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# Critical Investigation of Causes and Effects of Fire Disaster on Buildings in Imo State, Nigeria

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## *Authors' contributions*

*This work was carried out in collaboration between all authors. Author OOS initiated the idea, designed, carried out literature search and compiled the draft of the manuscript. Author MI was responsible for supervising every stage of the research, and proof reading while author OKC carried out the data acquisition and analysis. All authors read and approved the final manuscript.*

***Abstract:*** *The frequent occurrence of fire disasters in buildings in Nigeria has become a serious threat to the nation's fragile economy. The impact of this fire accident had created substantial lives, documents and property losses. To ascertain the causes, frequency and giving protection to buildings became challenges to the stakeholders. The aim of this study is to investigate the causes and effects of fire disaster on buildings in Imo State and proffer probable solution that can inhibit fire occurrence or reduce the impact on life and buildings. A set of structured questionnaires was used for data collection which was the primary source. Related literature was reviewed. Data were analysed with basic descriptive statistical tools such as frequency distribution table, percentage, mean, standard deviation with the aid of SPSS version 23.0. 88.1% of the respondents revealed that the use of faulty electrical appliances, use of sub-standard electrical materials and bad workmanship were the major causes of fire incidences in the study area. Again, the result revealed that most of the affected buildings were commercial. From the results obtained the level of fire safety awareness in study area was grossly inadequate because, commercial building operators and government agencies are operating on weak capacity to sufficiently respond to the needs of fire outbreak. The study recommends that there should be public enlightenment, orientation, training and education on fire disaster for commercial building operators so as to know their level of vulnerability to fire hazards and what to do when fire occurs.*

***Key words:*** *Fire Disaster, Fire Accident, Fire Safety Practices, Buildings.*

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## I. Introduction

The word fire refers to the natural phenomenon that occurs whenever a combustible fuel comes into contact with oxygen from the air and gives out light, heat and smoke. Fire is the byproduct of a chemical reaction in which heat stored in a combustible fuel is converted to a heat and accompanied by light. A fire's flame refers to the visual indication of light that occurs once the gas is heated, and is evidence that a fire has taken place (Tonui, 2009). Fire has been identified as the greatest challenge to the safety of not only the industrial plants but in all workplaces in Kenya (Kelvin, 2009).

A fire can result in extensive damage and destruction of property as well as injuries and death to occupants of a given premise (DiGuiseppi et al., 2012). Even when fires don't injure workers, they can because disrupt activities quite significantly and bring most operations to a standstill. Fires can lead to the destruction of property and loss of important records and information hence the need for clear fire safety rules to minimize outbreaks and the loss that can result from such hazards (Schifiliti, 2009).

Osaro (2013), defined fire disasters as those events that displace the structural, economic, organizational, cultural and spiritual well-being of communities by destroying their means of existence. Fire disaster could either be human-induced or natural occurrences. Fire disasters are natural if they just happen without being induced by humans like bush burning, electric sparks, fuel and gas explosion. According to United Nations International Strategy for Disaster Reduction (UNISDR, 2008), when fire disaster occurs, human beings are among the most vulnerable population group, especially those present in times of the fire event. Furthermore, during fire disasters, buildings are destroyed, taking away the precious lives of people and stalling access to activities in the aftermath of fire disaster (Dowd, 2012). Fire disaster could be natural or man-

made, however, its occurrence cannot be eliminated outrightly in the built environment, but could be prevented, reduced or mitigated through preparedness measures as indicated by (Chen, Chuang, Huang, Lin, C. Y., and Chien, 2012).

There have been several incidences of fire outbreak in Commercial buildings in Imo State which have resulted in loss of human lives, valuable property and documents destroyed. These fires have continued to render many jobless, damage the built environment. The effective solution to these fire incidents will require enhancing the capacity of the relevant regulatory authorities in evaluating the proneness of any building to fire outbreak with the view to proffering remedial measures to this fire threat (Buchanan, 2001).

**Table 1. Established Cases of Fire Disaster in Imo State.**

| S/No | Commercial Buildings gutted Fire | Causes of the fire event | Value of Property destroyed | Estimated Number of lives lost | Year of Occurrence |
|---|---|---|---|---|---|
| 1 | Chris Tee Filling Station, Road Safety Office, Egbu. | Electrical Fault | Multi-Million Naira | - | 2010 |
| 2 | G. Tower Hotel, Portharcourt Road | Electrical Fault | Multi-Million Naira | - | 2012 |
| 3 | Sea Master Industry, Orlu | Gas Explosion | Multi-Million Naira | 4 | 2014 |
| 4 | INEC Office, Nwaoruibi, Mbaitoli LGA | Petrol Generator | Multi-Million Naira | - | 2015 |
| 5 | Two Imo State Polytechnic Students at their lodge, Mgbirichi | Gas Explosion | Multi-Million Naira | 2 | 2016 |
| 6 | Pretoria Hotel and Suites, Owerri | Electrical Fault | Multi-Million Naira | - | 2016 |
| 7 | Stone Castle Hotel, Owerri | Electrical Fault | Multi-Million Naira | - | 2017 |
| 8 | Gas Explosion, Amawire, Okigwe Road, Owerri | Gas Explosion | Multi-Million Naira | 2 | 2017 |
| 9 | Newton hotel, Owerri | Electrical Fault | Entire Building | - | 2017 |
| 10 | Imo State Deputy Governor's House, New Owerri | Bush Burning | Multi-Million Naira | - | 2018 |
| 11 | Tetlow Plaza, Owerri | Faulty Electrical Appliances | Multi-Million Naira | - | 2018 |
| 12 | Night Club and Lounge, Owerri | Electrical Fault | Multi-Million Naira | - | 2018 |
| 13 | Old Stadium Plaza, Owerri | Electrical Fault | Multi-Million Naira | - | 2018 |
| 14 | All Progressive Congress (APC) Office, Okigwe Road, Owerri | Generator | Multi-Million Naira | - | 2018 |
| 15 | Ibari Ogwa Entertainment Spot, Portharcourt Road, Owerri. | Electrical Fault | Multi-Million Naira | - | 2018 |
| 16 | Imo State University, Faculty of Humanities, Owerri | Electrical Fault | Academic Documents | - | 2019 |
| 17 | Sam Mbakwe Airport, Owerri | Electrical Fault | Multi-Million Naira | - | 2019 |
| 18 | The Independent National Electoral Commission's (INEC) Office, Isiala Mbano, Imo North | Electrical Fault | Election Documents | - | 2019 |

**Source: Field survey, 2019**

## II. Literature Review

Fires start when a flammable or a combustible material, in combination with a sufficient quantity of an oxidizer such as oxygen gas or another oxygen-rich compound, is exposed to a source of heat or ambient temperature above the blaze point for the fuel/oxidizer mix, and is able to sustain a rate of rapid oxidation that produces a chain reaction (Murali and Vijayalakshmi, 2014). This is commonly called the fire tetrahedron. Fire cannot exist without all of these elements in place and in the right proportions. Some fuel-oxygen mixes may require a catalyst, a substance that is not directly involved in any chemical reaction during combustion, but which enables the reactants to combust more readily. Once ignited, a chain reaction takes place whereby fires can sustain its own heat by the further release of heat energy in the process of combustion and may propagate, provided there is a continuous supply of an oxidizer and fuel. If the oxidizer is oxygen from the surrounding air, the presence of a force of gravity, caused by acceleration, is necessary to produce convection, which removes combustion products and brings a supply of oxygen to the fire. Without gravity, a fire rapidly surrounds itself with its own combustion products and non-oxidizing gases from the air, which exclude oxygen and extinguish it (Nnabuko, 2015).

According to Makanjuola, Aiyetan, and Oke (2009), fire has been used in the daily life of human-kind from time immemorial. Traditionally, fire has been used for cooking, steam engines, wood and coal,

smelting of iron and other metal, drying hides and meat for preservation, charcoal burning, and communication signaling. Fire has been a significant tool for humans by playing a key role for conversion of raw material to usable food, energy and light. Within the hospitality industry, fire is used in cooking through use of gas, charcoal, electrical appliances and equipment. However, fire risk would be high due to the vulnerability factors such as lack of training and exposure to flammable materials. Thus, it would be important to incorporate fire preparedness among such businesses to safeguard them from loss or disruption of business (Ball, 2001).

According to Nadzim and Taib (2004), fire safety management is the combination of or co-ordination of some activities or programs towards the prevention of damage from fire. Such programs include fire drill training, staff training, fire prevention measures, escape routes, etc. Fire safety management can also be defined as "the application by a manager of policy, standards, tools, information and practices to the task of analyzing, evaluating and controlling fire safety" (Howarth, 1999). Shipp (1994) had described it as an "ongoing process throughout the life cycle of a building".

According to Della-Giustina (1999), when an effective fire safety management is appropriately and prudently developed, the end results can include reduced property insurance premiums, prevention of business interruptions, boosting customer services and public images, among others. Ramachandran (1999) asserts that safety is the complement of contrast of risk, i. e. if safety measure is increased, risk of fire would be reduced. The objective of fire safety/risk management is therefore to eliminate or reduce risk to life and property to fire to barest minimum to the benefit of building owners, users or occupants and society at large. This could be achieved by carrying out fire safety and prevention activities which would inhibit the occurrence of fires and installation of passive and active fire protection measures which would also minimize the damage when the fire occurs.

## III. Methodology

Though the study was essentially a descriptive survey, it however employed a mixed research design approach (quantitative and qualitative). Data collection were through questionnaire, observation, checklist, journal articles, seminar papers and review of related literature. Data collected were analyzed with the use of frequency distribution tables, percentage, mean scores, standard deviation. The benchmark for judgment was placed at 95% confidence interval which in other words is 0.05 level of significance. Statistical Package for Social Sciences (SPSS) version 23.0 was used in all the analysis.

### 3.1 POPULATION OF THE STUDY

According to the data collected from Owerri Capital Development Authority (OCDA), the population of the registered commercial buildings in Owerri was 1,463; Orlu 471; and Okigwe 334 which gave a total of 2,268. The population of this study constitutes the following unit of analysis: registered commercial buildings in the study area – Owerri, Orlu and Okigwe, officers of fire service stations and officers of the Town Planning Authorities in the three towns where the data for the registered commercial buildings and fire victims in the study area were derived, the design and construction teams (Architect, Builders, Electrical and Mechanical Engineers), who were solely involved at the design and construction stages of these commercial buildings, and the commercial building owners and users in the study area. Purposive method of sampling was used for the distribution of the questionnaire.

**Table 3.: Population of the study**

| S/N | Population of the study | Total |
|---|---|---|
| 1 | Building Owner/User or Occupant/Manager | 2268 |
| 2 | Architect | 72 |
| 3 | Builder | 26 |
| 4 | Electrical Engineer | 46 |
| 5 | Mechanical Engineer | 38 |
| 6 | Fire Brigade Personnel | 34 |
| 7 | Town Planning Authority | 22 |
| 8 | Fire Victims | 13 |
| | **Total** | **2519** |

Source: Field survey, 2019

### 3.2 Sample, Sample size and Techniques

The sample size for the study consists of 2,519. According to Peck, *Chris and Jay (2008),* a sample is the number of people drawn from a population large and good enough to represent the entire population. A representative size is an essential requirement of any research study. As a result, it is pertinent to apply a mathematical approach to obtain such representative sample.

Based on the above population premise, the sample size for this study was determined using Cochran's formula. According to Cochran, (1977), this formula is used where the population size for a study is known. Thus, it is stated:

$$n = \frac{z^2 Npq}{Ne^2 + z^2 pq} \quad \text{..... equation 1}$$

Where: n = Sample Size
N = Population Size
e = Allowable Errors (4%)
z = Normal Distribution
p = Proportion of population likely to be included in the sample (50% or 0.5 is assumed)
q = Proportion of population not likely to be included in the sample (50% or 0.5 is assumed)

There: $n = \frac{(1.96)^2 \times 2268 \times (0.5) \times (0.5)}{2268(0.04)^2 + (1.96)^2 (0.5)(0.5)}$

$$n = \frac{3.8416 \times 2268 \times (0.5) \times (0.5)}{2268\,(0.0016) + 3.8416\,(0.5)(0.5)} = \frac{2178.1872}{3.6288 + 0.9604} = \frac{2178.1872}{4.5892} = 474.633313$$

Approximately, n = 475. Base on the calculation, the sample size for building owner/user or occupants/manager is 475. Other sample sizes were collected from their various professional bodies; Fire Service Station Office; Town Planning Authority. Due to the insufficient figures in the other focus groups, the figures were used that way. Hence, the summary of figures used in this study are:

**Table 3.1:** Sample size

| Targeted Population/ Focus group | Total |
|---|---|
| Building Owner/User or Occupant/Manager | 475 |
| Architects | 72 |
| Builder | 26 |
| Electrical Engineer | 46 |
| Mechanical | 38 |
| Fire Brigade Personnel | 34 |
| Town Planning Authority | 22 |
| Fire Victims | 13 |
| **Total** | **726** |

Source: Field Survey, (2018).

**Table 3.2** Distribution of Questionnaire and Percentage Return rates

| Focused Groups | No of Questionnaire Distributed | No of Questionnaire Returned | No of Questionnaire Unreturned | Percentage Returned |
|---|---|---|---|---|
| Building Owner/User or Occupant/Manager | 475 | 462 | 13 | 97.3% |
| Architects | 72 | 65 | 7 | 90.3% |
| Builder | 26 | 26 | Nil | 100% |
| Electrical Engineer | 46 | 45 | 1 | 97.8% |
| Mechanical | 38 | 38 | Nil | 100% |
| Fire Brigade Personnel | 34 | 34 | Nil | 100% |
| Town Planning Authority | 22 | 22 | Nil | 100% |
| Fire Victims | 13 | 13 | Nil | 100% |
| Total | **726** | **705** | **21** | |

Source: Field Survey, 2019.

## IV. Results And Discussion

This section presents the results, analysis, discussions and findings of the data collected. This study established Eighteen (18) different cases of fire disaster in the study area. (Table 1).

**Table 4. Factors responsible for fire disaster**

| Suggested Factors | N | Mean | Std. Deviation |
|---|---|---|---|
| Use of Substandard Electrical materials | 462 | 4.5584 | 0.52264 |
| Bad workmanship (Electrical installations) | 462 | 4.6667 | 0.47192 |
| Lack of knowledge of fire safety rules and regulations | 462 | 4.1017 | 1.31256 |
| Faulty Electrical appliances | 462 | 4.8810 | 0. 32420 |

| | | | |
|---|---|---|---|
| Smoking in unauthorized places | 462 | 3.8658 | 1.38451 |
| Unseemly storage of combustible materials | 462 | 4.4035 | 1.01280 |
| Gas Leakages | 462 | 4.8680 | 0.33890 |
| Improper disposal of lighted ends of cigarette and matches | 462 | 4.6385 | 0.48095 |
| Lightning and thunder strikes | 462 | 4.1797 | 1.10813 |
| Tolerating fuels in areas vulnerable to fire emergence | 462 | 4.0065 | 1.23663 |

Source: Field Survey, 2019.

Table 4. shows that all the factors suggested could cause fire emergence in commercial buildings because the mean scores are above 3.0 the agreed criterion. 88.1% respondents strongly agreed that faulty electrical appliances has the mean score of (4.88) with standard deviation of (0.324) followed by 86.8% respondents strongly agreed that gas leakages with mean score of (4.87) and standard deviation of (.339), were the major causes of fire disaster emergence in most commercial buildings. The results of the causes of fire disaster in commercial buildings in the study area corroborates with Akomolede (2015), this indicates that the use of Sub-standard materials and faulty electrical appliances are the major causes of fire disaster in commercial buildings.

**Table 4.1: Availability of fire-fighting equipment in the buildings studied.**

| Fire equipment | SA | A | NS | D | SD |
|---|---|---|---|---|---|
| Dry chemical extinguishers | 201 | 261 | 0 | 0 | 0 |
| Halon extinguishers | 0 | 0 | 0 | 272 | 190 |
| Foam cylinders | 201 | 114 | 51 | 60 | 36 |
| Carbon dioxide extinguishers | 60 | 81 | 0 | 108 | 213 |
| Sprinklers/Hose reels | 20 | 22 | 0 | 148 | 272 |
| Wet chemical | 39 | 159 | 49 | 76 | 139 |
| Fire blankets | 22 | 43 | 0 | 165 | 232 |
| Sand | 232 | 216 | 0 | 9 | 5 |

Source: Field Survey, 2019.

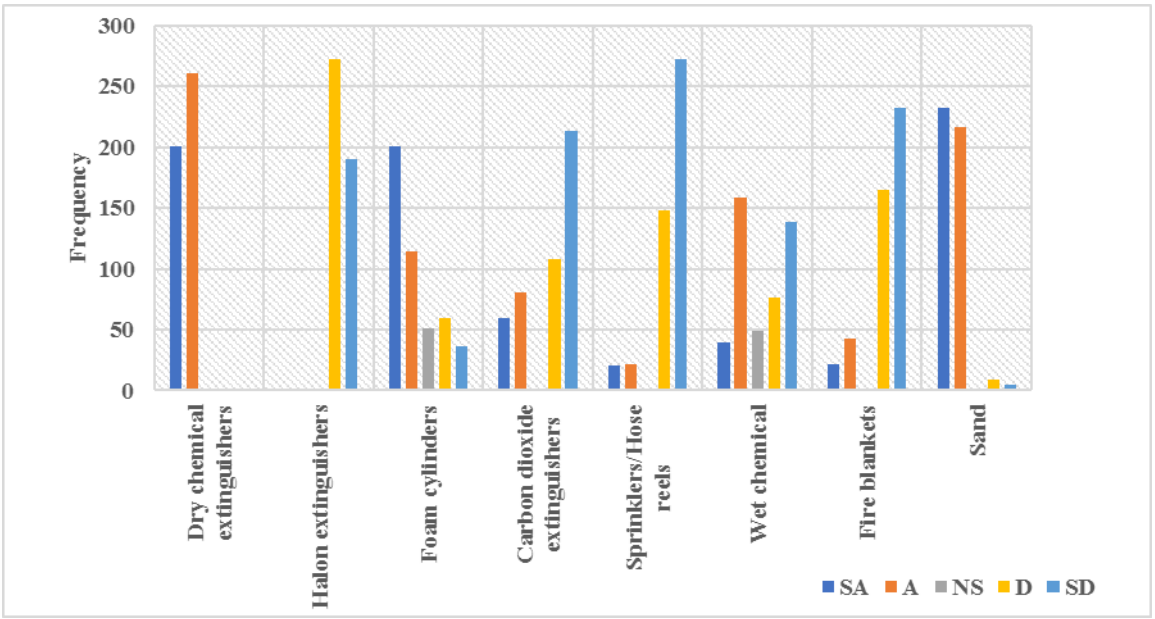


**Fig. 1 Availability of firefighting equipment**

Source: Field Survey, 2019.

Table 4.1 shows the decision rule of the respondents on the availability of fire safety equipment available in the commercial buildings. It could be summarized that the commonest firefighting equipment available in all the commercial buildings were dry chemical extinguisher, foam cylinders, wet chemical and sand with (462) respondents in each case. Since the major causes of fire outbreak are faulty electrical appliances and use of sub-standard electrical materials, it is obvious that the available extinguishers aforementioned are not the types that could suppress the class 'C' fire. This area of availability of firefighting equipment should be taken seriously by commercial building owners because different types of fires have its own suppressive extinguisher. So, all the types of fire extinguishers should be provided in the commercial

buildings. This shows that the level of fire safety measures adopted by commercial building owners were comparatively low.

**Table 4.2: Perception on availability of firefighting equipment in the building**

| Level of satisfaction | Frequency | Percent (%) |
|---|---|---|
| Satisfied | 98 | 21.2 |
| Not satisfied | 304 | 65.8 |
| Not Sure | 60 | 13.0 |
| **Total** | **462** | **100** |

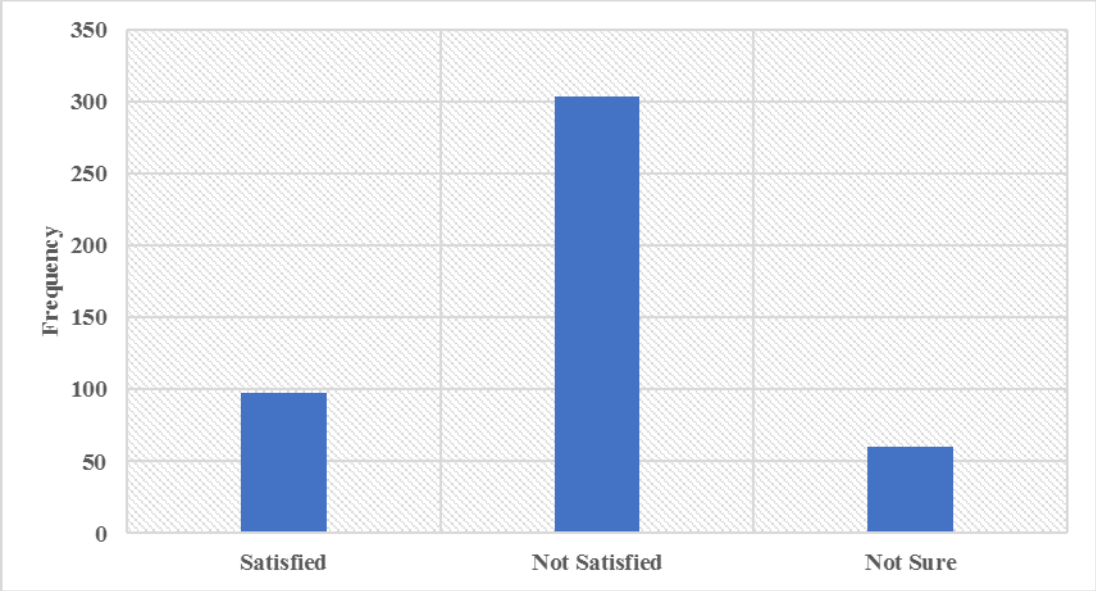


**Fig. 4.4 Level of satisfaction of Firefighting equipment availability**

Source: Field Survey, 2019.

From table 4.2, the respondents' view on the area of availability of firefighting equipment was not satisfied because the commonest among the firefighting equipment available in all the commercial buildings were dry chemical extinguisher, foam cylinders, wet chemical and sand which have not been effective in most cases.

**Table 4.3 Firefighting equipment that can be operated by Users**

| Fire equipment | SA | A | NS | D | SD |
|---|---|---|---|---|---|
| Dry chemical extinguishers | 216 | 246 | 0 | 0 | 0 |
| Halon extinguishers | 0 | 0 | 0 | 208 | 254 |
| Foam cylinders | 171 | 134 | 51 | 59 | 47 |
| Carbon dioxide extinguishers | 86 | 55 | 0 | 100 | 221 |
| Sprinklers/Hose reels | 15 | 16 | 0 | 206 | 225 |
| Wet chemical | 81 | 117 | 49 | 124 | 91 |
| Fire blankets | 33 | 32 | 0 | 170 | 227 |
| Sand | 238 | 210 | 14 | 0 | 0 |

Source: Field Survey, 2019.

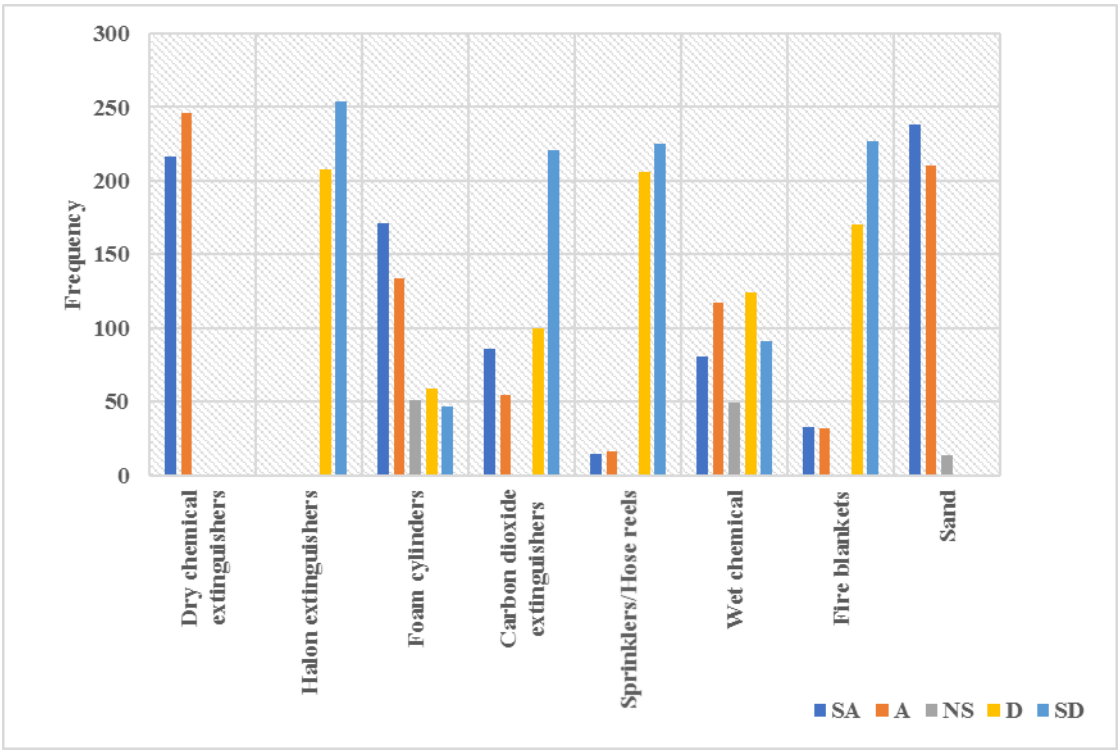


**Fig. 2 Ability to operate firefighting equipment**

Source: Field Survey, 2019.

From table 4.3, the result shows that there is a low level of fire disaster preparedness and awareness on fire safety measures in the study area. It could then be concluded that most of the owners/ occupants of commercial buildings in the studied area could only operate dry chemical extinguisher, foam cylinder and sand because it is the commonest among all the equipment. This means there is need for education and training of all the occupants of these commercial buildings on the use of different types of firefighting equipment. In determining the level of fire disaster preparedness of commercial building owners, availability of firefighting equipment and the operation were variables measured. Tables 4 – 4.2 show that the level of fire safety practices of commercial building owners in the area studied were far below expectation. This answers objective and research question three.

**Table 4.4: Ways fire disaster preparedness measures could be enhanced as suggested by some of the respondents.**

| Preparedness measures | Frequency | Percent (%) |
|---|---|---|
| Emphasis should be on fire drill and maintenance policy | 102 | 20.1 |
| More fire-fighting personnel should be employed | 115 | 24.9 |
| There should be fire insurance policy | 140 | 30.3 |
| Every building should have fire equipment | 105 | 22.7 |
| **Total** | **462** | **100** |

Source: Field Survey, 2019.

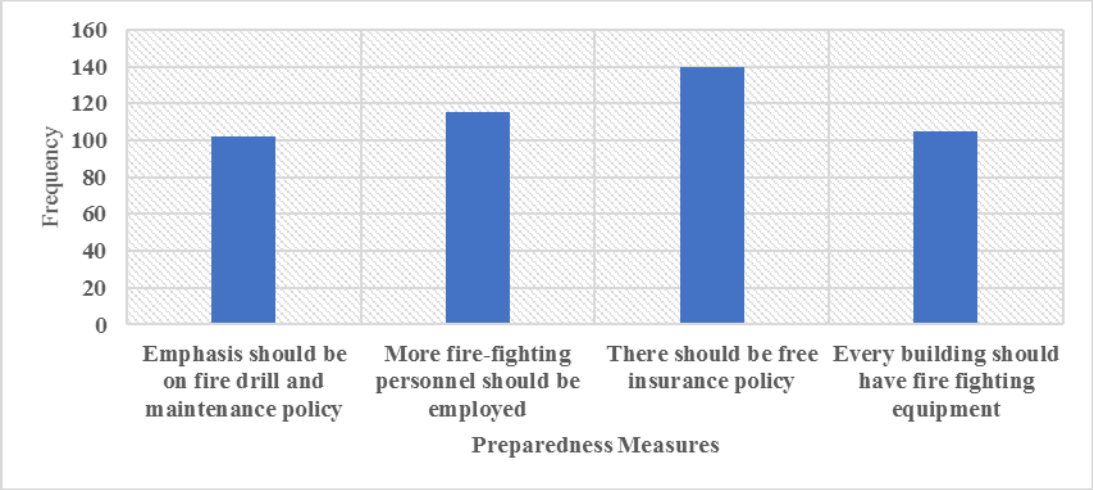


**Fig. 3 Ways to enhancing fire disaster preparedness for commercial buildings.**
Source: Field Survey, 2019.

From table 4.4, the respondents prescribed four (4) suggestions: 75 (31.9%) respondents suggested that Firefighting Personnel should be employed in all the commercial buildings. 58 (24.7%) suggested that fire drill (training and education) should be put in place at regular interval. 46 (19.6%) respondents perceived that there should be fire insurance policy in all the commercial buildings, this corroborates the fire safety regulation and code of the federal Republic of Nigeria. And 56 (23.85%) respondents viewed that every building should have various firefighting equipment since there are different type of extinguisher for different fire.

## V. Conclusion

Despite the technological advancement in fire safety and prevention, fire disaster remains the leading cause of lives and property loss at commercial facilities worldwide and fire could lead to the premature winding up of an organization no matter how big it is.

The study revealed that use of Sub-standard materials and faulty electrical appliances were the major causes of fire disaster in commercial buildings. Data in tables 1 established that fire disaster occurrence has been predominant in Imo State in the last two decade.

Again, the study examined the level of fire safety practices by the owners of these commercial buildings in other to ensure life's safety. The result revealed that level of fire safety practices was not adequate, because, there was inadequate provision of the required fire safety and suppressive devices, unavailability of fire safety trained personnel and lack of training and fire drill (see tables 4.1 and 4.2).

It is therefore expedient for all stake holders to collaborate and advocate the incorporation of all fire firefighting equipment, fire safety policies and strategies in the design and construction of these commercial buildings.

## VI. Recommendations

In recent times, efforts have been made by building owners at various levels to prevent the emergence of fire in buildings but failed. The occurrence of fire in most times is unavoidable due to human attitude to handling certain issues especially selection of materials for building components.

i. Each commercial building should have firefighting department and trained personnel adequately equipped to handle fire emergence at its inception stage.

ii. There should be public enlightenment, orientation, training and education on fire disaster for all commercial building operators so as to know their level of vulnerability to fire hazards and what to do when fire occurs.

iii. Parts of a building vulnerable to fires should be properly monitored in the course of construction. Mostly, kitchen area could be built to have dual roof that is, it is decked first and later roofed over with other parts of the building.

iv. At least three different types of fire suppressive devices should be installed in all commercial buildings to automatically intervene in the event of fire. Among the three, water sprinkler should be made compulsory.

v. Occupants/ Users should guard against overloading electrical sockets/outlets with a lot of appliances at the same time to prevent sparks that may lead to fire.

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