



# **Application of Cause-and-Effect-Analysis for Evaluating Causes of Fire Disasters in Public and Private Secondary Schools in Ilorin Metropolis, Nigeria**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author AEI carried out a literature survey, designed the study, data collection and analysis and wrote the first draft of the manuscript. Authors BAS and 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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## **ABSTRACT**

The contributions of fire disaster to the varying degrees of students', staff 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, Nigeria. The objectives were to identify latent causes of fire disaster, use the fishbone diagram to illustrate and analyze the root-causes of fire disaster in secondary schools. The 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 the target 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

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interviews, questionnaire, participatory observation, and were analyzed using cause-and-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 the fire outbreak.

**Keywords:** *Fire disaster; fishbone-analysis; Ilorin metropolis; secondary school.*

## 1. 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 [1] in the 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 [2,3,4]. The National Fire Data Center (NFDC) in 2007 [5] reported that Africa is one of the continents recording several fire incidents across its regions partly due to several reasons such as lack of preparedness and limited awareness programs among the citizenry and some key institutions.

The literature on causes of fire disasters has drawn a substantive conclusion that the rapid growth of fire disasters in secondary schools and other learning institutions are eminently linked to different reasons. One of the factors is arson which [6] defined as a deliberate 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 [7], 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 [8, 9], as an expression of dissatisfaction with the school administration [10].

Kahwa [11] and Anyanwu et al. [12] in their studies found faulty electrical installations, use of unqualified electrical engineers during installation [13], use of substandard electrical materials to

save cost [14], overloading of electrical appliances and maintenance of electrical wiring [15], as the cause of fires. Careless use of gasoline and naked flames such as candle, filling-up kerosene lamp tank while the lamp is lit [14], cooking materials, lighting devices like lanterns, cigarettes, and lighted mosquito coils [16], 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 [17].

Other causes of fire incidents identified by researchers include bush/waste burning [8], alcohol, drugs, and smoking which was one of the causes of fire disaster in Nepal in a survey carried out by Gautam [18]. Hall [19] maintained that smoking-related materials have been the historical cause of different fire deaths in the United State. Reinforcing this fact, [20] 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 is worrisome due to its persistence without cessation. Fire incidents in Nigeria are so incessant to the extent that they occur daily [21], 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. Also, 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 [22].

In a similar event, the fire outbreak in Government Girls College in Jogana, Kano State in November, 2015 claimed the lives of 7 female students and left 21 others injured [23]. 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 [24]. Books and other properties of students were lost to a fire that ravaged the entire 2 blocks of female hostels of Federal Government College, Keffi, Nasarawa State in November 2017 [25]. In December 2017, fire raid a hostel in Government Science Secondary School, Kware, Sokoto State. In the same vein, students' valuables in the four-room of A'isha hostel, a public secondary school exclusively meant for girls in Mabera, Sokoto State were completely devastated by fire from electric sparks in January 2018 [26].

Ilorin, the capital of Kwara State has over the years attracted migrants from various parts of the country. Reasons for such migrations may be partly down to its strategic location as a gateway between the northern and southern parts of the country [27]. The religious intolerance experienced in the northern parts of Nigeria in the late 90s [28], the insurgency in north-eastern parts of the country [29,27], and the recent herdsmen activities has contributed to the influx of people in the city. Human errors from the population exponentials are one of the major contributory factors to fire outbreaks. Demand and careless use of facilities and utilities such as gas cookers, electrical appliances and so on, in public and private secondary schools along with nearby houses are some of the influx hurdles.

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 generators 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's 2019 annual report. These huge losses are clear evidence of lack of preparedness, sense of urgency and mode of prevention [30].

Despite the fire incidents and losses incurred, researchers have been working relentlessly to provide different models and analytical tools to establish logical solutions to fire outbreaks. For instance, [31] invoked fuzzy logic model to analyze urban market fire disaster management in Nigeria while [32] 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 [33,34]. 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.

## **2. MATERIALS AND METHODS**

### **2.1 Study Area**

Ilorin Metropolis is located between latitude 8° 24' 0" N and 8° 56' 0" N of the Equator and between longitude 4° 32' 0" E and 4° 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 geopolitical zone with a landmass of 100km<sup>2</sup> [35, 27]. 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 a 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. The major occupation of Ilorin indigenes is weaving, pottery, petty trading, blacksmithing, and farming. A 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 private and public secondary schools by a 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 [36]. 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. These human errors could be linked to growing demands or needs of the growing population.

Data used for this study were obtained from both primary and secondary sources. The primary source of data was 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 the 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 the population of secondary schools in Ilorin metropolis. Also, 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 the map of the study area presented in Fig. 1.

This study adopted an exploratory research strategy. The target population constituted 18 senior public and private secondary schools having 18 principals, 965 teachers and 3765 SS 2 students [36]. From the target population, an attrition rate of 92.57% (or 343 persons) was added to the sample size of 370 persons obtained from [37] sample size determination table under .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

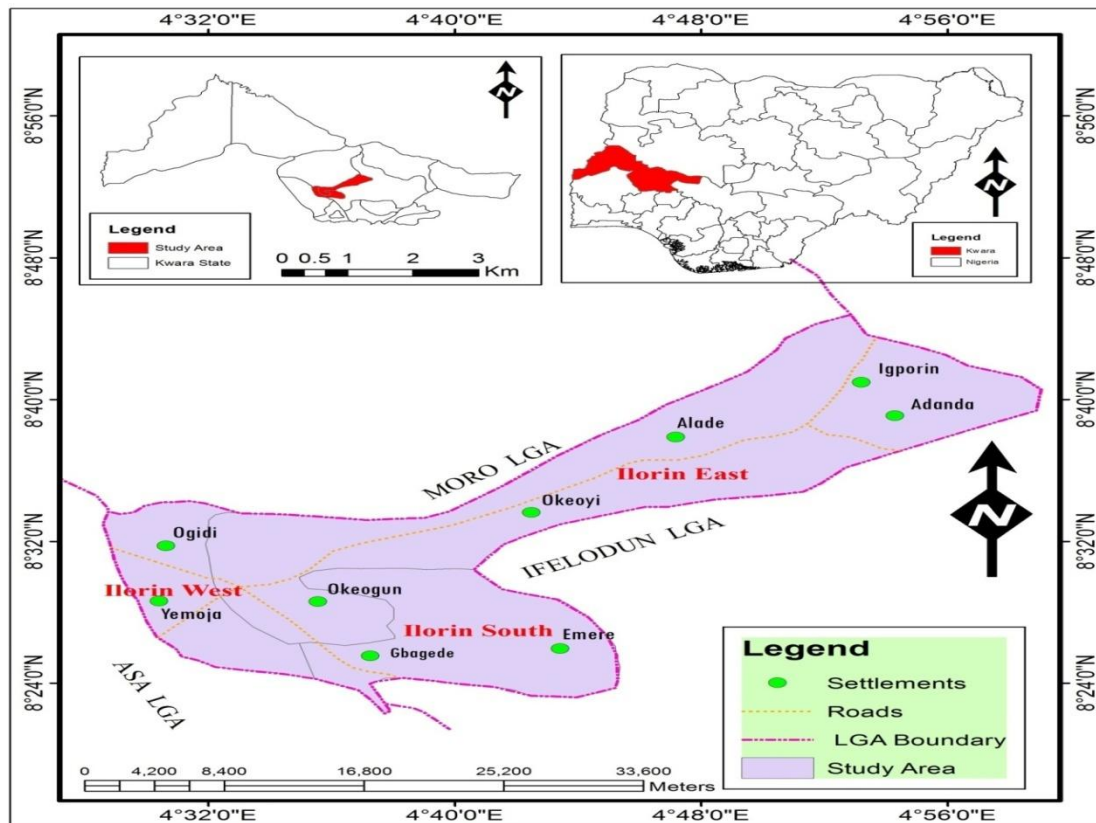
according to Goel [38] was used to justify 20.43% of the teachers and 79.57% of the students' respondents that were randomly sampled and helped in identifying the causes of fire disaster in public and private secondary schools in Ilorin. From 700 questionnaire administered, 645 questionnaires representing 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 [33]. The "fishbone diagram" known as a CEA model is a graphic tool used for identification, sorting and exhibition of potential causes of a problem [39]. The name "fishbone" emanates from its structural outlook and appearance [34]. 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 [40]. In other words, it was used to graphically illustrate the relationship between fire disaster and the causative factors [41]. Henrik [42] described CEA 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 been explored by other researchers in fire disaster incidences and safety management. To construct the fishbone diagram, the following steps identified in [43,44,45, and 34] were adapted. The steps were:

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- 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 labelled with the categories chosen in 4 below.
  - iv). The main categories of factors (causes) contributing to fire disaster identified were labelled. 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.
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#### **Scheme 1. Steps for constructing Fishbone Diagram**



**Fig. 1. Kwara State showing Ilorin Metropolis**  
**Source:** Adapted from Kwara State Ministry of Land and Survey (2017)

### 3. RESULTS AND DISCUSSION

This section presents results on the main aim of this study which sought to determine the root causes of fire disasters in public and private secondary schools in Ilorin Metropolis. Fishbone analysis is a good way of revealing an inside picture of a particular problem. In this section, the fishbone analysis model employs five contributing factors of several fire incidents in public and private secondary schools identified by the respondents and interviewees. The root-causes itemized by the target groups were placed accordingly against the primary factors. The second fishbone analysis illustrated in the Figure below (Fig. 3) was designed by placing the main problem (fire disaster) on 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 Fig. 3. The major causes depicted in the models constitute bush/waste burning, arson, electrical fault/wiring, carelessness, and alcohol, drugs and smoking alongside solution to these problems were presented in this section.

#### 3.1 Major Causes of Fire Disasters in Public and Private Secondary Schools in Ilorin Metropolis

**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 in 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 [46].

**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 the 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 [46]. 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 the non-insulated wiring system, overloading of junction boxes in some classrooms, computer laboratories coupled with leaving the 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.

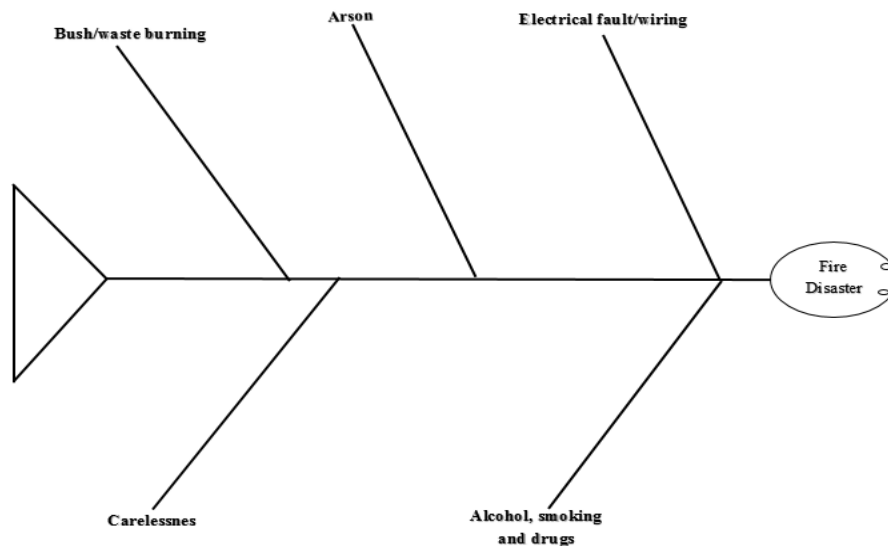


Fig. 2. Fishbone diagram of primary causes of fire disasters

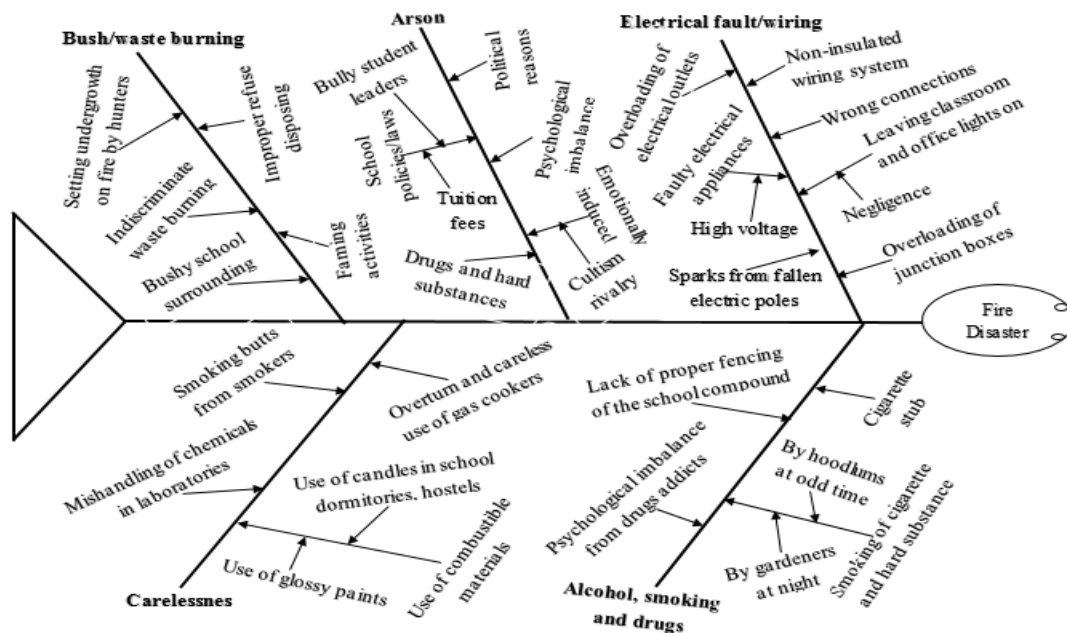


Fig. 3. Fishbone diagram for causes of fire disasters in public and private secondary schools in ilorin metropolis

**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 [7]. 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 [8]. 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. Another 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 [46] 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 a result of different reasons linked to mishandling of chemicals in various laboratories during experimentation, the nonchalant dropping of smoking butts 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 are also root-cause of fires. 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 in 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.

### **3.2 Target-oriented Measures to Curb Root Causes of Fire Disasters in Private and Public Secondary Schools in Ilorin Metropolis**

Several factors are responsible for fire disasters in public and private secondary schools in Ilorin metropolis. As such, schools need to take quick action to avert future fire even though the incident is few in secondary schools 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, other users, and the school itself here are some solutions that can help schools in improving the safety.

**Solutions of Bush/waste burning Problem:** The remedy to this may include; clearing of school compounds, strict punishment on students and teachers who litter the school compound, provision of waste bins in various classrooms, staff common rooms, and restriction of hunters and herders getting access to school compounds. Refuse dump should be managed effectively.

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

**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 by making matches sticks available to light gas burners in kitchens and laboratories. Adding to this, keeping gas cylinder outside kitchens and laboratories would help the flow and leakage into the air outside the laboratories and kitchens to prevent the 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 the kitchens, lantern or candlelight.

**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 secured gates and recruitment of experienced security men at various entrances. This would help schools in reducing fire disaster eventualities from the perpetrators. Prohibition of smoking within and around school premises during school hours by school users should viscusly be enforced. School management should consistently monitor school drivers who smoke or take in alcohol.

#### 4. LIMITATIONS OF THE FISHBONE ANALYSIS

Fishbone analysis is a tool that efficiently helped in identifying the root causes of fire disaster in public and private secondary schools in Ilorin as well as providing solutions to solve the problems. Despite its efficiencies, it has some drawbacks. One of the key limitations of the model states that the fishbone analysis model does not isolate major issues of the problems and presents each in the same way [34]. Fishbone analysis outlines the causes of fire disasters in the area but it does not clarify the sequence and magnitude of the primary causes [47]. Fishbone analysis also fails to satisfy the ambiguity of severities and contributions of each primary factors on fire menace in the area.

#### 5. 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 the huge cost of property loss faced by secondary 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.

#### 6. RECOMMENDATION

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

- i. Laboratory assistants and teachers should monitor students during practical sessions.
- 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 the fire outbreak.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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