Original Research Article

Fire incident statistics in the Tamale metropolitan area in the Northern Region of Ghana: A retrospective study

Abstract

The effect of a fire disaster is greater in developing countries due to no or inadequate preventive and support systems. There is therefore the need to analyze fire incident data to enable better fire safety and prevention strategies. The study was a retrospective cross-sectional study from January to June 2021. In all, 130 fire incident reports from 2017 to 2020 were collected. The data, consisting of 32 variables were analyzed using binary logistic regression. It was observed that fires due to electrical causes (53.9%), occurring in residential buildings (55.4%), and in the dry season (57.7%) were the most common. Fires due to nonelectrical causes were less likely to spread compared to fires due to electrical causes [AOR: 0.465(95%CI:0.221-0.977)]. Also, the likelihood of a fire spreading in the wet season was reduced, compared to the dry season [AOR: 0.341(95%CI:0.118-0.988)]. Moreover, apartment house's fires were less likely to spread as compared to compound house' fires [AOR: 0.341(95%CI:0.118-0.988)]. The source of energy, the design of a building and the climatic conditions are all associated with fire incidents in the study area. These findings will serve as guidelines for fire safety and prevention strategies in the Tamale metropolitan area.

Keywords: Fire incident, Electrical fire, Residential fire, Tamale metropolitan area, Ghana

1.0 Introduction

An incident may be regarded as a fire incident if unwanted smoke or flames are found within or around a dwelling, installation, institution, plantations, commercial buildings and the vegetation and possess the likelihood to cause damage or loss to life or property if it is left unattended [1]. Globally, about 9 million injuries were recorded emanating from fires, hot substances and heat in 2017 alone, resulting in about

120,632 deaths [2]. Also, there are over 300,000 annual deaths from fire-related burns alone and most of these deaths occurred in developing countries, which studies show to be about 11 times higher than in developed countries [3-6]. This figure keeps increasing due to rising human populations and advances in technology as well as climate change. Aside from the loss of life or property, fire outbreaks have long-term debilitating psychological effects arising from post-traumatic stress, burn injuries or disability with the associated socioeconomic implications for the victims and their dependents [3, 7-9]. The impact of fire incidents in the developing world such as Ghana is dire, as rescue services, preventive interventions and trauma or care systems are rare or lacking [4]. There have been a series of major market fires in Ghana, which is now becoming an annual affair. These market fires usually cause damage to goods amounting to thousands of Ghana cedis per incident [10].

The management of fire outbreaks and rescue is the responsibility of the Ghana National Fire Service [11]. It should be noted that fire outbreaks and their management are dynamic and change from time to time [12]. Multiple factors are associated with fire outbreaks: The rising city populations as a result of the rural-urban migration, urbanization, access to electricity, other energy sources and their usage, city planning and traffic management issues, climate change and weather conditions, peoples' behaviour, knowledge and awareness level regarding fire safety measures, the safety climate, organizational commitment and the readiness of fire personnel are all factors that can impact fire incidents in a city with their associated health and economic consequences [3, 7, 13-16].

There is a need for regular research to properly understand the dynamics of fire outbreaks. The analysis of fire statistics is advantageous in this regard [17]. The outcome of the research will inform policies, planning, strategies, and methods for the management and prevention of fires [9]. It will inform work ethics, personnel management, restructuring of the fire service including delimitation zones for fire stations or fire posts [18]. There are few fire-related studies in Ghana and for the northern part, studies are rare or nonexistent [10, 19]. This study aimed to analyze fire incident data to enable better fire safety and prevention strategies

2.0 Materials and methods

2.1 Study design and settings

The study was cross-sectional and retrospective, from January to June 2021 in the Tamale Metropolis of the Northern Region of Ghana. The Tamale metropolis is the capital of the Northern Region, with a population of about 672,000 inhabitants [20]. The management of fire and rescue in Ghana is the responsibility of the Ghana National Fire Service (GNFS). The national headquarters of the GNFS is located in Accra and it is headed by the Chief Fire Officer (CFO), with various departments headed by directors. There are also offices of the GNFS at the regional and district levels for administrative purposes. The regional office of the GNFS is situated in Tamale and is headed by the Regional Fire Officer (RFO). However, the metropolitan office is responsible for the management of fire and rescue in the Tamale metropolis. The metropolis has four fire stations with delimitated zones: The metro office station (Zone M), the Teaching Hospital station (Zone T), the Sagnarigu station (Zone S) and Substation at the regional headquarters (RHQ). There is one call centre (control room) where reports of fire incidents are received and then routed to the nearest fire station. Also, reports of fire incidents may be reported in person at the nearest fire station or from the media (radio or television). Reports are written at the various stations, following an incident, and copies are made and sent to the regional and national headquarters of the GNFS [11].

2.2 Variables

In all, 32 variables were considered in the study. The variables pertained to time, structures, the nature of the fire, the response of the GNFS, injuries or fatalities and the economic implications of the fire incident. The dependent variables were (1) the cause of the fire, (2) the type of fire (3) the spread of fire and (5) the extent of the damage.

2.3 Data sources and collection

A fire incident was defined as any incident involving unwanted flames or smoke, either small or large, that occurred in or around a dwelling, installation, institution, plantations, commercial buildings and the

vegetation with a tendency to cause damage to life or property if left unchecked [1]. These fire incident reports from three zones (M, T and S) were retrieved from the Tamale Metropolitan office. These were fire incidents that occurred between 2017 and 2020 within the Tamale metro area of the GNFS. The forms were examined by the authors for completeness. Of the 135 documents that were examined, three (3) were duplicate reports and two (2) were incomplete. In the end, 130 reports were selected and used for the study.

2.4 Statistical analysis

The data were collected onto an Excel spreadsheet before statistical analysis in SPSS (v23) and GraphPad Prism (v8). Descriptive statistics were performed for each variable and were presented as frequency (%). The dependent variables were binary and were dummy coded (0 or 1). The rest of the variables were also dummy coded. The associations between the dependent and the independent variables were determined using binary logistic regression analysis. To reduce the effect of location on the outcome, each independent variable was entered into the same regression model, simultaneously with the location variable. The effect size was then reported as an adjusted odds ratio (AOR) with the 95% confidence interval (CI). All statistical analyses were 2-tailed at $P<0.050$.

2.5 Ethical consideration

The study received approval from the institutional review board of the Tamale Metropolitan office of the Ghana National Fire Service. The identities of the victims of the fire incidents were not disclosed or used as part of the study. The confidentiality of the data was strictly observed

3.0 Results

The general characteristics of the study variables are summarized in Table 1 and Figure 1. From Fig. 1, more of the fire incidents were recorded in 2020 (47.7%) and 2016 recorded the least (12.3%). The first quarter (January-March) of the year recorded more fire incidents (35.4%). Also, the dry season recorded the majority of fire incidents (57.7%). The majority of the fires occurred in the evening between 18.00 to 06.00 Greenwich mean time (GMT) and usually in occupied structures (77.7%). The majority of the fire incidents reported to the GNFS were through telephone calls (65.4%). Only 2 (1.5%) people were injured

as a result of the fire and no fatalities were recorded. Most premises of the fire incidents attended did not have the recommended fire safety measures in place (91.5%). Factors that are associated with the cause of fire in the Tamale metropolitan area are summarized in Table 2. It was observed that fire incidents of nonelectrical sources were more associated with other structures as compared to compound houses [AOR: 3.323(95%CI: 1.415-7.804)]. Also, fire incidents originating from nonelectrical sources were less likely to spread as compared to fire incidents emanating from electrical sources [AOR: 0.465(95%CI:0.221-0.977)]. From Table 3, nonresidential fires had greater odds of being influenced by the wind relative to power fluctuations [AOR: 5.000(95%CI:2.013-12.417)]. The factors that are associated with the tendency of a fire to spread are summarized in Table 4. The tendency of a fire in the dry season not to have spread was reduced relative to the wet season [AOR: 0.341(95%CI:0.118-0.988)]. Also, apartment house's fires were less likely to spread as compared to compound houses [AOR: 0.341(95%CI:0.118-0.988)]. From Table 5, unoccupied structures were less likely to sustain major damages as a result of fire compared to structures that were occupied [AOR: 0.110(95%CI:0.013-0.906)]. Also, major damages caused as a result of the fire were less influenced by wind compared to power fluctuations [AOR: 0.250(95%CI: 0.069-0.905)].

4.0 Discussion

The study sought to analyze fire incident data to enable better fire safety and prevention strategies in the Tamale metropolitan area of Ghana. Fire incidents due to electrical causes were more frequent compared to fires due to nonelectrical causes. More fire incidents occurred in residential buildings, during the dry season and in the evening. Fires were more likely to spread in the dry season and also in compound houses. Fires that were influenced by power fluctuations were more likely to cause major damages. Moreover, structures that were not occupied were more likely to sustain major damages due to fire. Finally, fire measures at the places attended following a fire incident were low although casualties' statistics were low.

Fire outbreaks due to electrical causes were the most common in the Tamale metropolis [10]. Similar findings have been reported from studies regarding the causes of fire [3, 17]. Studies regarding fire incidents in rural settings, however, show that most rural household fires are from nonelectrical sources. Low access and high electricity cost often lead to inhabitants adopting the energy stacking approach i.e., alternating between electricity and other sources of energy such as kerosene, charcoal or firewood. These alternative sources of energy usually involve open flames, posing a higher fire risk [13]. The population of Ghana has increased five (5) folds since the 1960 post-independence census to about 30.8m as of the last population and housing census. Similarly, the population of the Tamale metro have grown to about 672,000 in 2021, an increase of about 5% of the preceding year's figure [20]. There is also increased rural-urban migration as people seek better conditions and employment opportunities. Increasing population without commensurate provision of housing and amenities may result in overcrowding, informal settlement dwellings (ISDs) and backyard dwellings (BYDs). These informal dwellings are usually constructed from easily combustible materials such as wood, cardboard or tarpaulins[6, 13, 19, 21, 22]. Access to electricity in Ghana is high particularly in cities. Most people find it convenient to cook and perform a task using electrical appliances. Formal households usually acquire their power supply from the national grid while the ISDs or the BYDs may tap power from these households or tap it illegally from power lines using makeshift wring or extensions cords. Challenges with acquiring a meter, high fees charged by landlords for power usage and low economic status of tenants may lead to these illegal arrangements which are usually poorly executed by less qualified electricians [13, 22]. The power supply system in Ghana experiences episodes of irregular supply, popularly known as "*dumsor*" with the associated power fluctuations [10]. Poor wiring, use of old electrical wires and overloading of electrical sockets are also associated with fire outbreaks. These and the associated factors are partly responsible for the frequent market and related fires in Ghana and Tamale [3, 10, 13].

Fire outbreaks were more frequent in the dry season and the evening and were more likely to spread and cause major damages. Lizhong, Xiaodong [17], found that the incidents of fire in the evening was higher than the total average. Tamale is located in the northern part of Ghana, an area that falls within the

climatic zone of the guinea savannah. There are only two seasons in a year; the wet season, from April to September and the dry season from October to March of the following year. However, there are annual variations in the duration of the wet and the dry seasons. The dry season is usually characterized by little to no rain, dry winds and high temperatures [23]. It is also a period for hunting for wild animals and this usually involves the burning of the bushes by children in search of rodents. The temperature in the savannah regions can reach 45^{o}C in the dry season. This means that inhabitants may resort to the use of cooling systems and appliances such as fans and air conditioners during the night when most people would have returned from work [17].

The outbreak of fires was more common among residential and occupied dwellings or structures [17]. The start, the spread and the extent of damage of fire partly depended on the type of structure. It was observed that residential fires spread easily among compound houses as compared to apartment houses. Compound houses are the most common residential houses in Tamale. They are usually built in a shape of a rectangle or square with shared amenities for the many occupants [24]. Unlike apartment houses that are built from carefully drawn plans using qualified personnel, compound houses are usually built by individuals using artisans who may not have any formal training in building and construction. Therefore, compound houses are built without any fire safety considerations. A compound house may be inhabited by between 10-50 individuals, either from one large extended family or tenants and their families [25]. The usage of liquified petroleum gas (LPG), heaters and other electrical gadgets are common among households in compound houses. Gas leakages, overloading of electrical systems and negligence may all increase the risk of residential fires in compound houses [6].

There was a general reduction in the observance of fire safety measures among victims of fire incidents[19, 26]. The fire extinguisher is the most common fire safety equipment in most households relative to fire alarms, however, the extinguisher is most likely acquired after a fire incident. The occurrence of a fire does not necessarily increase the level of fire safety awareness of the affected people [27]. Although reports of injury were low without any recorded fatality, there is the need for vigorous fire

safety awareness in the Tamale metropolis as this will lead to a reduction in fire incidents [28]. To reduce fire risk, Francioli [13] recommend the following: (1) reduce overheating by avoiding simultaneous use of electrical appliances, (2) regular maintenance of all electrical connections and appliances, (3) when not in use and during power cuts, all electrical appliances should be switched off and disconnected (4) special education for children, the vulnerable and the aged, (5) reporting fire outbreaks promptly and encouraging the use of fire safety equipment such as extinguishers, alarm systems and community vigilance. Measures should also be taken regarding fire personnel as studies show that fire personnel with positive safety climate perceptions exhibit positive affective organizational commitment, necessary for protecting the public from fire-related disasters and that home visits by fire personnel lead to a reduction in fire incidents [14, 29]. It is recommended that fire personnel respond to emergencies within 5 minutes or the Golden 5 minutes. It is therefore prudent for a proper service area delimitation to reduce delays emanating from a distance, traffic or related factors [18]. The establishment of a national fire information database (NFID) will facilitate research, policy, monitoring and evaluation in the GNFS [9].

This study has some strengths: studies regarding fire statistics in Ghana are few and rarely involved in the Northern part of Ghana [10, 19]. The study analysed multiple variables to determine the factors that were associated with fire incidents in the Tamale metropolis. However, the use of a larger sample size, coupled with risk assessment and fire safety knowledge and awareness of the inhabitants would be an added advantage.

In conclusion, it was observed that electrical and residential fires were the most common and these fires mostly occurred in the evening, the dry season and occupied dwellings or structures. Also, fire emanating from electric sources and occurring in compound houses were more likely to spread and cause more damage. In conclusion, the source of energy, the conditions of the weather, occupancy and the design of a dwelling are associated with fire outbreaks, their spread and the extent of damage caused. This study will enable better strategies for safety and prevention in the Tamale metropolitan area.

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Table 1. General characteristics of the study variables

Variable	Frequency (%)
Quarter of the year	
1st	46(35.4)
2nd	32(24.6)
3rd	23(17.7)
4th	29(22.3)
Season of the year	
Wet (April-September)	55(42.3)
Dry (October-March)	75(57.7)
Time of the month	
1st -10th	59(45.5)
11th -20th	29(22.3)
21st -30th	42(32.3)

Day of the week	
Monday-Wednesday	52(40.7)
Thursday-Friday	45(34.6)
Saturday-Sunday	33(25.4)
Time of fire incident (GMT)	
6.00-11.59	32(24.6)
12.00-17.59	32(24.6)
18.00-05.59	66(50.8)
Discovery-report (minutes)	
<10	86(66.0)
≥ 10	44(34.0)
Mode of reporting	
Telephone call	85(65.4)
Running call	45(34.6)
Reporter	
Male	116(89.0)
Female	14(11.0)
Number of crew dispatched	
1-4	42(32.3)
>4	88(67.7)
Weather condition	
Good/clear	113(86.7)
Bad/cloudy	17(13.3)
Road condition	
Good/tarred	124(95.1)
Bad/rough	6(4.9)
Location	
Zone M	81(62.3)
Zone T	30(23.1)
Zone S	19(14.6)
Occupied	
Yes	101(77.7)
No	29(22.3)
Occupant	
Male	106(81.4)
Female	24(18.6)
Nearest fire station (km)	
< 3	83(63.8)
≥ 3	47(36.2)
Type of fire	
Residential	72(55.4)
Nonresidential	58(44.6)
Type of structure	
Compound house	45(36.3)
Apartment house	24(19.4)
Others	55(44.4)
Construction materials	
Sand Crete blocks	89(68.9)

Other materials	41(31.1)
Cause of fire	
Electrical	69(53.9)
non-electrical	61(46.1)
Influencing factor	
Power fluctuation	56(42.9)
Wind	46(35.7)
Others	28(21.4)
Human factors	
Negligence	49(37.5)
Children	35(27.1)
Others	46(35.4)
Fire spread	
Yes	61(46.6)
No	69(53.4)
Fire was tackled by the public	
Yes	83(64.2)
No	47(35.8)
Method used by the GFS	
Cooling with water	119(91.8)
Other methods	11(8.2)
Fire under control (minutes)	
<15	59(45.9)
≥ 15	71(54.1)
Fire safety measures in place	
Yes	12(8.5)
No	118(91.5)
Injured persons	
Yes	2(1.5)
No	128(98.5)
Sex of the injured	
Male	0(0.0)
Female	2(100)
Causalities recorded	
Yes	0(0.0)
No	130(100)
Damage caused	
Minor	94(72.9)
Major	36(27.1)
Cost of damage (GHc)	
<1000	46(35.2)
≥ 1000	84(64.8)

The results were presented as frequency (%)

Table 2. Factors associated with the cause of fire in the Tamale Metropolitan area

Variable	Cause of fire			
	Electrical	**Nonelectrical**	**AOR (95%CI)**	**P-value**
Season of year				
Wet (April-September)	35(63.0)	20(37.0)	1	
Dry (October-March)	35(47.3)	40(52.7)	0.528(0.258-1.081)	0.081
Day of the week				
Monday-Wednesday	30(57.7)	22(42.3)	1	
Thursday-Friday	27(60.0)	18(39.5)	0.892(0.393-2.029)	0.785
Saturday-Sunday	13(39.4)	20(60.0)	2.098(0.862-5.103)	0.102

Time of fire incident (GMT)				
6.00-11.59	18(54.8)	14(45.2)	1	
12.00-17.59	16(50.0)	16(50.0)	1.214(0.451-3.269)	0.701
18.00-05.59	36(55.4)	30(44.6)	0.978(0.414-2.311)	0.960
Type of fire				
Residential	46(63.9)	26(36.1)	1	
Non-residential	24(41.1)	34(58.9)	2.538(1.239-5.202)	0.011
Type of structure				
Compound house	33(73.3)	12(26.7)	1	
Apartment house	12(50.0)	12(50.0)	2.750(0.974-7.762)	0.056
Others	25(45.3)	30(54.7)	3.323(1.415-7.804)	0.006
Construction materials				
Sand Crete blocks	55(61.4)	34(38.6)	1	
Other materials	18(43.2)	23(56.8)	2.092(0.953-4.592)	0.066
Fire spread				
Yes	25(40.7)	36(59.3)	1	
No	41(59.7)	28(40.3)	0.465(0.221-0.977)	0.043
Damage caused				
Minor	44(46.9)	50(53.1)	1	
Major	27(73.7)	9(26.3)	0.316(0.099-1.013)	0.053

Results are presented as adjusted odds ratios (AOR) and their 95% confidence intervals (CI). Odds ratios were adjusted for the location variable.

Table 3. Factors associated with residential and non-residential fires in the Tamale metropolitan area

Variable	**Type of fire**			
	Residential	**Nonresidential**	**AOR (95%CI)**	**P-value**
Season of year				
Wet (April-September)	34(61.8)	21(38.2)	1	
Dry (October-March)	38(50.7)	37(49.3)	1.576(0.777-3.199)	0.207
Day of week				
Monday-Wednesday	30(57.7)	22(42.3)	1	
Thursday-Friday	25(55.6)	20(44.4)	1.091(0.488-2.441)	0.832

Saturday-Sunday	17(51.5)	16(48.5)	1.283(0.534-3.084)	0.577
Time of fire incident (GMT)				
6.00-11.59	19(59.4)	13(40.6)	1	
12.00-17.59	16(50.0)	16(50.0)	1.462(0.544-3.929)	0.452
18.00-05.59	37(56.1)	29(43.9)	1.146(0.486-2.698)	0.756
Influencing factor				
Power fluctuation	40(72.9)	16(27.1)	1	
Wind	16(35.0)	30(65.0)	5.000(2.013-12.417)	0.001
Others	15(54.2)	13(45.8)	2.278(0.818-6.347)	0.115
Fire safety measures in place				
Yes	2(20.0)	10(80.0)	1	
No	66(55.6)	52(44.4)	0.200(0.021-1.909)	0.162

Results are presented as adjusted odds ratios (AOR) and their 95% confidence intervals (CI). Odds ratios were adjusted for the location variable.

Table 4. Factors affecting the spread of fires in the Tamale metropolis

Variable	**Fire Spread**			
	Yes	**No**	**AOR (95%CI)**	**P-value**
Season of year				
Wet (April-September)	19(34.7)	36(65.3)	1	
Dry (October-March)	41(55.1)	34(44.9)	0.433(0.204-0.923)	0.030
Occupied				
Yes	43(42.5)	58(57.5)	1	

No	14(47.8)	15(52.2)	0.806(0.318-2.045)	0.650
Time of fire incident (GMT)				
6.00-11.59	12(36.7)	120(63.3)	1	
12.00-17.59	18(55.6)	14(44.4)	0.463(0.160-1.339)	0.155
18.00-05.59	31(47.5)	35(52.5)	0.639(0.261-1.566)	0.327
Type of structure				
Compound house	18(39.0)	27(61.0)	1	
Apartment house	16(65.2)	8(34.8)	0.341(0.118-0.988)	0.047
Others	25(44.9)	30(55.1)	0.785(0.338-1.825)	0.574
Construction materials				
Sand Crete blocks	39(44.3)	50(55.7)	1	
Other materials	21(50.0)	20(49.0)	0.795(0.349-1.811)	0.586
Influencing factor				
Power fluctuation	20(36.4)	36(63.6)	1	
Wind	25(55.0)	21(45.0)	0.468(0.195-1.121)	0.089
Others	13(47.4)	15(52.6)	0.635(0.213-1.889)	0.414
Fire safety measures in place				
Yes	5(40.0)	7(60.0)	1	
No	52(40.4)	66(59.6)	0.984(0.151-6.404)	0.987

Results are presented as adjusted odds ratios (AOR) and their 95% confidence intervals (CI). Odds ratios were adjusted for the location variable.

Table 5. Factors associated with the extent of damage in fire incidents in the Tamale metropolitan area

Variable	**Extent of damage**			
	Minor	**Major**	**AOR (95%CI)**	**P-value**
Season of year				
Wet (April-September)	41(73.9)	14(26.1)	1	
Dry (October-March)	54(72.3)	21(27.7)	1.083(0.350-3.350)	0.889

Time of fire incident (GMT)				
6.00-11.59	20(61.1)	12(38.9)	1	
12.00-17.59	26(80.0)	6(20.0)	0.393(0.092-1.672)	0.206
18.00-05.59	50(75.0)	16(25.0)	0.524(0.152-1.811)	0.307
Occupied				
Yes	64(63.8)	37(36.2)	1	
No	27(94.1)	2(5.9)	0.110(0.013-0.906)	0.040
Type of structure				
Compound house	28(61.9)	17(38.1)	1	
Apartment house	18(75.0)	6(25.0)	0.542(0.112-2.619)	0.446
Others	42(77.1)	13(22.9)	0.481(0.148-1.571)	0.226
Construction materials				
Sand Crete blocks	60(67.4)	29(32.6)	1	
Other materials	34(82.6)	7(17.4)	0.435(0.126-1.507)	0.189
Influencing factor				
Power fluctuation	34(60.0)	22(40.0)	1	
Wind	39(85.7)	7(14.3)	0.250(0.069-0.905)	0.035
Others	25(87.5)	3(12.5)	0.214(0.023-1.971)	0.174
Fire safety measures in place				
Yes	6(50.0)	6(50.0)	1	
No	84(71.4)	34(28.6)	0.400(0.051-3.125)	0.382

Results are presented as adjusted odds ratios (AOR) and their 95% confidence intervals (CI). Odds ratios were adjusted for the location variable.

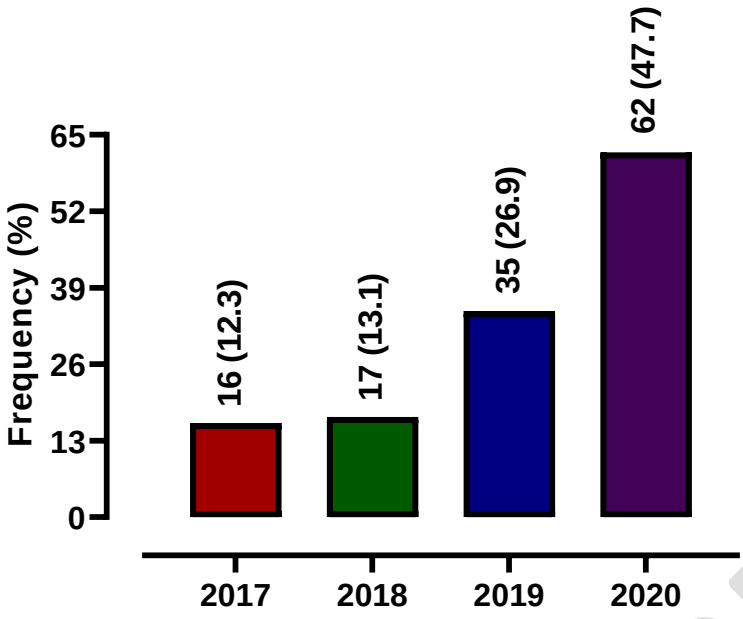

Figure 1. A bar graph showing the annual distribution of fire incidents in the Tamale metropolitan area