

# **APPLICATION OF CAUSE-AND-EFFECT-ANALYSIS FOR EVALUATING CAUSES OF FIRE DISASTERS IN PUBLIC AND PRIVATE SECONDARY SCHOOLS IN ILORIN METROPOLIS, NIGERIA**

**A.E, Ilori\* ; B.A, Sawa and A.A Gobir**

Centre for Disaster Risks Management and Development Studies, Ahmadu Bello University, Zaria, Nigeria

**Corresponding author: A.E, Ilori\* [ilorიაely@gmail.com](mailto:ilorიაely@gmail.com);**

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## **ABSTRACT**

The contributions of fire disaster to the varying degrees of students', staff's and schools' property and/or lives lost in secondary schools in Nigeria is recently alarming. The study assessed causes of fire disaster in public and private secondary schools in Ilorin metropolis, Kwara State, Nigeria. The objectives were to identify latent causes of fire disaster, use fishbone diagram to illustrate and analyze root cause of fire disaster in secondary schools. Exploratory research strategy was used. The target population was 18 senior public and private secondary schools, Ilorin having 18 principals, 965 teachers and 3765 Senior Secondary 2 students. From these population, simple random sampling technique through a pick and not-return balloting was employed to sample 72.22% of the principals, 14.8% each of the teachers and students. Data were collected through in-depth interview, questionnaire, participatory observation checklist, and were analyzed using cause-effects-analysis. The findings reveal fire disasters in public and private secondary schools in Ilorin metropolis are primarily caused by bush/waste burning, electrical fault/wiring, arson, carelessness, and alcohol, smoking. Results also showed that the root-causes of fire phenomenon from the classic categories were setting undergrowth on fire, non-insulated wiring system and sparks from wrong connections, emotional induced from cultism rivalry among male teachers and

students over a girl and superiority within and outside the school, mishandling of chemicals in various laboratories during experimentation, and lack of proper fencing of school compound. The study recommends that schools in the metropolis should prepare and anticipate future fire tragedy. Consequently, since there are several factors responsible for fire incidents, further studies could be conducted to clarify the sequence or magnitude of each cause of fire outbreak.

## **INTRODUCTION**

Fire disaster has become a global prevalent disaster experienced in most public and private secondary schools and other learning institutions with likely no country is exempted from this disaster whether developed or developing. Lending credence to this, not fewer than 43% of 938 secondary schools surveyed by the Arson Control Forum ACF (2006) in United Kingdom recorded large numbers of fire incidents between 2003 and 2006 alone. Kenya, a developing country in Africa has fire disaster as a common phenomenon experienced in secondary schools and other learning institutions (Kirui, 2009; Akumu, 2013; Shibusse, Omuterema, and China, 2014b). The National Fire Data Center (NFDC) in 2007 reported that, Africa is one of the continents recording a number of fire incidents across its regions due to different reasons such as lack of preparedness and limited awareness programs among the citizenry and some key institutions.

Literature on causes of fire disasters has draws substantive conclusion that the rapid growth of secondary schools and learning institutions fires are majorly linked to different reasons. One of the factors is arson which Ilori (2017) defined as a deliberately fire set by an individual or group of persons on private or public properties, mainly in a form of protest or vengeance against institutions or government. According to Tolofari (2010) some fire outbreaks are caused by some individuals with malicious intent to show displeasure or create destruction. Arson was a cause of

secondary schools fires in Kenya (Shibutse *et al.*, 2014a; Kisurulia, *et al.*, 2015), as an expression of dissatisfaction with the school administration (Nderitu, 2009).

Kahwa (2009) and Anyanwu *et al.* (2016) in their studies found faulty electrical installations, use of not qualified electrical engineers during installation (Muzungu, 2008), use of substandard electrical materials to save cost (Jimoh, 2012), overloading of electrical appliances and maintenance of electrical wiring (Rubaratuka, 2013), as the cause of fires. Careless use of gasoline and naked flames such as candle, filling-up kerosene lamp tank while the lamp is on (Jimoh, 2012), cooking material, lighting devices like lanterns, cigarettes, and lighted mosquito coils (Simpson, 2010), are some of the causes of fire disasters. For example, fire outbreak from candle used by a student to study at night took 12 girls lives and left 15 others injured in a secondary school dormitory in Tanzania (Daily Newspaper, 2009).

Other causes of fire incidents identified by researchers include bush/waste burning (Shibutse *et al.*, 2014a), alcohol, drugs, and smoking which was one of the causes of fire disaster in Nepal in a survey carried out by Gautam (2011). Hall (2012) maintained that smoking-related materials have been historical cause of different fire deaths in the United State. Reinforcing this fact, Abu (2013) reported that 75% of fire outbreaks in Ghana are caused by smoking and use of drugs.

The incidents of fire-outbreak in Nigeria are grossly increasing every year ranging from different locations like residential buildings, warehouses, learning institutions and so on. Fire disasters situation in learning institutions precisely secondary schools are worrisome due to its persistence without cessation. Fire incidents in Nigeria are so incessant to the extent that they occur on a daily basis (Adamu, 2013), with enormous contributions, amplifying toll of death and property loss among students and staff in public and private secondary schools. Notable among these incidents in Nigeria include that of the year 2001 when a public secondary school in Bwalbong-Gindiri

village, Plateau State, recorded 23 deaths among its students. In addition, the school segregated for girls in the aforementioned village had 40 students been injured. In the incident, students were trapped in the dormitory because it was locked and chained with iron bars and a chain (The Independent Newspaper, 2001).

In a similar event, the fire outbreak in Government Girls College in Jogana, Kano State in November, 2015 experienced claimed the lives of 7 female students and left 21 others injured (Mohammed, 2015). Similarly, important documents including class register, records of students, books, some learning aids were reduced to ashes by fire in 2016 in a section of Ogbe Secondary School, Edo State (Ibileke, 2016). Books and other properties of students were lost to a fire that ravaged entire 2 blocks of female hostels of Federal Government College, Keffi, Nasarawa State in November, 2017 (Premium Times, 2017). In December, 2017 fire burnt down a hostel in Government Science Secondary School, Kware, Sokoto State. In the same vein, students' valuables in the four-room of A'isha hostel of a public secondary school exclusively for girls in Mabera, Sokoto State were completely devastated by fire from an electric sparks in January, 2018 (Punch Newspaper, 2018).

Ilorin, the capital of Kwara State has over the years attract migrants from various parts of the country. Reasons for such migrations maybe partly down to its strategic location as a gateway between the northern and southern parts of the country (Usman, Malik and Alausa, 2015). The religious intolerance experienced in the northern parts of Nigeria in the late 90s (Ahmed, 2005), the insurgency in north-eastern parts of the country (Ibrahim, Adetona and Olawoyin, 2014; Usman et al., 2015), and the recent herdsmen activities has contributed to the influx of people in the city. Human errors are one of the major contributory factors to fire outbreaks. Demand and

careless use of facilities and utilities such as gas cooker, electrical appliances and so on, in public and private secondary schools along with nearby houses.

However, losses emanating from the fire incidents in public and private secondary schools in Ilorin metropolis are very alarming. For instance, 3 fire disaster events purported from sparks of working generator and setting undergrowth on fire by unknown persons in 2012 resulted in the loss of properties worth ₦ 6,600,000 million naira at St. Mary International School, and Cherubim and Seraphim College, Ilorin between 2015 and 2019 in Kwara State Fire Service Headquarters, 2019 annual report. These huge losses are clear evidence of lack of preparedness, urgency and mode of prevention (Pascal, 2006).

Despite the fire incidents and losses incurred, researchers have been working relentlessly to provide different models and analytical tools to explain establish logical solutions to fire outbreaks. For instance, Oladokun and Emmanuel (2014) invoke fuzzy logic model to analyzed urban market fire disasters management in Nigeria while Oladokun and Ishola (2010) used a risk analysis model to explained fire disasters situation in commercial complexes in Nigeria. The purpose of providing such tool(s) is/are to assist in unveiling the key causes of fire disasters, take results oriented actions for prudent management and continuous improvement on fire situations (Balanced Scorecard Institute, 2007; Tarun, 2012). Therefore, this study sought to find out “the cause-and-effect-analysis (fishbone-analysis)” along with its application to latent analysis and causes as well as proposing solutions to fire incidents and cost of property loss in public and private secondary schools in Ilorin metropolis.

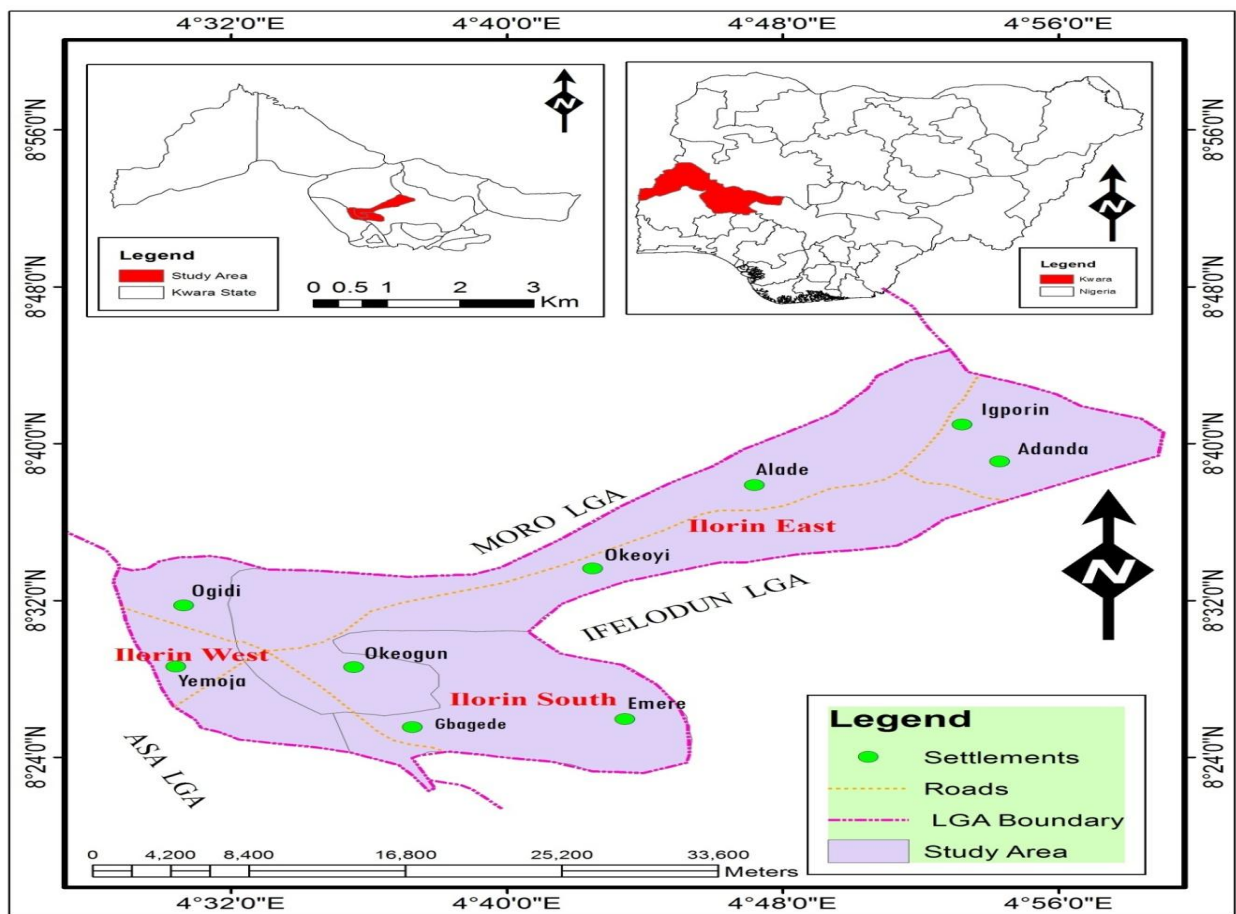
## **MATERIALS AND METHODS**

### **Study Area**

Ilorin Metropolis is located between latitude  $8^{\circ} 24' 0''$  N and  $8^{\circ} 56' 0''$  N of the Equator and between longitude  $4^{\circ} 32' 0''$  E and  $4^{\circ} 56' 0''$  E of the Greenwich Meridian with an elevation of 290m above sea level. It lies on the southern fringes of savanna region and north of the forest zone of Nigeria. The city is situated in the north central geo-political zone with a land mass of  $100\text{km}^2$  (Adediji, Ajayi and Olawole, 2009; Usman et al., 2015). The metropolis has 20 political wards, and comprises of three Local Government Areas (L.G.As) namely: Ilorin East, Ilorin South, and Ilorin West.

Ilorin is a fast growing city in Nigeria with high growth rate. The city is a confluence of cultures, primarily dominated by Yoruba, Hausa/Fulani, Nupe, Baruba, Igbo whilst the minors are other native, and foreigners. The indigenous people's religion is predominated by Muslims and Christians. Major occupation of Ilorin indigenes is weaving, pottery, petty trading, blacksmithing, and farming. Large number of people in the area are into enterprises, civil services, and corporate services such as estate agents, bankers, and so on. Presence of social and physical amenities in Ilorin give rise to different urban development like expansion and establishment of more public and private secondary schools by private organization and state government. Ilorin metropolis has 64 public and 45 registered private senior secondary schools with 52,687 key element population i.e. 47,568 students, 5010 teachers, and 109 principals/head teacher (Ministry of Education and Human Capital Development MOEHCD, 2017). Significant increase in population in recent years have contributed to different human errors such as careless use of gas cookers and electrical appliances in schools and houses close to schools.

Data used for this study were obtained from both primary and secondary sources. Primary source of data were collected from principals/vice-principals through an in-depth interview, teachers and students through the use of questionnaires, and participatory observation. The data include information on causes of fire disasters and the physical outlook of public and private secondary schools surroundings. The secondary data was sourced from Kwara State’s Ministry of Education and Human Capital Development (MOEHCD) for population of secondary schools in Ilorin metropolis. In addition, Kwara State Fire Service Headquarters (KSFSH) further provided detailed data on cases related to fire incidents in secondary schools, as well as Kwara State Ministry of Lands and Surveying for map of the study area presented in Figure 1.



**Figure 1. Kwara State showing Ilorin Metropolis**

**Source:** Adapted from Kwara State Ministry of Land and Survey (2017)

This study adopted exploratory research strategy. The target population constituted 18 senior public and private secondary schools having 18 principals, 965 teachers and 3765 SS 2 students (MOEHCD, 2017). From the target population, an attrition rate of 92.57% (or 343 persons) was added to the sample size of 370 persons obtained from Bartlett et al. (2001) sample size determination table under 0.05 precision to obtain an overall sample of 713 persons. Out of the 713 persons sampled, 1.83% was purposively set aside for principals that were randomly sampled and interviewed. For other 700 persons, a proportionate stratified sampling technique according to Goel (2014) was used to justify 20.43% of the teachers and 79.57% of the students' respondents that were randomly sampled and helped in identifying the causes of fire disaster in public and private secondary schools in Ilorin. From 700 questionnaire administered, 645 questionnaire representing a response rate of 92.14% were suitable and used for analysis.

However, Cause-and-Effect-Analysis (CEA) model was used to evaluate the causes of fire disaster in the region (Balanced Scorecard Institute, 2007). The "fishbone diagram" known as a CEA model is a graphic tool used for identification, sorting and exhibition of potential causes of a problem (Institute for Healthcare Improvement IHI, 2016). The name "fishbone" emanates from its structural outlook and appearance (Tarun, 2012). The study further asserts that in a typical fishbone diagram, the main problem which is required to be resolved is linked to the head of the diagram, the causes are related to the bones and the smaller bones are created and used as sub-causes.

Fishbone diagram or analysis was used to evaluate the causes, sub-causes and aid to uncover the symptoms of fire disasters in public and private secondary schools in Ilorin (American Society for Quality, 2005). In other words it was used to graphically illustrate the relationship between fire disaster and the causative factors (IHI, 2004). Henrik (2009) described cause-and-effect-diagram



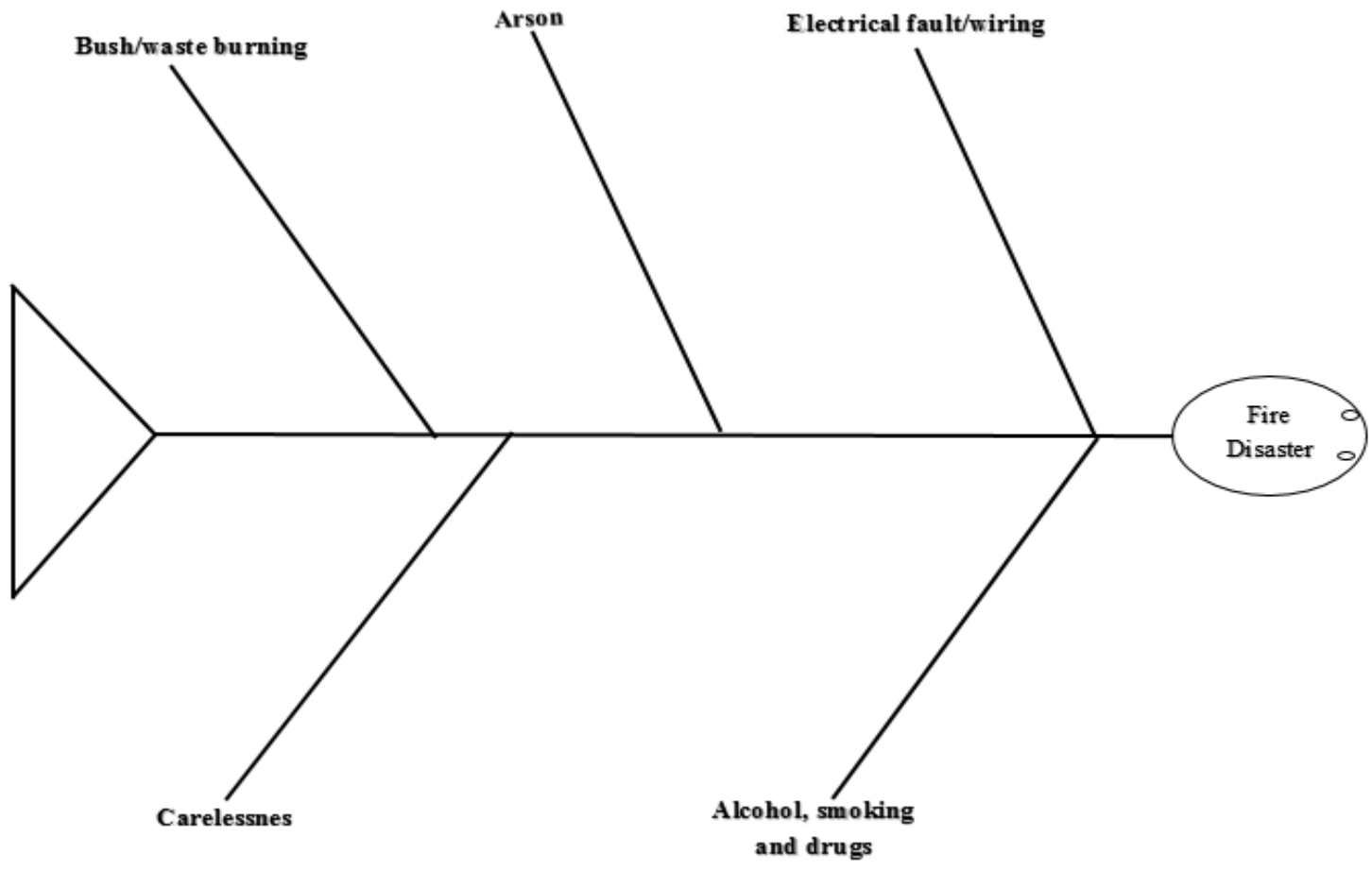
as a simple and pragmatic way of doing root cause analysis. The essence of using this model was to identify the root causes of fire disasters in public and private secondary schools in Ilorin metropolis. The study therefore considered this model as useful to achieve the specific objectives of this study. The model has not being explored by other researchers in fire disaster incidences and safety management. To construct the fishbone diagram, the following steps identified in Ishikawa (1968), Brassard (1988), Vivek (2008) and Tarun (2012) were adapted. The steps were:

- i). Fire disaster (i.e. effect) was written in a box on the right-hand side of the page (fish head).
- ii). A horizontal line (spine) was drawn to the left of the effect.
- iii). Diagonal lines were drawn above and below (these are the fish bones) the horizontal line (spine), and were labeled with the categories chosen in 4 below.
- iv). The main categories of factors (causes) contributing to fire disaster identified were labeled. The major categories typically utilized were electrical fault, arson, carelessness, bush/waste burning, and drugs (including alcohol and smoking).
- v). List of causes for each category was generated, and branch bones off the fish bones connecting the causes to their respective categories were drawn to produce sub-factors.
- vi). Analyzes of the results were done after an adequate amount of detail has been provided under each major category.

### **Steps for Constructing Fishbone Diagram**

## **RESULTS AND DISCUSSION**

Fishbone analysis is a good way of revealing inside picture of a particular problem. In this section, first of all a general fishbone analysis was done by drawing first the fish bone with the five contributing factors of several fire incidents in public and private secondary schools identified by the respondents and interviewees. The root-causes the groups itemized were placed accordingly against the primary factors. From there, the second fishbone analysis were done by putting main problem (fire disaster) into the head of the second diagram. The various primary causes as well as the root causes of fire incidents identified in public and private secondary schools in Ilorin metropolis are presented in Figure 3. The major causes: bush/waste burning, arson, electrical fault/wiring, carelessness, and alcohol, drugs and smoking alongside solution to these problem were presented in this section.



**Figure 2: Fishbone Diagram of Primary Causes of Fire Disasters**

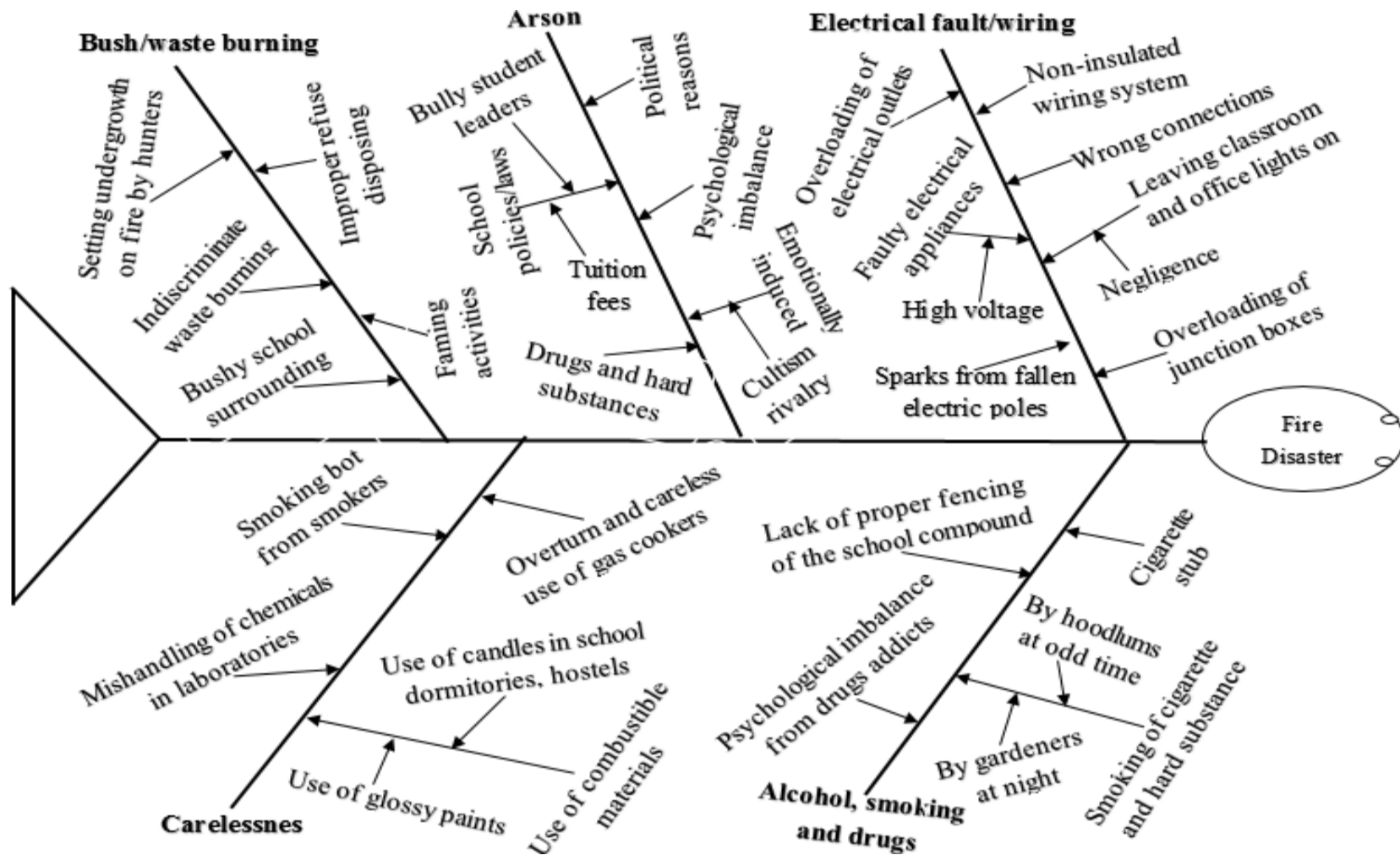


Figure 3: Fishbone Diagram for Causes of Fire Disasters in Public and Private Secondary Schools in Ilorin Metropolis

### **Electrical fault/wiring Problem:**

Usage of electrical appliances for day-to-day activities are good but bears some consequences when not properly used. Findings show faulty electrical appliances, wrong connections, overloading of electrical outlets, sparks from fallen electric poles and so on have been endangering lives and especially property of students, teachers and school valuables in public and private secondary schools Ilorin metropolis. For instance, properties worth over ₦2million naira were destroyed in a fire incident at St Mary International College, Ilorin in 2012 as a result of sparks from a working generator (KSFSH, 2019). Citing electrical problems in public and private secondary schools in Ilorin as case scenario through study observation reveals the root causes of these problems could be attributed to non-insulated wiring system, overloading of junction boxes in some classes, computer laboratories coupled with leaving classroom and office lights on even after school hours from negligence. Sparks happened from high voltage leading to fire disaster when bulbs were not put off and when overloaded boxes were heated and could no longer bear the loads.

### **Bush/waste burning Problem**

Bush/waste burning has been one of the problems faced by public and private secondary schools in Ilorin from indiscriminate waste burning in nearby houses, school premises and immediate environs particularly during the dry season. Setting undergrowth on fire by hunters amongst others are other root causes of some fire disasters in public and private secondary schools in Ilorin resulting to huge losses and destruction of personal and public properties. An example of huge loss from bush/waste burning in secondary schools in Ilorin were fire incidences in 2015

and 2019 at Cherubim and Seraphim College, Ilorin. Properties worth ₦4, 100, 000 million naira were lost to this phenomenon (KSFSH, 2019).

### **Arson Problem**

Arson (intentional fires) is a fire deliberately set by an individual or group of persons on private or public properties, mainly in a form of protest or vengeance against institutions or government (Ilori, 2017). Some fire outbreaks in public and private secondary schools in Ilorin are caused by some individuals with malicious intent to show displeasure or create destruction (Tolofari, 2010). Public and private secondary schools in Ilorin are not free from arson. Fires set up are engineered politically or psychologically through the use of drugs, hard substances or when individuals are psychologically depressed. Resultant fires may be emotionally induced from cultism rivalry among male teachers and students over a girl or superiority within and outside the school. Other root factor is school policies/laws with sub-causes such as tuition fees and student leaders fond of bullying other students. On arson caused fires, KSFSH (2019) documented that arson suspected individuals gutted Government High School, Ilorin on fire in November 2012. The culprits could probably do so to show dissatisfaction due to one or more of the aforementioned reasons.

### **Carelessness Problem:**

Some public and private secondary schools in Ilorin has experienced some form of destruction from carelessness. Carelessness is as result of different reasons linked to mishandling of chemicals in various laboratories during experimentation, nonchalant dropping of smoking bot by smokers, overturn and careless use of gas cookers amongst others. Careless use of combustible materials like the use of candles in school dormitories, hostels, glossy paints and

other combustible materials for decoration and beautification of offices, classrooms and hostel rooms. For instance, during visitation to schools some students at Cherubim and Seraphim College, Ilorin were jokingly discussing between themselves how one of them played with fire which later escalated beyond his expectation. Carelessness is a contributory factor to fire outbreaks in most public and private secondary schools resulting to loss of lives, personal and public properties.

### **Alcohol, drugs and smoking Problem:**

Lack of proper fencing of the school compound has resulted in the intrusion of drug addicts and smokers at odd periods. Improper disposal of cigarette butts and stub, leakage of fuel from school buses as itemized by 23% of the principals interviewed were notable root causes of fire disaster in public and private secondary schools in Ilorin. Per observation, some hoodlums often smoked in the evening after school hours. Furthermore, findings show 61.11% of public and private secondary schools in Ilorin are partially or not fenced. Partially and not fenced school compound has made intrusions so easy for the drug addicts and smokers in the area. Of which, during visitations some classrooms were seen littered with pieces of papers which are potential fuel of fire disaster.

### **Problems and Solutions:**

Several factors are responsible for fire disasters in public and private secondary schools in Ilorin metropolis. It is much important for schools to take quick action to avert future fire even though the incident is few in secondary school within the metropolis but the emerging losses from the few incidents are in millions of naira. Hence, for the safety of lives and property of students,

teachers, principals, the school itself and other users here are some solutions to that can help schools in improving the safety.

#### **Solutions of Electrical fault/wiring Problem:**

To get rid of these electrical fire problems in public and private secondary schools in Ilorin, conscientious actions must be taken such as putting off all electrical appliances like computer systems, fans, electric kettle, cookers, socket and air-conditioning systems when not in use in the laboratory, kitchen, hostel and offices even for a short moment. By so doing sudden sparks from high voltage that causes alarming destruction to lives and property will be prevented. Replacing burnt fuses with cables of higher melting point personally may result into a great fire disaster hence; trained engineers/qualified electrician(s) should be employed by each school to fix electrical problems.

#### **Solutions of Bush/waste burning Problem:**

The remedy to this may include; clearing of school compound against bushy environment, strict punishment on any student and even teacher who littered the school compound, provision of waste bin in all classes, staffrooms, and strict restriction of hunters and herders getting access to school compound. Refuse dump should be far to school buildings.

#### **Solutions of Arson Problem:**

To curb arson problems, proper and full fencing of school compound with secure gates and placement of security men at the entrances would help schools in reducing such crime and also help to bring culprits to book.



### **Solutions of Carelessness Problem:**

Carelessness can be prevented among other methods by making matches sticks available to light gas burner in kitchens and laboratories before turning on the burner. Adding to this, keeping gas cylinder outside kitchens and laboratories would help the flow and leakage into the air outside the laboratories and kitchen to prevent sudden explosion from careless use of this equipment. Avoidance of use of combustible materials such as papers for decoration. In any circumstance if petrol must be stored, it should be kept far away from kitchen, lantern or candle light.

### **Solutions of Alcohol, drugs and smoking Problem:**

To tackle this drug addict act in or around public and private secondary schools in Ilorin, full fencing of school compound with secure gates and recruitment of security men at the entrances would help schools in reducing fire disaster eventualities from the perpetrators. Prohibition of smoking within and around the school premises especially during school hours by school users should viscosly enforced. School management should consistently monitor a school driver that engaged in smoking or that takes alcohol.

### **LIMITATIONS OF THE FISHBONE ANALYSIS:**

Fishbone analysis is a tool that efficiently helped in identifying the causes and the root-causes of fire disaster in public and private secondary schools in Ilorin as well as providing solutions to solve the problems. Despite it efficiencies, it has some drawbacks. Some of the drawbacks are; fishbone analysis does not isolate major issues of the problems and presents each in a same way (Tarun, 2012). Fishbone analysis outlines the causes of fire disasters in the area but it does not clarify the sequence and magnitude of the primary causes (Public Health Infrastructure, 2008).

Fishbone analysis also fails to satisfy the ambiguity of severities and contributions of each primary factors on fire menace in the area.

## **CONCLUSION**

Based on the results of this study, application of cause-and-effect-analysis for evaluating causes of fire disasters in public and private secondary schools in Ilorin metropolis, the following conclusions were drawn:

- i. The main challenge with huge cost of property loss faced by schools and its users in Ilorin metropolis is fire disaster.
- ii. Analysis of different classic categories of the fishbone outlined that bush/waste burning, electrical faults, arson, carelessness, and alcohol, drugs and smoking are the primary causes of fire phenomenon.
- iii. Results also showed that the root-causes of fire phenomenon from the classic categories were: setting undergrowth on fire, non-insulated wiring system and sparks from wrong connections, emotional induced from cultism rivalry among male teachers and students over a girl and superiority within and outside the school, mishandling of chemicals in various laboratories during experimentation, lack of proper fencing of school compound, and so on.

## **RECOMMENDATION**

Based on the outcome of the study the following recommendations are made:

- i. Laboratory attendant/assistant and teachers should monitor students in the laboratories during practical.
- ii. Overloading of electrical outlets like plugs and sockets should be avoided.

- iii. School compound should be fenced to curtail drug addicts and smokers intrusion into the compound.
- iv. Since there are several factors responsible for fire incidents, further studies could be conducted to clarify the sequence or magnitude of each cause of fire outbreak.

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### **AUTHORS' CONTRIBUTIONS**

This work was carried out in collaboration between all authors. Author AEI carried out literature survey, designed the study, data collection and analysis, and wrote the first draft of the manuscript. Author BAS and Author AAG served as project supervisor and co-supervisor. Author BAS directed action on the first draft. All authors read and approved the final manuscript.

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