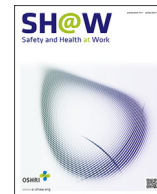




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Original Article

Trend of Fire Outbreaks in Ghana and Ways to Prevent These Incidents

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ABSTRACT

Background: In Ghana, fire incidents have become a regular occurrence, with thousands of lives and millions of dollars lost every year. Hardly a day passes without news of a fire outbreak in some part of Ghana, causing fear and panic among the people. This generates much discussion centering on rumors relating to politics, sabotage, misfortune, religious differences, etc. This article seeks to discuss the trend of fire incidents occurring in Ghana from 2000 to 2013 and the different ways to prevent these incidents.

Methods: The pattern of fire incidence in Ghana as a whole as well as in each region is discussed. The study took into consideration the causes, mechanisms, as well as preventive measures against the fire menace. Data were obtained from the head office of Ghana's national fire service.

Results: It was noticed that in general the rate of fire incidence increased each year. This increase was attributed to several factors: rate of population growth and industrialization, unstable electricity, urbanization, negligence, illegal electrical connection, etc. The cause of fire was categorized into domestic, industrial, vehicular, institutional, electrical, commercial, bush, and others. Among these causes, domestic fire accounted for 41% of the total number of fire incidents in the country.

Conclusion: Finally, this study presents several recommendations to help prevent and mitigate fire incidents in Ghana.

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1. Introduction

For longer than recorded history, fire has been a source of comfort and catastrophe for the human race. Early humans used fire to keep warm, cook food, and frighten predators. Sitting around the fire also helped them to unite and strengthened family groups and consequently speeded up evolution. However, fire also posed great risks and challenges to early people, including the challenge of starting and controlling fires, and grappling with the threat of burns and wildfires [1]. Fire continues to be a basic everyday element of most people's lives. This tendency of one of man's best friends to turn into his worst enemy cannot be underplayed, as improper handling and use of fire has led to several accidents in homes, offices, schools, and other public places with very serious repercussions [2].

Fire is a rapid, self-sustaining oxidation process accompanied by the evolution of heat and light in varying intensities. Fire is believed to be based on four elements being present: fuel, ignition source, oxidizing agent (usually atmospheric oxygen), and mechanism of the reaction. The most common fuels that cause fires include flammable gases used for cooking in homes, furniture, clothing, solvents used in our daily activities, such as kerosene and gasoline, and combustible dusts, such as toners used in offices and starch sold in markets. A list of combustible dusts is presented in Occupational Safety and Health Administration's combustible dust guide [3]. Fires can even occur for a mixture of flammable gas and combustible dust even if the lower flammability limit of the mixture is below the flammability limit of the individual substances [4–6]. The most common ignition sources include cooking/heating equipment, intentional electrical open flames or embers,

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appliances, tools or air conditioning, other heat sources, as well as natural causes, such as earthquakes and volcanic eruptions [7]. When fire occurs, there are several contributing factors that help it to spread easily and become more destructive. Some of these factors include wood shingle/thatched roofs, high wind, congested access, inadequate water distribution system, lack of exposure protection, inadequate public protection (i.e., fire department inadequacies), unusual hot or dry weather conditions, delay in discovery of fire, inadequate personal fire protection, and delay in raising the fire alarm. Fire disasters can occur above the ground (in tall buildings and in planes), on the ground, and below the ground (in mines). Sometimes they occur in circumstances that are unexpected or unpredictable [8]. The occurrence of fire disasters is not a new phenomenon in Ghanaian history. In 1983, the fire that engulfed Ghana and led to a severe hunger crisis has become the major point of reference in the country's history [9]. Hardly a day passes without news of a fire outbreak in any part of Ghana. There is no doubt, therefore, that these recent fire outbreaks have generated numerous discussions centering on rumors relating to politics, sabotage, or religious differences. However, the question that needs to be addressed is: "What is the real cause of these recent outbreaks of fire in the country?" [10].

Most of the recent fire outbreaks have taken place in state facilities that are of great strategic value, thereby making fires an issue of public concern and debate. For example, the Kumasi Central Market has suffered from a series of fire outbreaks. The first occurred on May 28, 2009, with another occurring on January 2, 2010. In December 30, 2012, it also experienced another outbreak within which more than 150 shops were gutted by fire [11]. Fig. 1 shows the fire outbreak that occurred in Kumasi market. The left image shows the initiation stage, the middle image shows the burning stage, and the right image shows the end stage and clearing of debris.

Other important places that were destroyed by fire include the following: the Ministry of Information, the loading gantry of Tema Oil Refinery, offices of the Electoral Commission, and the Ridge residence of former President Rawlings [11]. The country keeps incurring huge losses in terms of property damage and resources lost because of fires; for example, in 2013 approximately 11,000 Ghanaians were affected by fire and explosion, and the cost of these type of incidents was approximately \$7 million [13,14]. Most of these fires—whether domestic, industrial, institutional, commercial, vehicular, or bush—come with devastating consequences, including loss of lives and properties. Anaglatey [15] observed that one of the main causes of fire outbreak in Ghana has been electrical problems resulting from faulty wiring and misuse of

electrical gadgets. According to Simpson [14], electrical faults originate from poorly designed and poorly constructed electrical circuits, and the electrical wiring found in many domestic buildings in Ghana is designed not by an electrical engineer, but by an artisan with scant knowledge of electrical circuit design. Electrical cables are commonly found strewn haphazardly on the ceiling of most domestic buildings, and when the cables' insulation deteriorates with time, short circuitry occurs, resulting in fire outbreaks. Causes of naked flames are defined by Simpson to include cooking (e.g., kerosene stoves, electric cookers, gas cookers, coal pots), lighting devices (e.g., candles lanterns), cigarettes, and lighted mosquito coils. Boateng [16] noted that improper electrical fittings, use of substandard electrical materials, defective generators, power fluctuations resulting from frequent power outages, and illegal tapping from the national grid are some of the possible causes of fire outbreaks. Boateng [16] also indicated that the rise in fire outbreaks can be traced to intense Harmattan, overloading of electrical appliances on the same fuse, and improper electrical installation in homes and workplaces. He also noted that illegal, improper, and old wiring systems, as well as cooking in the home and workplace with naked fire, are some of the major causes of frequent fire outbreaks. Abu [17] reports that 75% of fire outbreaks in Ghana are caused by smoking, 15% by ignorance, and 10% by accidents. The effects of these fire outbreaks, which have become a frequent occurrence, have been devastating. However, nothing seems to have been done to prevent their occurrence even though the situation keeps worsening as these incidents continue to increase, yet only a small amount of information is available [2]. This paper seeks to evaluate the trend of fire incidence in Ghana and offers recommendations to help prevent or mitigate these incidents.

2. Materials and methods

2.1. Mechanism for fire development

Fire development is usually a function of many factors including: fuel properties, fuel quantity, ventilation (natural or mechanical), compartment geometry (volume and ceiling height), location of fire, and ambient conditions (temperature, wind, etc.). This kind of development can be classified into traditional and structural.

Traditional fire development shows the time history of a fuel-limited fire as shown in Fig. 2. In other words, fire growth is not limited by a lack of oxygen. As more fuel becomes involved in the fire, the energy level continues to increase until all of the fuel



Fig. 1. Scenes from a fire outbreak in Kumasi central market [12].

Note. From "A call for action to improve occupational health and safety in Ghana and a critical look at the existing legal requirement and legislation," by J.-S. Annan et al, 2015, *Saf Health Work*. Copyright 2015. Elsevier. Reprinted with permission.

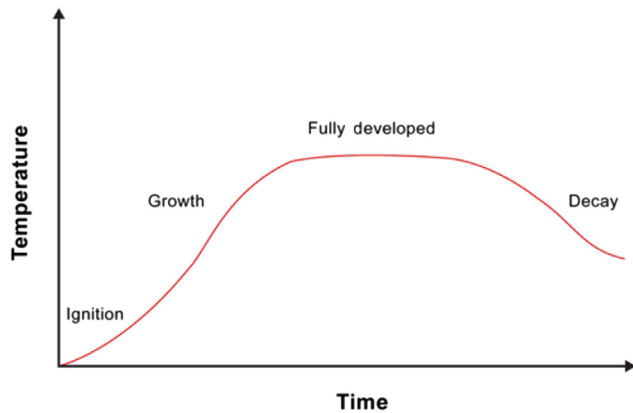


Fig. 2. Traditional fire development [18].

Note. From "Fire dynamics: the science of firefighting," by D. Madrzykowski, 2013, *Int Fire Service J Leadership Manage*, 7, p. 9. Copyright 2012. Fire protection publication/IFSTA. Reprinted with permission.

available is burning (fully developed). Then as the fuel is burned away, the energy level begins to decay. The key is that oxygen is available to mix with the heated gases (fuel) to enable the completion of the fire triangle and the generation of energy.

In the case of fire behavior in a structure, it demonstrates the history of a ventilation-limited fire as shown in Fig. 3. In this case, the fire starts in a structure whose doors and windows are closed. Early in the fire growth stage, there is adequate oxygen to mix with the heated gases, which results in flaming combustion. As the oxygen level within the structure is depleted, the fire decays, the heat release from the fire decreases and as a result the temperature decreases. When a vent is opened, such as when a firefighter enters a door, oxygen is introduced. The oxygen mixes with the heated gases in the structure, and the energy level begins to increase. This change in ventilation can result in a rapid increase in fire growth, potentially leading to a flashover (fully developed compartment fire) condition [18].

2.2. Fire prevention and protection

As noted in the previous section, fire normally occurs when three main components come together: fuel source, ignition source or heat, and an oxidizing agent. These popular four components

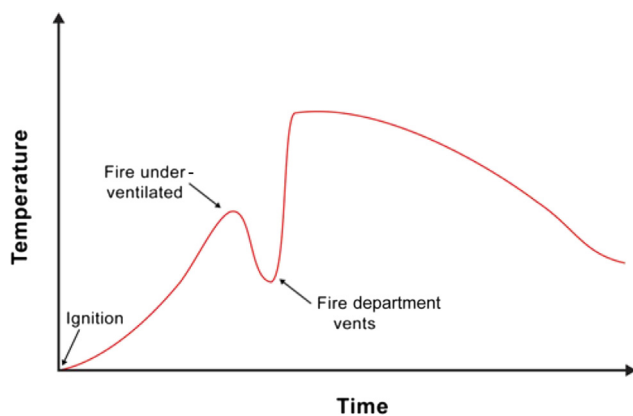


Fig. 3. Structural fire development [18].

Note. From "Fire dynamics: the science of firefighting," by D. Madrzykowski, 2013, *Int Fire Service J Leadership Manage*, 7, p. 9. Copyright 2012. Fire protection publication/IFSTA. Reprinted with permission.

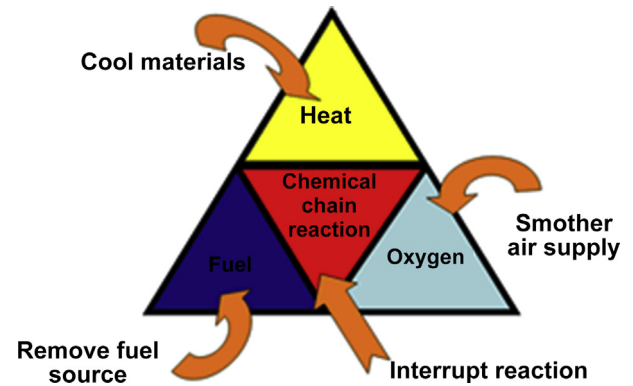


Fig. 4. Fire prevention triangle.

lead to a term fire tetrahedron as shown in Fig. 4, but if any one of these components is removed, the propagation of fire will be prohibited.

There are several methods to prevent both domestic and other types of fires, as described in the following discussion.

2.2.1. Electrical fires

Preventive measures include maintaining facilities in good condition to avoid overcharging, poor contact, and short circuits; avoiding the use of plugs and wires in poor conditions; and lowering the recommended gauge. Consumers should never replace fuses or circuit breaker for direct connections with wires or currencies, and should not overload electrical outlets with multiple devices connected at the same time, because the wires become hot and can cause a fire. One should never leave an electric iron on while doing something else, even for only a few minutes, as this has been frequently cited to cause fires. One should always ensure that the holes and air vents of home appliances (e.g., television and microwave ovens) are not located near any clothing material or decorative covers, and one must also avoid placing lamps, candles, and heaters near curtains, papers, or other combustible materials.

2.2.2. Burnable gas fire

One should handle gas cylinders with care to avoid falling or suffering from stroke. Gas cylinders should be stored in clean, well-ventilated, and oil-and-grease-free areas, and should be protected from the rain, sun, and other heat sources. Domestic gas cylinders should not be kept together with the stove, but should be placed outside the home and connected to metal pipes. If the gas is installed inside the house and a leak occurs, one should not strike a match or light up or turn off the lights. When installing a new cylinder, use soapy water to test for leaks; one should never use a flame for this purpose, but must remember that soap should not be used to seal leaks. When lighting a stove oven, strike the match first and then open the gas; if the house is unoccupied for an extended period, close the gas cock.

2.2.3. Fire incidence in the kitchen

One should not use plastic bags or towels in the kitchen; one should not place a piece of cloth or decorative paper near the stove, and the cables of the pots should be directed to the center of the stove, etc.

2.3. Methods of data collection and analysis

This study covers all 10 regions in Ghana. Raw data were obtained from the regional head office of the Ghana fire service. The

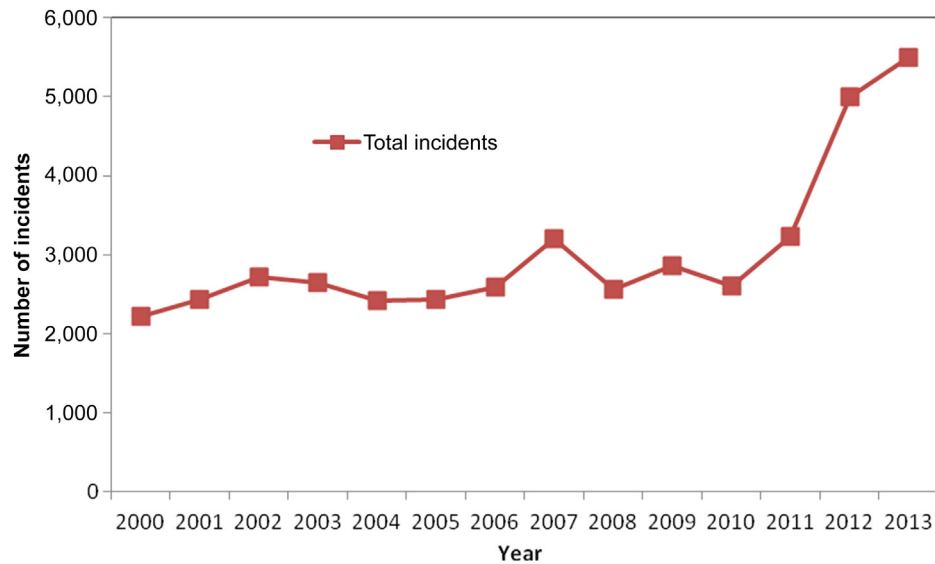


Fig. 5. Pattern of fire incidents (yearly basis) in Ghana.

study took into consideration the following causes of fire during the analysis of raw data: domestic, industrial, vehicular, institutional, electrical, commercial, bush, and others. Data from 2000 to 2013 were selected and analyzed using pie charts, bar charts, and trend lines.

3. Results

This study was conducted to investigate the trend of fire incidents in Ghana during a 13-year period (2000–2013). The study covered 10 regions in Ghana, with emphasis on areas where fire incidents have occurred frequently. The results have been grouped into three main parts: the northern part (i.e., the Northern region, Upper east region, and Upper west region), the middle part (i.e., the Brong Ahafo region, Ashanti region, Volta region, and eastern region), and the southern part (i.e., the Greater Accra region, Central region, and Western Region). The total number of incidents as well the number of deaths for each region were also considered. It must be noted that only reported fire incidents were considered in this study. There might have been several unreported fire incidents throughout the country for which estimates are not available, and hence are not considered in this study.

Fig. 5 illustrates the number of fire incidents that have occurred in Ghana from 2000 to 2013. It can be seen from the figure that in 2000 to 2010, the rate of fire incidence was almost the same, but there was a sharp increase from 2011 to 2013. The reason for this constant rate of fire incidents could be a result of the constant

supply of electricity in the country throughout those years. As explained in the Introduction section, electrical related problems are the leading cause of domestic fires, resulting from old wiring, poor wiring, overloading of electrical circuits, heating appliances, etc. From 2011 to 2014, the country has grappled with a series of energy crises that led to an unstable supply of electricity. This unstable electricity supply generates a constant ignition source that can ignite flammable gases because most gases have a minimum ignition energy of less than 1 mJ. For example, LPG (liquefied petroleum gas), which is one of the main sources of cooking fuel in the country, can cause fire if there is any accidental leakage, from which a combustible atmosphere is created and with electrical spark as the ignition source.

Moreover, Twum-Barima [19], who evaluated the causes of fire in Kumasi Central Market, noted that power fluctuations accounted for 26% of the total fire incidents in markets. He further underscored the following causes (with percentage): cooking with naked fire in the market, 19%; overloading of electrical appliances, 16%; improper and old electrical wiring system, 13%; illegal tapping of electrical power from the national grid, 11%; use of substandard electrical materials, 8%; and use of defective generators, 7%. He also highlighted the extent of severity in cases of fire due to congested situations in this market, as shown in Fig. 6. As markets do not have proper layouts, accessibility by fire tenders is always difficult when there is a fire outbreak because every major market in Ghana faces the problem of congestion. For this reason, fire hydrants have been obscured by stalls, and lanes that fire trucks need to use to access



Fig. 6. Kumasi central market.

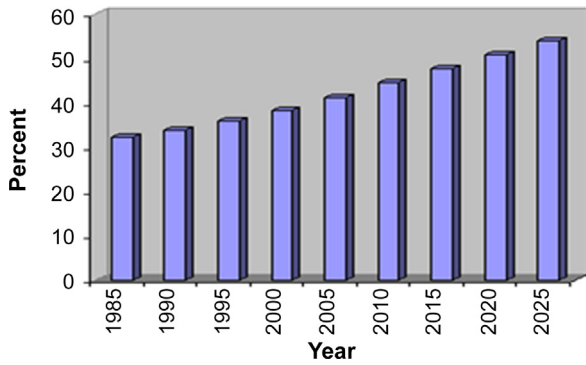


Fig. 7. Urbanization growth in Ghana [20].
 Note. From "Population distribution," by D. Owusu-Ansah, in: La Verle B (Ed), A country study: Ghana, Library of Congress Federal Research Division, 1994, Copyright 1994. Federal Research Division, Ghana. Reprinted with permission.

Another vital reason for the increase in the yearly number of fire incidents could be attributed to the increase in human population. As the population increases, human activities involving the use of fire also increase, and more people tend to become careless while handling fire. Owusu-Ansah [20] noted that Ghana's population increases yearly by a factor of 6.7%.

Urbanization could be another reason for the increase of fire incidents in Ghana. This is because most people in rural areas move to big cities in search for greener pasture. Ghana, like most developing countries, is undergoing rapid urbanization. This rapid increase in urban population has exerted severe pressure on most cities' limited infrastructure, the consequence of which includes the proliferation of informal and slum communities. In general, most dwellers in these settlements have become vulnerable to a wide range of disasters, particularly fire hazards. This puts a tremendous amount of pressure on urban cities and leads to congestion in human settlements, hence creating more slum areas. It can be seen in Fig. 7 that as time goes by, the level of urbanization also increases. Fig. 8 shows a photo of the settled area of Ashaiman and a typical slum area in Ghana. Because of congestion in these areas, most residents have resorted to illegal electrical connections, which have been identified as one of the major causes of shack fires, thus contributing to the residents' vulnerability to fires. This is because the electricity provided to residents in such localities comes from unapproved sources.

the markets are converted into stalls, etc. All of these factors come together to cause the kind of destruction that occurs during such outbreaks of fire. The typical result of these outbreaks is the destruction of goods and structures whose costs run into thousands of Ghanaian Cedis. These losses always become a burden for the traders because they do not have fire insurance to compensate for their losses.



Fig. 8. Settlement in Ashaiman.

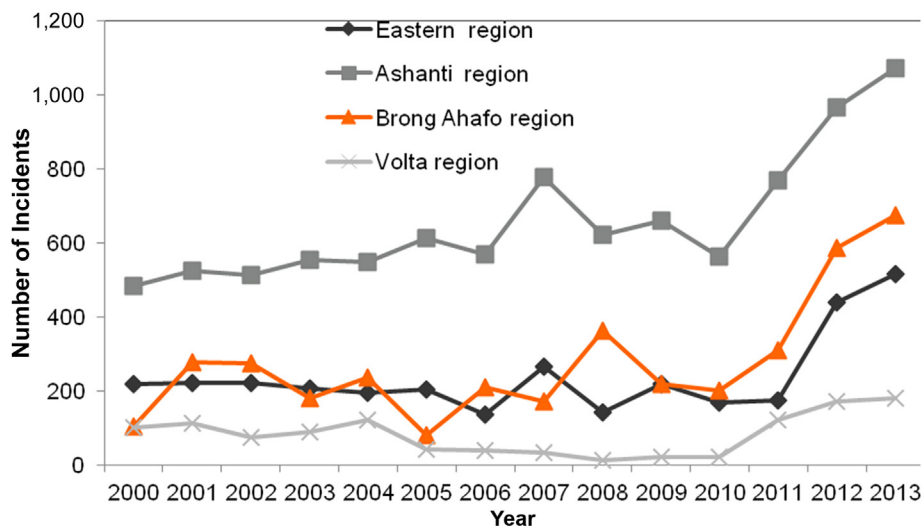


Fig. 9. Pattern of fire incidents (yearly) for the middle part of Ghana.

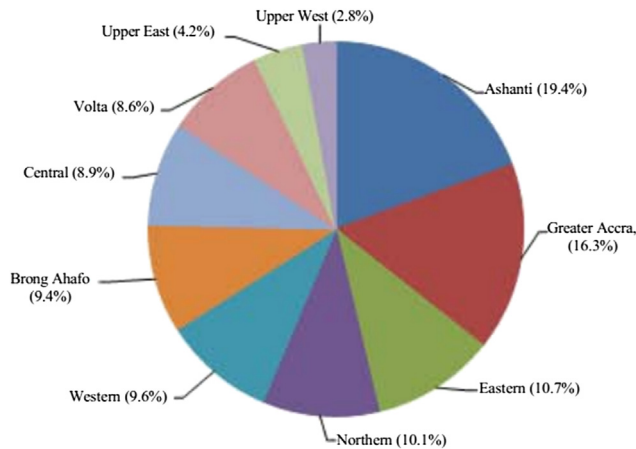


Fig. 10. Regional population distribution in Ghana [21].
 Note. http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf. Reprinted with permission.

Fig. 9 shows the number of fire incidents from 2000 to 2013 in the middle part of Ghana. It can be seen that the number of incidents generally increased each year. This could be as a result of the increase in human population. As the population increases, human activities involving the use of fire also increase. Among the four regions in the middle part of Ghana, the Ashanti region recorded the highest number of fire incidents, followed by the Brong Ahafo region, the eastern region, and the Volta region. Fig. 10 shows the population distribution of these four regions—i.e., 19.4%, 9.4%, 10.7%, and 8.6% for the Ashanti region, Brong Ahafo region, Eastern region, and Volta region, respectively. Apart from population increase, industrialization also plays an important role for the increase in fire incidents. This is because as human activities increase, the likelihood of people getting involved in fire accidents also increases. For example, Kumasi, the capital of the Ashanti region, is one of the busiest cities in Ghana and harbors most of the country's industries; it also reports at least five fire incident cases per week.

Fig. 11 shows the number of fire incidents (2000–2013) in the southern part of Ghana. Notably, the Greater Accra region recorded

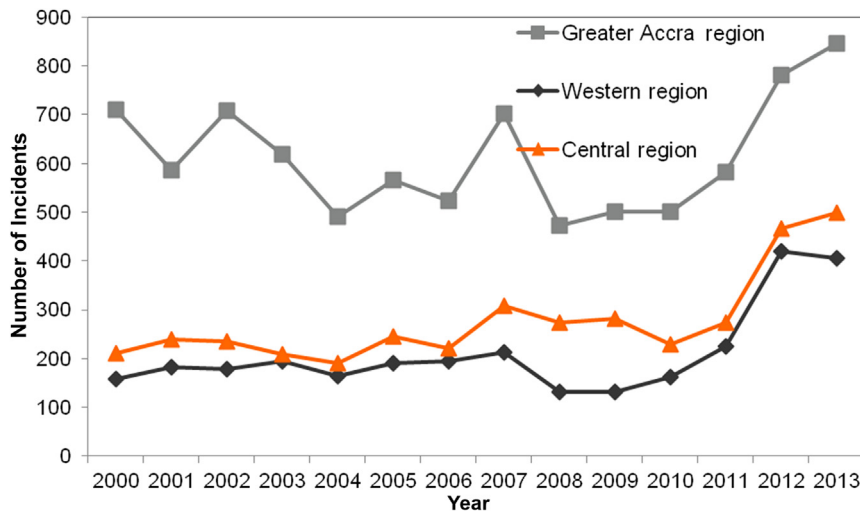


Fig. 11. Pattern of fire incidents (yearly) for the coastal part of Ghana.

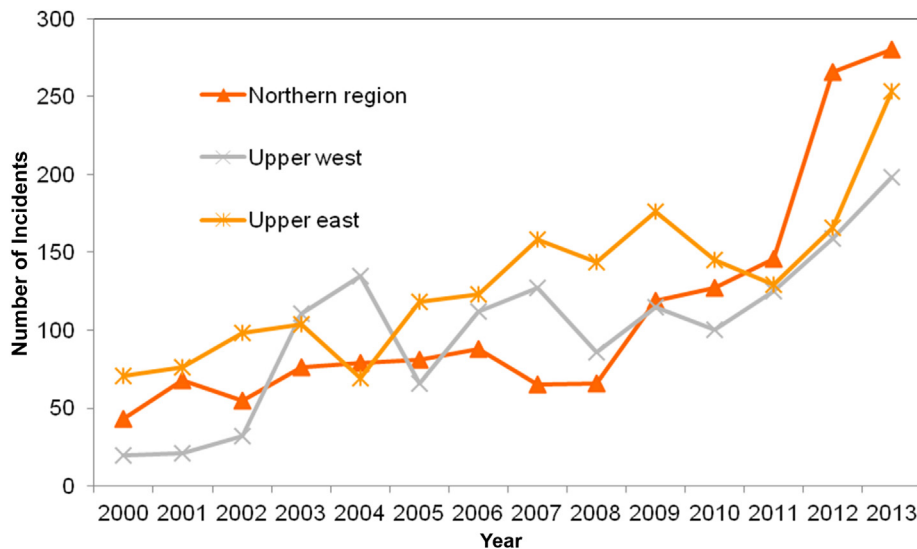


Fig. 12. Pattern of fire incidents (yearly) for the northern part of Ghana.



Fig. 13. Pattern of incidence of injuries and death (yearly) in Ghana.

the highest number of incidents followed by the Central region and the Western region. This trend could be attributed to population growth as well as industrialization. Accra, the capital of the Greater Accra region as well the capital of Ghana, is the busiest and most densely populated city in Ghana. It is also the center of most activities in the country, playing host to many government offices, markets, and industries, and because of this, the possibility of people encountering fire and burnable materials is high.

Fig. 12 shows the number of fire incidents (2000–2013) in the northern part of Ghana. It can be seen that from the year 2000 to 2010, the three regions in the northern part recorded almost the same number of incidents; from 2011 to 2013, however, the northern region took the lead, followed by the upper east and upper west regions. This could be attributed to increased human population, urbanization, industrialization, and other activities.

Fig. 13 shows the number of injuries as well as the mortality rate as a result of these fire incidents from 2007 to 2013. The graph shows that both mortality rate and number of injuries increased yearly. The same trend is also apparent in the number of incidents. Hence, as the number of incidents increased, so did the number of injuries as well as the mortality rate. For example, 379 people lost their lives in 5,489 fire incidents across the country from January to December 2013 following the rampant outbreak of fires recorded nationwide, including property losses worth more than 25 million Cedis. This represents an incremental increase in terms of death and fire incidents as compared to the 2012 figures of 375 deaths and 4,995 incidents, which incurred a financial loss of 10.3 million Cedis.

With regard to the origin of various fire incidents, in this work the following areas were considered: domestic, industrial, vehicular, institutional, electrical, commercial, bush, and other sources. Table 1 shows the various categories of fire from 2007 to 2013,

Table 1 Causes of fire in Ghana from 2007 to 2013

	2007	2008	2009	2010	2011	2012	2013	Total
Domestic	1,354	1,267	1,241	1,075	1,315	2,040	2,063	10,355
Industrial	130	128	91	84	123	153	161	870
Vehicular	271	323	361	367	415	662	757	3,157
Institutional	52	66	64	87	95	113	94	565
Electrical	233	213	239	262	263	459	594	2,263
Commercial	277	277	283	270	327	454	534	2,422
Bush	370	463	355	229	238	559	653	2,864
Others	511	512	224	233	457	555	635	3,127

whereas Fig. 14 shows the percentage of the total number of incidents for these categories.

Fig. 14 shows that domestic fires accounted for 41% of the total number of fire incidents in the country, whereas institutional fires represented only 2% of the total (the least frequent cause).

4. Discussion

The study evaluated the pattern of regional fire distribution in Ghana as a whole. It was noticed that the rate of fire incidents generally increased each year. Most of the fire incidents occurred in the populated cities of Ghana. Domestic fire accounted for 41% of the total fire incidents in the country. The most common causes of fires were unstable electricity, improper handling of fire, illegal connections, etc.

From the preceding discussion, the following recommendations were made to help reduce the number of incidents in Ghana.

4.1. Public education on fire safety

Based on the nature of the fire situation Ghana, we suggest that the issue of public education be intensified within the country. Both the Fire Service and the National Disaster Management Organization should embark on an intensive educational campaign among the residents regarding fire prevention and safety measures, because it was highlighted that most fires actually occur out of ignorance and negligence on the part of the residents.

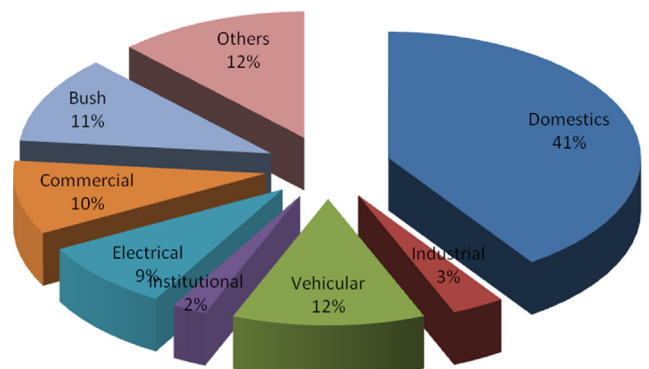


Fig. 14. Percentage distribution of various causes of fire in Ghana from 2000 to 2013.

4.2. Enforcement of fire safety regulations

This can be carried out by ensuring that fire safety regulations are consistently followed throughout the country. This also includes the rehabilitation of the electrical wiring system (one that follows standard regulations during installation), proper use and handling of combustible materials, installation of fire hydrants, and widening of roads for easy access to fire services. Households should also be provided with fire extinguishers.

4.3. Redevelopment and regularizing of informal settlements

This mode of intervention refers to a complete replacement of the physical fabric through gradual demolitions and *in situ* construction of alternative housing. This mode targets the informal areas where housing conditions are highly deteriorated; the urban fabric is irregular, and reconstruction of markets should be considered. The issue of electricity supply to such informal communities needs to be revisited. From all indications, the current administrative fiat, which bars the provision of electricity to residents without building permits, is a recipe for disaster and must be reviewed. For instance, largely because of the lack of formal electricity being provided to residents in such localities, most residents have resorted to making illegal connections, which have been identified as one of the major causes of shack fires—thus contributing to the residents' vulnerability. In view of this, it has been suggested that policy makers and key informants should facilitate the granting of legal permits to the occupiers of the land [22]. At the outset, the authorities and the ECG may want to consider granting amnesty to all residents who have indulged in illegal connections, and then ask them to voluntarily rectify their connections, while appropriate procedures are being devised to formally connect all residents to the national grid.

4.4. Formation of community fire volunteers

This involves training a group of individuals from the community and providing them with the necessary equipment to act in case of a fire outbreak. For example, in Ban Hatsady village, this was done by organizing a group of 24 community volunteers composed of youth, women, and men who acted as guards for the community against any threat of fire. Every local community should be encouraged to set up its own fire management system to reduce the effects and prevent the occurrence of fires, encompassing both prevention and control methods. It is therefore obvious that well-trained, simply equipped, community-level fire volunteers can act as an effective solution to the high vulnerability of residents to fire hazards in Ghana [23]. Similarly, Germany uses volunteer service to mitigate the risk of fire outbreaks. The Fire Service Department selects several individuals who are willing to voluntarily serve the community, then train and provide them with the necessary equipment. These people should be alert as soon as there is a fire incident within their communities, and rush to the scene to start quenching the fire or prepare the way and resources prior to the arrival of fire service personnel at the scene.

4.5. Need for international assistance

Areas in which international bodies can assist to strengthen fire safety in Ghana include the following:

- (1) Strengthening of advocacy to sensitize Ghanaian leaders and those of other African countries to see fire as an important component of the human dimension of sustainable development. One of the ways in which this can be achieved is by

integrating the preconditions for development projects including development assistance. This framework will ensure that measures promoting fire safety components are built into plans much in the same way that the World Bank and other agencies ensure that measures of environmental performance (in the case of fire safety) are incorporated into feasibility studies/environmental assessments of such projects and programs.

- (2) Sensitization of governments toward the adoption of a common policy on fire safety and its integration into development and poverty reduction efforts at the regional level, for example, within the context of the Economic Community of West African States and the New Partnership for Africa's Development, should be encouraged.
- (3) Assistance by multilateral agencies in terms of communication on the International Labor Organization/World Health Organization strategy would help political leaders to appreciate the need for intensive intersectional collaboration to achieve the objective of attaining basic fire protection strategy.
- (4) Technical support from external partners for capacity building efforts for locals would help strengthen the human capacity base. An aspect of this—in addition to strengthening technology transfer, which also serves to curb the brain drain of trained professionals—would be to include local counterparts in consultancy (collaboration) assignments, so they could work hand in hand with foreign consultants.

4.6. Improving building codes

Building codes are rules that specify the minimum standards for constructed structures such as buildings. The main objective of these codes is to protect public health, safety, and general welfare as they relate to the construction and occupancy of buildings and structures. Fire prevention can be achieved by strictly implementing regulations to improve building codes—for example, the type of materials to be used, building safety regulations, provision of portable fire extinguishers, installation of fire and smoke detectors and fire alarms, and provision of emergency fire exits.

4.7. Provision of fire hydrants at various strategic locations in the country

Fire hydrants are an active fire protection measure, and a connection point by which firefighters can tap into a water supply. It must be ensured that fire hydrants are installed at every strategic point of the country with constant water flow. This makes it easier for firefighters to easily have access to water in case of fires so that they can quench the fire as fast as possible. Details on how to install fire hydrants as well as color codes are well explained in the recent book published by Lamm Willis [24].

Conflicts of interest

All authors have no conflicts of interest to declare.

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References

- [1] Barnett JR. *Fire*. Microsoft Student 2009 (DVD). Redmond (WA): Microsoft Corporation; 2008.
- [2] Ayarkwa J, Danso AK, Adinyira E. Incidence of domestic fire outbreaks in Ghana: causes and prevention. *Ghana Surveyor* 2010;4(1):1–13.
- [3] Occupational Safety and Health Administration, U.S. Department of Labor. Combustible dust [Internet]. 2016 [cited 2016 Mar 14]. Available from: <https://www.osha.gov/dsg/combustibledust/index.html>.
- [4] Addai EK, Gabel D, Krause U. Lower explosion limit of hybrid mixtures of burnable gas and dust. *J Loss Prevent Process Ind* 2015;36:497–504.
- [5] Addai EK, Gabel D, Krause U. Explosion characteristics of three component hybrid mixtures. *Process Saf Environ Protect* 2015;9:72–81.
- [6] Addai EK, Gabel D, Krause U. Experimental investigation on the minimum ignition temperature of hybrid mixtures of dusts and gases or solvents. *J Hazard Mater* 2016;301:314–26.
- [7] Nolan DP. *Handbook of fire and explosion protection engineering principles*. 3rd ed. Kidlington (UK): William Andrew; 2014. 496 p.
- [8] Swetnam TW. Fire history and climate change in giant sequoia groves. *Science* 1993;262:885–9.
- [9] Sam-Okyere E. Infernos in our offices; demystifying the facts. *The Chronicle* 2010; February 25. p. 3.
- [10] Gakpe BK, Mahama PY. Reportage of stories on fire outbreaks in Ghana: an analysis of the Daily Graphic and the Chronicle. *New Media Mass Commun* 2014;24:1–11.
- [11] Ghana National Fire Service Ghana National Fire Service Act, 1997 [Internet]. 2014 [cited 2014 Jan 6]. Available from: <http://www.epa.gov.gh/ghanalex/acts/Acts/GHANA%20NATIONAL%20FIRE%20SERVICE%20ACT,1997.pdf>.
- [12] Annan J-S, Addai EK, Tulashie SK. A call for action to improve occupational health and safety in Ghana and a critical look at the existing legal requirement and legislation. *Saf Health Work* 2015;6:146–50.
- [13] Tulashie SK, Addai EK, Annan J-S. Exposure assessment, a preventive process in managing workplace safety and health, challenges in Ghana. *Saf Sci* 2016;84:210–5.
- [14] Simpson DE. Fire protection and safety. A presentation of Ghana National Fire Service (GNFS), Ashanti Regional office at a Symposium of Building Technology Students Society (BTSS) Week celebration, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, 24–27 March 2010.
- [15] Anaglatey PB. Accra continues to record fire outbreaks. *The Chronicle* 2013; July 30.
- [16] Boateng W. Electricity company of Ghana explains causes of fire outbreaks. *Ghanaian Times* 2013; January 24.
- [17] Abu J. Smoking is number one cause of fire outbreak in Ghana. *Ghana News Agency* 2013; March 18.
- [18] Madrzykowski D. Fire dynamics: the science of fire fighting. *Int Fire Service J Leadership Manage* 2013;7:7–15.
- [19] Twum-Barima LM. An assessment of the awareness of fire insurance in the informal sector: a case study of Kumasi central market in Ghana. *Int J Hum Soc Sci Educ (IJHSSE)* 2014;1:41–7.
- [20] Owusu-Ansah D. Population distribution. In: La Verle B, editor. *A country study: Ghana*. Library of Congress Federal Research Division; November 1994 [This article incorporates text from this source, which is in the public domain.].
- [21] Ghana Statistical Service. 2010 Population & housing census. Summary report of final results [Internet]. Accra (Ghana): Ghana Statistical Service. 2012 May. Available from: http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf.
- [22] Sarpong AO. Fire risk vulnerability in informal settlements the case of Ashaiman. MS thesis. Accra (Ghana): University of Ghana; 2013.
- [23] Asian Disaster Preparedness Center (ADPC). Reducing fire threat to homes: piloting community-based fire risk assessment in Ban Hatsady Village. *Safer Cities* 2004;9.
- [24] Lamm W. Hydrant color codes and markings [Internet]. 2000 [cited 2015 Mar 31]. Available from: <http://www.firehydrant.org/info/design07.html>.