on the safe handling of Liquefied Petroleum Gas (LPG) cylinders by domestic users in a suburb of Afienya Township as a case study. Information gathered included Knowledge on reasons for using LPG, state of LPG cylinders, origin, composition, expiration, cylinder pressure rating, cylinder filling, cylinder maintenance, mode of cylinder transportation, place of cylinder storage at home, challenges and safety knowledge in LPG usage. A total of 148 individuals were interviewed.

#### 3.1 Years of LPG Usage

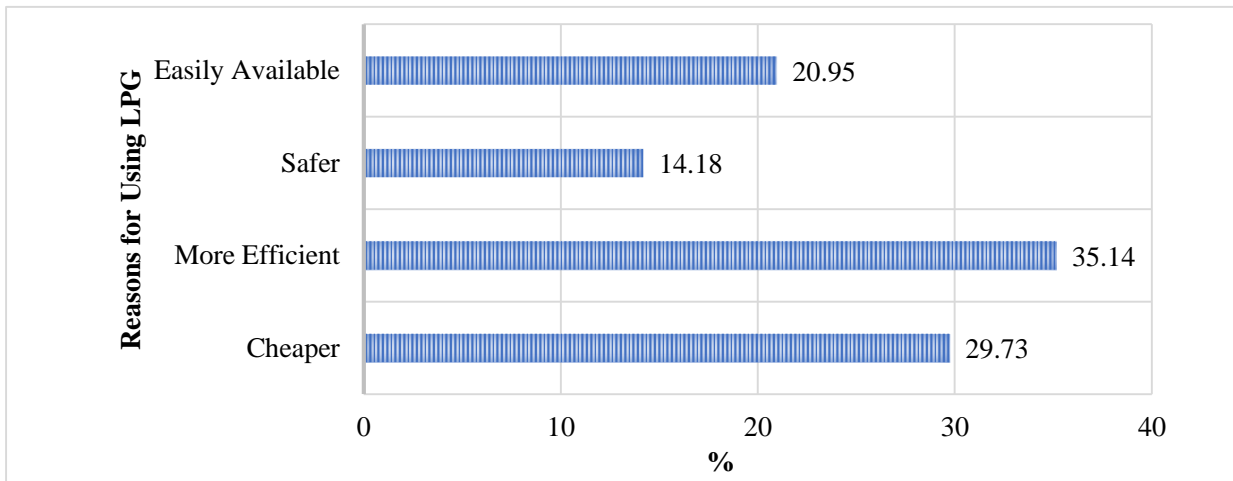
Based on the number of years for using LPG in the research area, six categories were established. The categories range in ages from zero to five, six to ten, eleven to fifteen, sixteen to twenty, twenty to twenty-five, and twenty-five to thirty. According to figure 1, 52.70% or the majority, have been using LPG for 6 to 10 years while 22.97% are between the ages of 11 and 15. 17.57% and 5.40% are between the ages of 0 and 5, and 16 and 20 respectively. Both 21 to 25 and 26 to 30 recorded 0.68% each.



**Figure 1: Years of LPG Usage**

#### 3.2 Reason for Using LPG

Figure 2 shows the percentages corresponding to the reasons for using LPG. It was noted that 35.14% preferred LPG because it is more efficient compared to other sources of fuels, whereas 29.73% preferred it because it is cheaper. 20.95% also use LPG due to its availability and 14.18% use LPG because it is safer. This aligns with the work done by Amorin *et al.* in 2018.

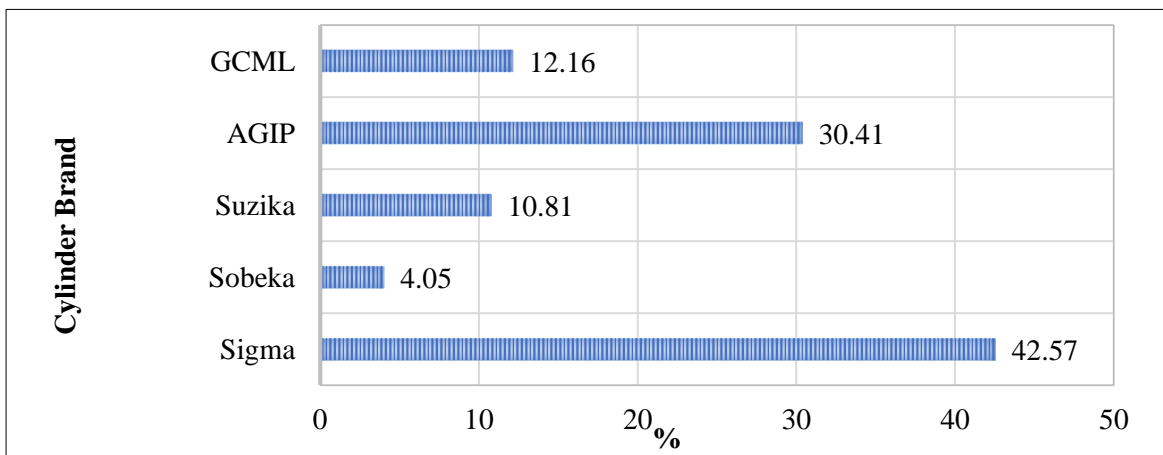


**Figure 2 Reasons for using LPG**

### 3.3 State of LPG Cylinders

#### 3.3.1 Origin of Cylinder

According to the data gathered, 53.73% of the respondents own a locally manufactured cylinders while 45.27% use imported ones. Figure 3a shows the brand of LPG cylinders owned by individuals. Cylinders in circulation included Sigma and Ghana Cylinder Company Limited (GCML) cylinders both from Ghana, Azienda Generale Italiana Petroli (AGIP) from Italy, Sobeka and Suzika both from China. The majority of individuals prefer Sigma brand cylinders making up 42.57%. Followed by AGIP brand cylinder with a 30.41%. GCML and Suzika recorded 12.16% and 10.81% respectively. It was observed that 4.05% were using Sobeka brand cylinders. Figure 3b show a Sigma branded cylinder.



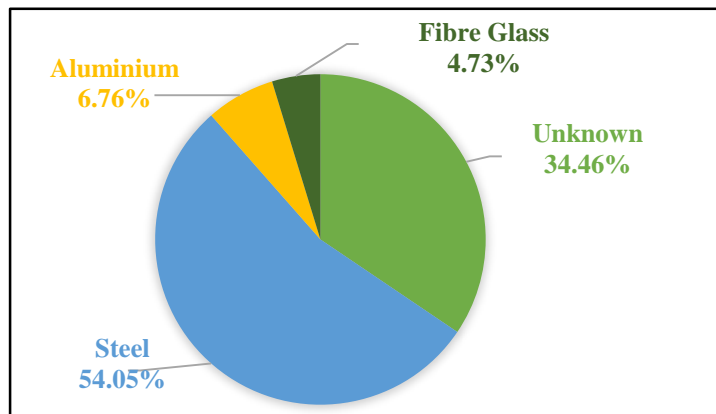
**Figure 3 (a): Brand of LPG Bottles**



**Figure 3 (b): A Sample of Sigma Cylinder**

### 3.3.2 Cylinder Composition

The materials used in the manufacturing of the cylinder vary widely. From the study, majority of respondents (65.54%) responded that they knew the material used in the production of their cylinders while 34.46% did not. The percentage corresponding to the materials used in the manufacturing of the cylinder is shown in figure 4. It was noted that 54.05% of the respondents have their cylinders manufactured from steel while 6.76% and 4.73% have theirs made of aluminum and fibreglass respectively.



**Figure 4: Various Materials Used in Manufacturing of the Domestic LPG Cylinders**

### 3.3.3 Expiration of LPG Cylinders

From table 1, 67.57% do not know the expiry date of their cylinder for mandatory retesting whereas 32.43% know the expiry date of their cylinders. It is also reported that most LPG cylinders imported into Ghana and Nigeria are either halfway or fully expired in terms of their mandatory test date (Amorin *et al.*, 2018). Figure 5 shows an expired mandatory test cylinder due for retesting in 2012. This may be one of the reasons why Nigeria has set the life span of their domestic LPG cylinders to 15 years according to Alike report in 2014.

**Table 1: Knowledge of Expiration of LPG Bottles for Retesting**

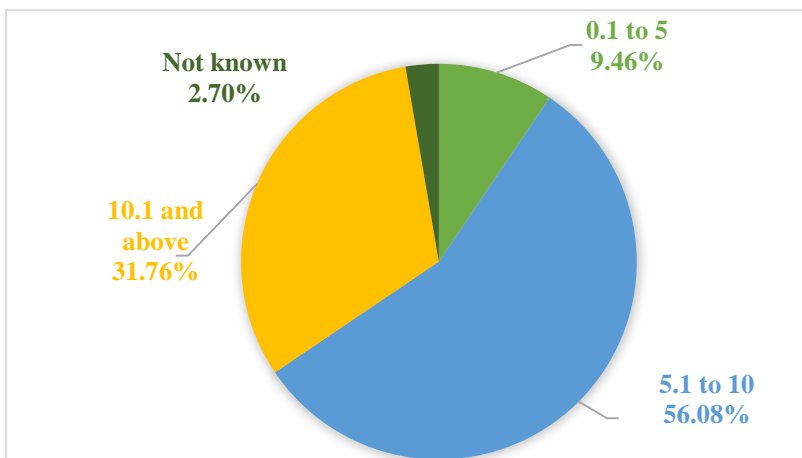
LPG Bottle Expiration Knowledge	Frequency	Percentage (%)
Yes	48	32.43
No	100	67.57
<b>Total</b>	<b>148</b>	<b>100.00</b>



**Figure 5: An Expired Mandatory Test Date for an Imported LPG Cylinder**

### 3.3.4 Cylinder Pressure Rating

Knowing the pressure rating of one's cylinder is very important. No knowledge of cylinder pressure can lead to overfilling of the gas cylinder. Figure 6 is a pie chart representing the pressure rating with their respective percentages. It was observed that 56.08% have cylinder pressure rating between 5.1 to 10 kg/sqcm, 31.76% have their cylinder pressure rating above 10 kg/sqcm. Also, 9.46% have cylinder pressure rating below 5.1 kg/sqcm. However, 2.70% do not know the pressure rating of their cylinders.



**Figure 6: Cylinders Pressure Rating**



### 3.4 Usage and Safe Handling of LPG Cylinders

#### 3.4.1 Cylinder Filling

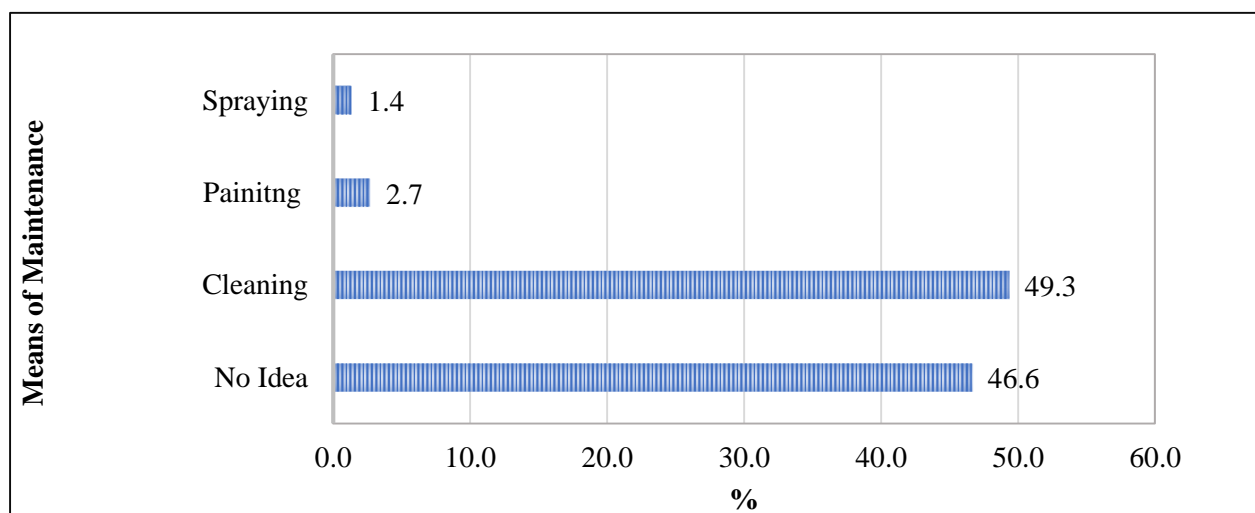
Accidental or intentional overfilling of a cylinder can have catastrophic effects including explosion, causing damage, and even injury due to expansion of pressurized gas in the cylinder in warm weather. Filling one’s gas cylinder to the brim is dangerous because LPG expands naturally, thus cylinders should be filled to about 80 to 85 percent to allow for gas expansion when possible (Tochi, 2021). From table 2, 75.68% prefer filling their gas cylinders partially while 19.59% fill their cylinders by full gauge or full rating. 4.73% prefer to fill their cylinder above gauge level. Overfilling a cylinder or any piping system is a very dangerous practice since any defeat in the unit could lead to high leakage and or possible explosion (Tochi, 2021; Amorin & Dabo, 2022).

**Table 2: Level of Filing Cylinders**

Level of Filling Cylinder	Frequency	Percentage (%)
Partially	112	75.68
Fully (By Gauge)	29	19.59
Fully (Over Gauge)	7	4.73
<b>Total</b>	<b>148</b>	<b>100.00</b>

#### 3.4.2 Cylinder Maintenance

From figure 7, 49.3% maintain their cylinder by cleaning them. However, an alarming 46.6% had no idea as to how they should maintain their cylinders. About 2.7% preferred painting their cylinders as a means of maintaining them while about 1.4% maintain their cylinder through spraying.



**Figure 7: Means of Cylinder Maintenance**

### 3.4.3 Mode of Cylinder Transportation

All LPG cylinders during transporting must be stored vertically, and be secured in stands or with chains, straps, or other suitable restraints and capped. This is necessary to prevent them from toppling over and getting damaged, leading to potentially harmful gas leaks. From table 3, 51.35% preferred to transport their cylinders home vertically (figure, 8a) while 48.65% transport their cylinders home horizontally (figure 8b). Transporting cylinder home horizontally is not advisable due to excessive shaking of the gas cylinder. When the cylinder holding the gas can no longer contain the pressure inside due to the high temperature generated by excessive shaking, the result can lead to an explosion (Tochi, 2021). Figure, 7c shows an individual carrying a filled cylinder horizontally.

**Table 3: Mode of Handling Cylinders When Transporting**

Mode of Handling Cylinder When Transporting	Frequency	Percent (%)
Vertical Position	76	51.35
Horizontal Position	72	48.65
<b>Total</b>	<b>148</b>	<b>100.00</b>



**Figure 8 (a): Transporting Cylinder Vertically**



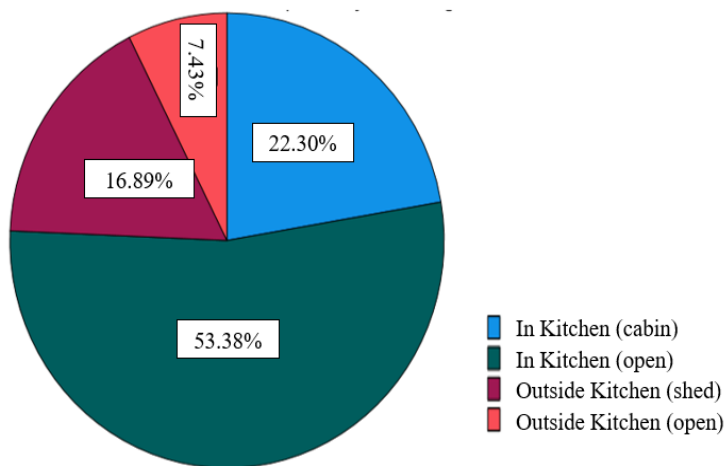
**Figure 8 (b): Transporting Cylinder Horizontally**



**Figure 8 (c): A Filled Rusted Cylinder Carried Horizontally**

### 3.4.4 Place of Cylinder Storage at Home

From figure 9, 53.38% preferred to store their cylinders in the open in their kitchen while 22.30% store their cylinders in a cabin in the kitchen. 16.89% store their cylinders outside the kitchen under a shed while 7.43% preferred storing their cylinders in the open outside the kitchen. The LPG cylinder pressure in bar goes from 0 bar at  $-43^{\circ}\text{C}$  to 24.8 bar at  $70^{\circ}\text{C}$ . Most pressure relief valves are set at around 25 bar, so that is about as high as LPG cylinder pressure will go. LPG pressure and how much pressure in LPG cylinder is dependent upon temperature (Anon, 2022e). It is therefore necessary to store the cylinders below the  $70^{\circ}\text{C}$  to avoid possible explosion (Anon, 2022b).



**Figure 9: Places of Cylinder Storage at Homes**

The continuous use of one's cylinder inside a kitchen where continuous generation of heat is ongoing can cause the gas temperature to increase which is a very unsafe practice. Again, any leak to a concentration of about 2% LPG will cause the gas to catch fire if there is a source of ignition (Beheshti *et al*, 2021; Tochi, 2021). Gas cylinder storage units need to be appropriately ventilated

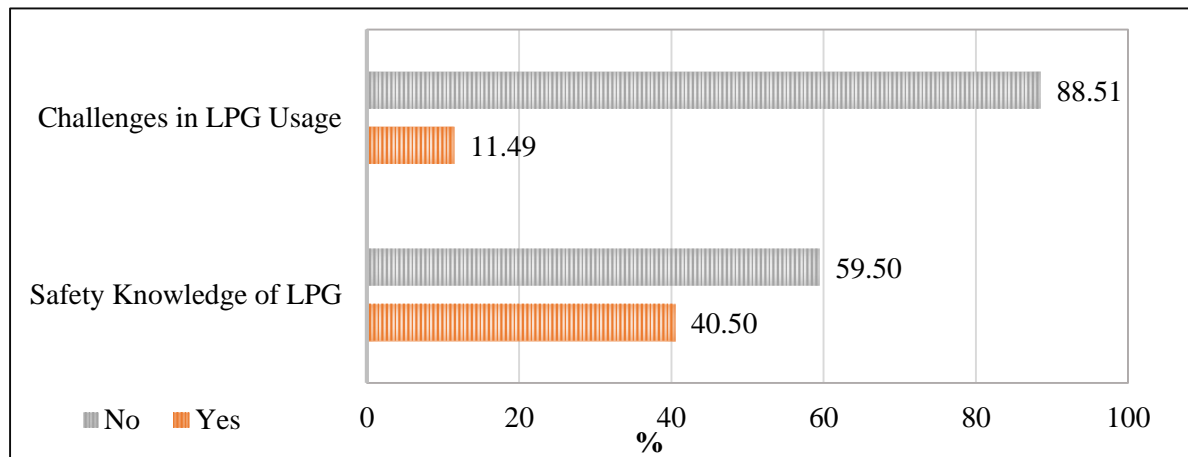
to prevent the accumulation of any leaked gases. The gas cylinder should also be stored under a shed and ideally located externally on a level, well-drained surface, away from ignition sources, building entry or exit points and drains (Anon, 2021a). Figure 10 shows the right way of storing a cylinder at home outside the kitchen.



**Figure 10: Right way of Storing a Cylinder at Home**

### 3.5 Challenges and Safety Knowledge in LPG Usage

Generally, most respondents did not seem to have issues and challenges with the use of LPG. It was noted that 88.51% did not have issues with the use of LPG while 11.49% faced some challenges (figure 11); 7.1% face transportation challenges and 3.5% had cylinder heating issues which may be likely due to the place of storage while 0.7% had some leakage issues.



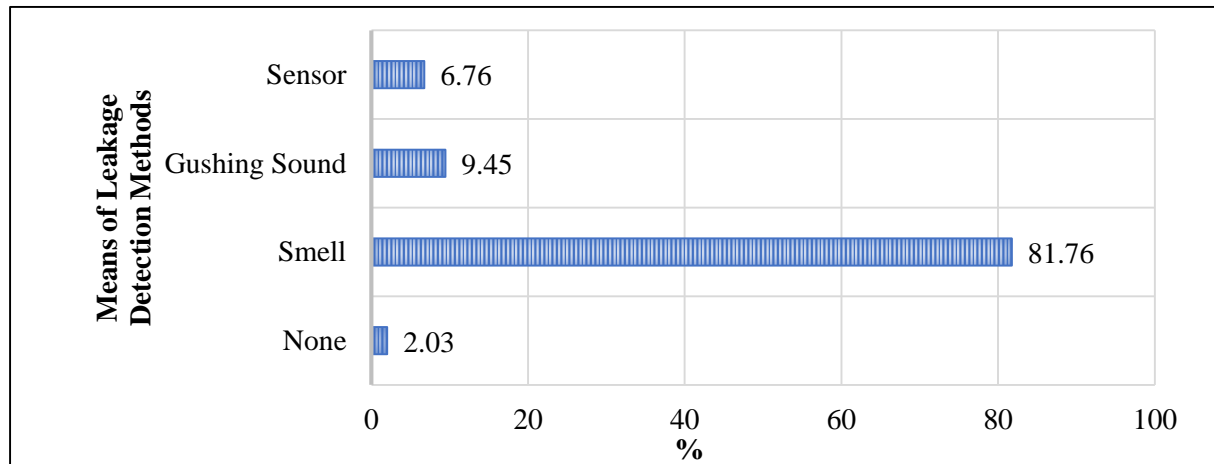
**Figure 11: Challenges and Safety Knowledge in LPG Usage**

Concerning safety knowledge, an alarming 59.50% had virtually no idea or safety knowledge on LPG usage while 40.50% demonstrated some safety knowledge on usage. The safety knowledge on LPG usage stated by the 40.50% are summarized below:

1. Allowing gas smell to clear before putting on a burner.
2. Children are not allowed to tamper with the cylinders.
3. The cylinders are kept from moisture to prevent rusting.
4. Cylinders are not exposed to naked flame.
5. Ensuring burner is turned off before and after cooking.
6. Storing gas cylinders outside the kitchen.
7. Frequent replacement of pipe hose.
8. Avoid dropping cylinder from heights; and
9. Frequent repainting of the cylinder.

### 3.5.1 Methods and Means of Checking Leakages

Mercaptan is added to LPG for the smell so that any leakage can be easily identified. Soap solution can be applied to all possible areas of leakage, the body of the cylinder, near the valve, the hose, and the regulator. If one sees bubbles or smell rotten egg, it indicates leakage. One can also install a gas leak detector. Option provided in the questionnaire includes Smell, Gushing sound and sensor. From figure 12, 81.76% detect gas leakage through smell, 9.45% detect gas leakage by gushing sound and while 6.76% have sensors for detection of gas leakage. 2.03% have no means of detecting gas leakage. Detecting leaked gas through smell is not reliable in windy environments. Individuals who have issues with their sense of smell are most likely to detect the leaked gas when it has reached its saturation point. Research has proven that continuous exposure to an odour can desensitize one's sense of smell.



**Figure 12: Means of Leakage Detections**

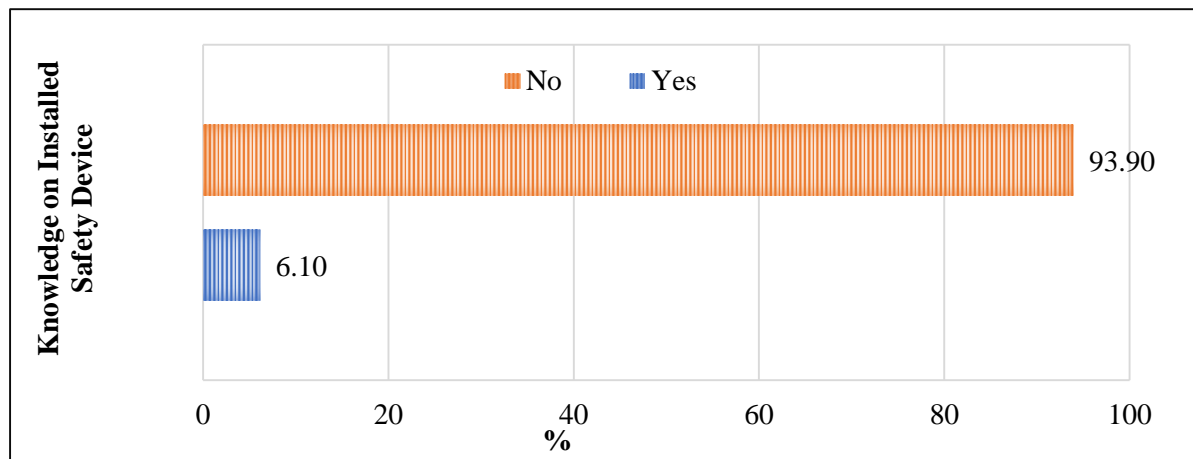
From table 4, 75.00% consult experts as a means of rectifying gas leakage while 25.00% rectify gas leakage by themselves.

**Table 4: Means of Rectifying Leakage**

Frequency	Mode of Leakage Correction	Percentage (%)
Self	37	25.00
Consult	111	75.00
<b>Total</b>	<b>148</b>	<b>100.00</b>

### 3.6 Knowledge on Installed Safety Device

From figure 13, 93.9% have no knowledge of the presence of safety devices (Pressure relief valve) installed on the cylinders while 6.10% do know. In situations where there is increase in temperature beyond the threshold of the cylinder, the responding pressure buildup is vent out automatically through the pressure relief valves on the cylinder to allow pressurized excess gas out until the required pressure is attained, then the valve closes to retain the leftover gas in the cylinder (Anon, 2022b). This is a very key safety device.



**Figure 13: Knowledge on Installed Safety Device**

## 4.0 CONCLUSIONS

From the Study, it can be concluded that the people of Afienya use LPG for domestic purposes for different reasons including efficiency (35.14 %), low cost (29.73%), availability (20.95%) and safety (14.18%). The use of LPG for domestic purposes spans from 0 to 30 years, the majority (52.70%) having been using the LPG between 6 to 10 years with 22.97% falling between 11 to 15 years. Most of the LPG cylinders in circulation are locally produced (53.73%). The Sigma brand dominates with 42.57%. It was noted that 65.54% of the respondent know the material used in manufacturing their cylinder, cylinders made of steel dominating with (54.05%). Most individuals (75.68%) fill their cylinders partially while 19.59% fill their cylinders by full gauge or full rating. 4.73% prefer to fill their cylinder above gauge level. It was observed that 49.32% respondents maintain their cylinder by cleaning while a sizeable percentage of individuals (46.62%) do have an idea of how to maintain their cylinder.

Most individuals (53.38%) prefer to keep their cylinders in the kitchen in the open, 16.89% keep their cylinder outside in a shed which is the recommender method of cylinder storage. An encouraging 88.51% of individuals have no issues with LPG usage. Unsafely, 81.76% detect leakage by smell which is a bit unreliable in windy environments. Encouraging 75.00% consult experts in leakage rectification; and alarmingly, 93.90% do not have any idea of an installed safety device on their LPG cylinders.

Based on the findings of the study, it can therefore be stated that the general safety knowledge and handling of domestic LPG cylinders in Afienya is unsatisfactory. It is therefore recommended that the Government of Ghana (GoG) should strengthen and enforce existing legislation and standards that govern the LPG market to ensure both public and consumer safety. Again, GOG must enforce regular test and maintenance of cylinders are undertaken to avoid failure of the cylinders through leakages, rupture or exploration and There should be continues education to improve upon safety standards for handling domestic LPG usage by GoG.

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