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Lightning Fatalities in Malawi:

A retrospective study from 2010 to 2017

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***Abstract*—There is a scarcity of information on lightning fatalities in many regions of the world, despite the need to have such information for decision-making and policy formulation to address this risk. This retrospective study covers the period of 2010-2017 and uses data from both online and hard copies of newspapers. The results show a fluctuation in both lightning deaths and injuries in the period, but with a general increase in the number of these incidents from 2010 to 2017. Lightning fatalities only occurred from November to February with December being the highest at 15 fatalities. More males are injured and killed by lightning than females, mainly due to men being exposed to risky outdoor activities more than females. In terms of age, the older population is less vulnerable to lightning. Most fatalities occurred outdoors while only 36% occurred within enclosed spaces. Malawi's rate of lightning deaths is about 50 times greater than in some developed countries. There is a need for more research and awareness campaigns on lightning issues in this region.**

Keywords-Malawi, lightning, fatality, annual, monthly

I. INTRODUCTION

Lightning is a common occurrence globally, including thunderstorms that occur over tropical and subtropical regions [1], and causes many deaths and injuries every year [2], including Africa [3, 4]. Malawi occupies an area of 118,484 km^2 between 9 and 18 S, and 32 and 36 E and has a population of approximately 17 million people. Malawi experiences a subtropical climate, which is characterized by seasons and influenced by oscillations of equatorial meteorological regimes such as the Intertropical Convergence Zone. The seasons are as follows [5]:

- Wet season: November to April (rain may linger longer in northern and eastern mountains).
- Cool season: May to August.
- Hot season: September and October.
- Post-rainy season: April to May.

Lightning fatality rates are higher in developing countries than in developed nations [2, 3]. This difference in fatality rates can be attributed to 1) a lack of substantial lightning-safe buildings where people stay, work and attend school, 2) a larger proportion of the population is involved in high-risk activities such as labor-intensive agricultural work, 3) fewer easily available fully enclosed metal-topped vehicles, and 4) a lack of education programs that put much emphasis on lightning safety [1, 2, 3, 4].

II. JUSTIFICATION FOR STUDY

Lightning casualty data from developing nations of the world have been scarce compared with those from developed nations [6]. For instance, in Malawi, lightning fatalities occur every year yet there is little knowledge about it. Documentation in [7] showed that the annual lightning fatality rate per million people from 2007-2010 in the Nkhata Bay district of Malawi was 84.0, which is an extremely high rate compared with other countries of the world. Therefore, this paper will investigate Malawi's lightning fatality rate over a larger region in the 2010 to 2017 period and the circumstances surrounding those fatalities. The information generated will help stakeholders including the government, private sector, and academia as well as local communities in decision making regarding

lightning fatalities. This information is also very useful in the implementation of some of the Sustainable Development Goals [8], especially Goal 9: Industry, Innovation and Infrastructure and Goal 11: Sustainable Cities and Communities.

III. Study Area and Methodology

The study used lightning fatality data for 16 of Malawi's 28 districts covering a period of seven years from December 2010 to January 2017. These 16 districts come from all regions of Malawi. The period was chosen because relatively more data were available covering this period. One of the reasons why more data are available in this period is the proliferation of social media and an increase in the number of mobile phones with time. This change makes it easier for the media houses to obtain information from outlying regions of the country, including lightning. Measures of this increase in information dissemination will be explored in subsequent studies in more detail.

Due to the scarcity of lightning fatality data in some regions of Malawi, information from a total of 16 of the 28 districts in Malawi were analyzed from 2010 to 2017 as shown by shading or hatching in Fig. 1. Most of the data are fatalities, although a few categories include sufficient injury data to be included. The 16 districts are from the following three Regions in Fig. 1:

- Southern Region: Districts of Balaka, Blantyre, Machinga, Mangochi, Mulanje, Phalombe and Thyolo.
- Central Region: Districts of Dedza, Dowa, Kasungu, Lilongwe, Ntcheu and Salima.
- Northern Region: Districts of Karonga, Mzimba and Nkhata Bay.

Secondary data obtained from various newspapers are summarized in this retrospective study. Most of the data were extracted from *The Daily Times* newspaper [9], and some are from online newspapers including Nyasatimes [10], Malawi 24 [11], Zodiak Online [12], and Nation Online [13]. The newspaper reports of lightning casualties consist of the following information:

a. Year, month, and day of the event.
b. Time of lightning occurrence in some cases.
c. Location of the incidents.
d. Number of people killed and injured.
e. Gender of the victims.
f. Activities and locations at the time of the incident in most instances.

All of the elements that were not clear or unknown were recorded as missing. The 2008 population data for Malawi were obtained from the National Statistical Office website [14].

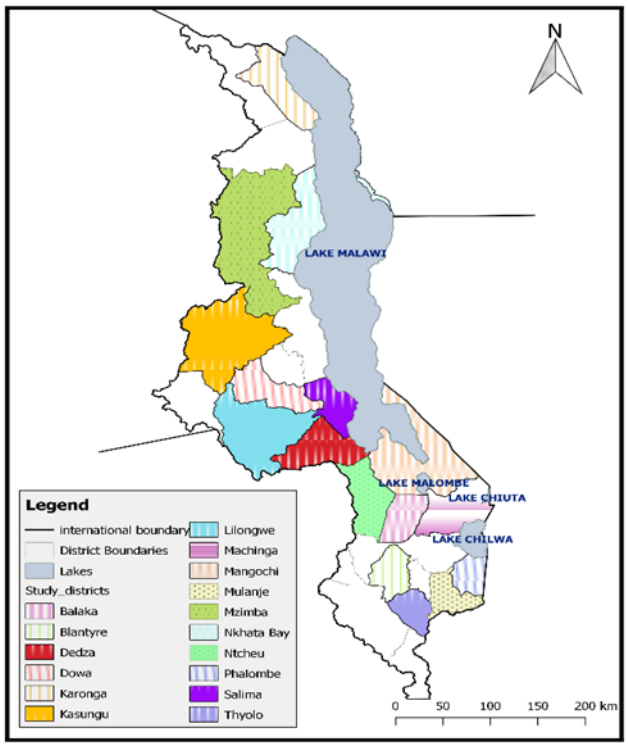

Figure 1. Map of districts in Malawi. Shading and hatching indicate the 16 districts with lightning fatalities and injuries analyzed for this study. Districts in white have insufficient reports for analysis.

IV. Results and Discussion

A. Monthly Distribution of Lightning Fatalities

All lightning fatalities for the period 2010 to 2017 occurred between November and February (Fig. 2). This is slightly different from [7] who found that fatalities were common between December and March. The largest number of fatalities was recorded in December with 15 fatalities, followed by January with nine.

B. Iinterannual Distributions of Lightning Fatalities and Injuries

Both lightning deaths and injuries fluctuate annually in Malawi, but with a general increasing trend (Fig. 3). The highest number of 22 deaths was recorded in the 2015/2016 rainy season and the lowest in the 2011/2012 rainy season with only a single incident. Similarly, the largest number of injuries were in the 2012-2013 period with 48 injuries and

the lowest number of reported injuries was in the 2010-2011 period at zero.

The sum of lightning fatalities plus injuries in Fig. 4 indicates an increase through the years of the study (Fig. 3). For each of the 2010 to 2013 rainy seasons, a total of six lightning deaths plus injuries was recorded. The number has increased since 2014. In the 2015/2016 and 2016/2017 rainy seasons, a total of nine and 12 lightning deaths and injuries respectively were recorded per season.

The increasing trend of lightning deaths and injuries in Malawi may be partially due to an increase in the number of mobile phones resulting in a proliferation of social media that leads better reporting in outlying regions of Malawi by the media, as found for Bangladesh [15]. Additional measures of these technological changes in Malawi will be pursued in the near future.

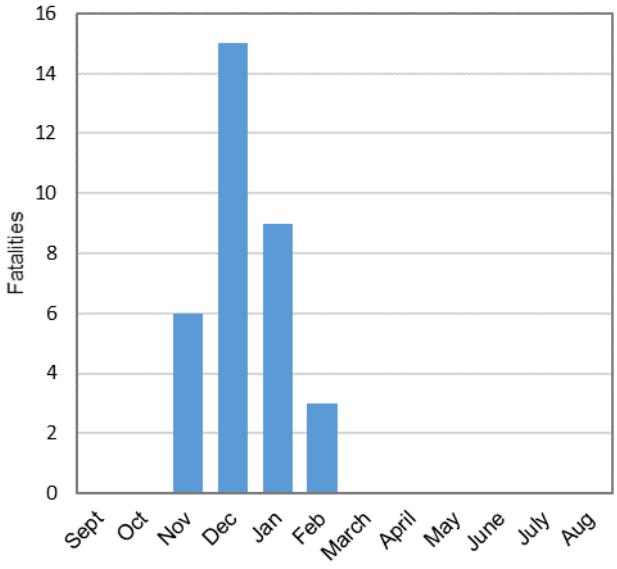

Figure 2. Lightning fatalities by month in 16 districts of Malawi from 2010 through January 2017.

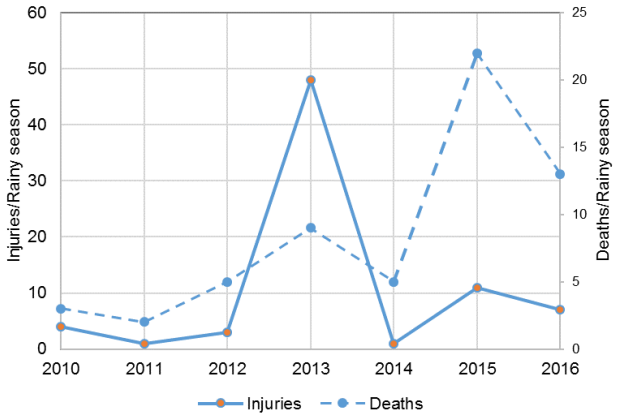

Figure 3. Annual totals of deaths and injuries per year in 16 districts of Malawi from 2010 to 2016.

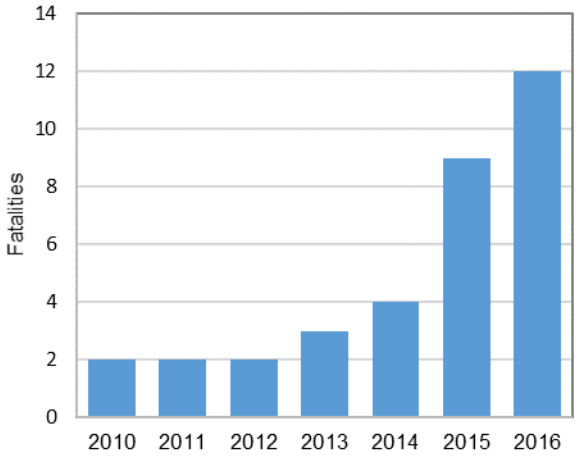

Figure 4. Annual sums of lightning deaths and injuries per year in 16 districts of Malawi from 2010 to 2016.

C. *Gender*

A total of 28 males (52%) and 26 females (48%) were reported as killed by lightning for the seven-year period (Fig. 5). The resulting mean death rate is 4.0 and 3.4 for males and females respectively. The ratio of the number of females killed by lightning to that of males is 1:1.08, a slight increase in male over female deaths. In terms of reported injuries, again more males sustain injuries with 41 male (55%) compared with 33 female (45%) injuries (Fig. 6).

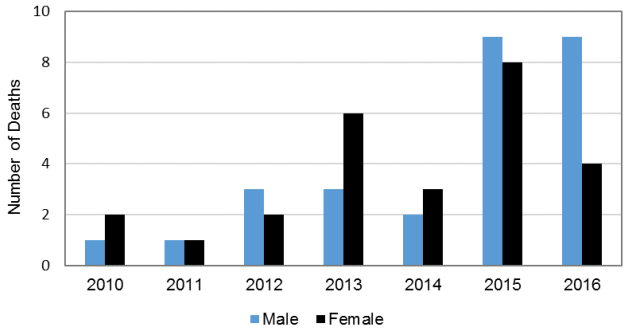

Figure 5. Annual number of lightning fatalities by gender in 16 districts of Malawi from 2010 to 2016.

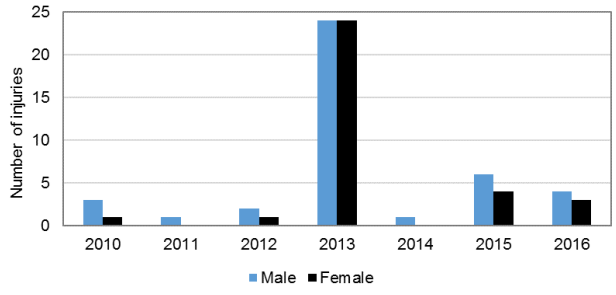

Figure 6. Annual number of lightning injuries by gender in 16 districts of Malawi from 2010 to 2016.

These findings are generally similar to statistics from other countries. For example, in Bangladesh it was found that 86% of males died due to lightning on 12 to 13 May 2016 [16]. Similar research in Colombia [17] found that most of those who died due to lightning were young males. Furthermore, in Swaziland, 68% males were killed [18]. In developed countries, the male ratio is 65% in the United Kingdom [19], and more males than females in the United States [20] and Australia [21].

The differences between females and males killed or injured by lightning has been attributed mainly to more males tending to be involved in outdoor and perhaps more risky chores. For Malawi, the question that needs to be posed is: "Why is the difference between male and female deaths due to lightning much smaller than is the case for Southern Africa as a whole (i.e. 64% for Southern Africa)?" Is it because compared to their counterparts in other countries Malawian women are much more involved in outdoor activities such as collecting firewood and farming and usually walk longer distances as they carry out their daily chores of providing for their families hence exposing them much more to the hazards of lightning strikes than their counterparts in other countries?

It was reported in [22] that Malawi rural women account for 52% of the population while rural men are 48%. The share of female-headed households in rural areas is 24% while in the urban areas is 15%. Poorer rural households (in particular female-headed) are more involved in agricultural labor and low paid jobs. The population of Malawi is 85% rural [22] compared to Swaziland, for example, whose rural population is at 79%.

It has been observed that in sub-Saharan Africa, women contribute 60 to 80% of the labor used to produce food [22]. Estimates of women's contribution to the production of food crops range from 30% in the Sudan to 80% in the Congo. Their proportion of the economically active labor force in agriculture ranges from 48% in Burkina Faso to 73% in the Congo and 80% in the traditional sector in Sudan. These ratios show that contributions of women to the different chores such as agriculture varies from country to country depending on many issues including culture and poverty levels. For Malawi, more women than men are rural and they tend to be involved in more labor intensive, low paid outdoor activities. This could lead to increased exposure and vulnerability to lightning strikes hence why there is only a small difference between men and women in lightning fatalities.

D. Lightning Fatalities by Age

The people most affected by lightning are children and young men (Fig. 7). The most affected age group is between 16 and 30 years, which accounts for 39% of the total number of people killed by lightning, followed by the age group of between 0 and 15 years (26%). Another 24 percent of the individuals affected falls in the age range of 31 to 45 years. In general, the highest percentage age group affected is between 15 and 45 that coincides with the reproductive age group of Malawi. Deaths and injuries of people in the reproductive age group usually affect other sectors of economy such as agriculture and infrastructure development. The least affected group were those individuals above 56 years, which accounts for about 2% of the total casualties. These individuals may be less active in the outdoors hence less exposed to labor-intensive activities such as farming compared to other age groups.

These findings are broadly similar to studies in several other countries. For example, in Bangladesh, most fatalities are between 21 to 30 year age group and this is followed by 41 to 50 year olds [15]. In Colombia, most fatalities are in the category of 16-25 years whilst 12% of those who died were children of mean age of 4.8 years while eight women were pregnant when they died representing 7% [17]. In Swaziland 26% of lightning victims were between 10 and 19 years (largest group), 30 and 39 years old were the second largest age group and broadly the 10 to 39 year group represented 67% of the total fatalities [16]. In the Transkei region of South Africa, it was found that 26% of the victims were 11 to 20 years old [24] while in the United Kingdom, the average age for most of the fatalities is 30 years [19]. In Singapore, more than half of the fatalities were in the age group of 10 to 29 years [25] and similar results to those of Singapore apply for the United States [26

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E. Lightning Fatalities by Place of Occurrence and Activity

More fatalities are in open than in covered places (Fig. 8). Open places are defined to include gardens, verandas, on water bodies and incidences occurring under trees. On the other hand, covered places include any incidences occurring inside a building. Of the 28 lightning cases with clearly identified locations, 18 were in open places while the remaining cases occurred in covered places representing 64% and 36% respectively (Fig. 8). For the cases in an open place, 33% occurred in an open field whereas 28% occurred at gardens while the victims were engaged in various agricultural activities. Another 6% occurred on water bodies (lakes) while fishing. The remaining open places contribut-

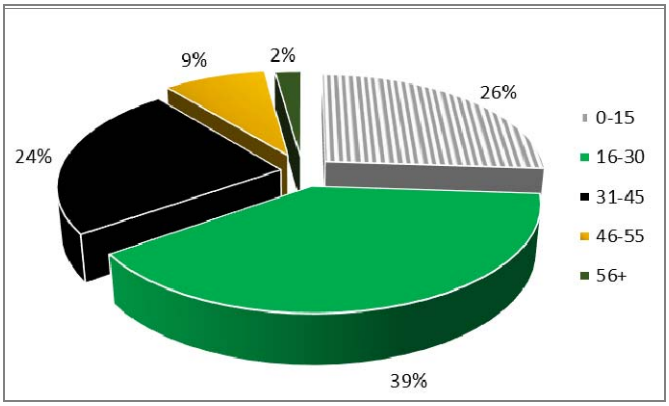

Figure 7. Percentage of people killed by lightning by age groups.

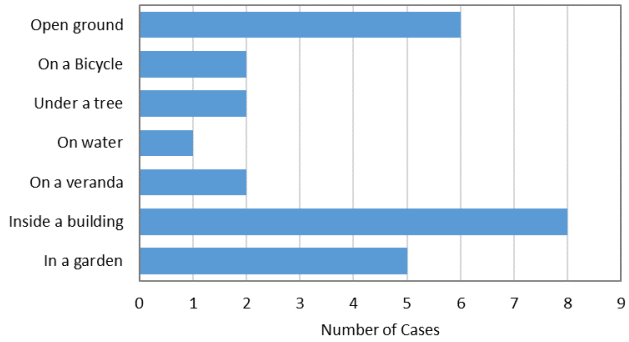

Figure 8. Lightning fatalities by place of occurrence.

ed 11% of the cases. The above results concur with [16] who recorded 61% of lightning related deaths in Bangladesh were linked to fieldwork in the agricultural sector and 8% on water, as in [1].

F. Property Damaged by Lightning

The only property damaged by lightning that was reported by the media was four buildings. This limited information indicates that there are few lightning safe buildings and poor construction practices prevail in Malawi, thus making them susceptible to lightning strikes. A different study by the authors using questionnaires discovered that the media, while they reported deaths and injuries, in many occasions did not report property damage such as radios and trees. The media tends to print/broadcast the most sensational human aspects of the incident thereby sometimes ignoring very useful economic information.

G. Lightning Casualty Rates by District of Malawi

The yearly lightning death rate ranges on a national scale from 0.1 to 21 per million people per year around the world [2]. The study in [7] was only for part of Malawi, the Nkhata Bay region, and is not directly comparable with the national fatality rates in [1]. For the current study, Table I shows the death, injury, and total rates from 2010 to 2016 for the 16 reporting districts of Malawi.

The injury plus death rate varies by district from 2.0 per million for the Machinga district to 71.2 per million in the Lilongwe district. The rate also varies among the districts, since no injuries were recorded in some districts (Machinga, Dedza and Kasungu) while with the highest rate is 59 per million in Lilongwe. In terms of deaths, it varies markedly among districts, from no fatalities in the Salima district to 13.4 deaths per million per year in Mulanje. Note that numerous studies such as [27] have found that injuries are often much less reliably reported than deaths.

For the entire 16-district dataset, the following rates are obtained (bottom line of Table I):

- Deaths: 5.5 per million people per year.
- Injuries: 10.0 per million people per year.
- Deaths plus injuries: 15.5 per million people per year.

This annual rate of 5.5 fatalities per million in Malawi is consistent with those found in other developing countries [2, 3]. Developed countries have fatality rates of 0.3 fatalities per million or less [2]. Thus, the annual death rate of Malawi is extremely high compared to other countries in the world such that it is 16 times higher than that of the Transkei sub-region of South Africa which has an annual death rate of 0.31 per million per year [24] and 50 times higher than that for the United States which has a rate of 0.1 deaths per million annually [2]. Note that fatality and injury data from 12 districts of Malawi are missing in the present database.

V. CONCLUSIONS

Although very little research has been done on the challenges that Malawi faces due to lightning, the current work has shown that lightning is indeed a very serious threat to the country's socio-economic development. More young males (16 to 30 years) are being injured or killed by lightning than older people. November to February is the period when all of the fatalities occurred during the period of study. There is a need for more research in order to have a much better understanding of the impacts of lightning on the country, including changes in communications in recent years. This information is also very useful in the implementation of some of the goals in [8], especially Goal 9: Industry, Innovation and Infrastructure and Goal 11: Sustainable Cities and Communities.

It is also very important that strategies be initiated for awareness of the effects of lightning and how to mitigate them. The awareness should stress the need for seeking safety and where these safe places are located. The data gathered from more research should be used by policy makers to formulate lightning hazard mitigation policies.

TABLE I. ANNUAL RATES OF BEING STRUCK, INJURED, AND KILLED BY LIGHTNING BY DISTRICT IN MALAWI

District	Annual number of deaths plus injuries	Mean number of injuries	Mean number of deaths	Population	Annual injury plus death rates per million	Annual injury rate per million	Annual death rate per million
Mulanje	9	2	7	521,391	17.3	3.8	13.4
Mzimba	5	4	1	727,931	6.9	5.5	1.4
Karonga	4	1	3	269,890	14.8	3.7	11.2
Ntcheu	4	2	2	471,589	8.5	4.2	4.2
Balaka	4	1	3	317,324	12.6	3.2	9.5
Lilongwe	48	40	8	674,448	71.2	59.3	11.9
Mangochi	4	2	2	797,061	5.0	2.5	2.5
Blantyre	9	7	2	661,256	13.6	10.6	3.0
Kasungu	2	0	2	627,467	3.2	0	3.2
Phalombe	5	2	3	313,129	16.0	6.4	9.6
Dedza	3	0	3	624,445	4.8	0	4.8
Dowa	14	10	4	558,470	25.1	18.0	7.2
Nkhatabay	4	2	2	215,789	18.5	9.3	9.3
Thyolo	3	1	2	587,053	5.1	1.7	3.4
Machinga	1	0	1	490,579	2.0	0	2.0
Salima	5	5	0	337,895	14.8	14.8	0
Total	**124**	**79**	**45**	**8,195,717**	**15.1**	**10.0**	**5.5**

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