A Year of Global Lightning Deaths and Injuries

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***Abstract*—In 2003, the author, with Dr. R. López, proposed an annual global toll of 24,000 lightning deaths. This estimate is based on multiplying 1) a fatality rate of six deaths per million people per year, times 2) four billion people living in lightning-vulnerable locations. Both numbers are subjective. Next, the present author published a journal article where data were compiled from publications for 23 countries with multiple-year fatality data from recent decades. For the current study, the 2016 publication is updated for 30 countries that indicate a recurring annual total of 3,806 lightning deaths per year. While this is an undercount since so many nations have no published lightning fatality totals, these are all known national studies for multiple recent years. The present study explores the value of summarizing one calendar year of lightning-related deaths and injuries using hourly online search results mainly from Google Alerts for the English word "Lightning." A total of 505 incidents were found including 765 deaths and 560 injuries from 46 nations; half are from India. The dataset indicates a ratio of 1.4 deaths per injury. There is a bias toward incidents with multiple injuries and deaths, such that single-casualty events are greatly underreported. Most events (88%) are from the Northern Hemisphere (NH). NH events dominate all seasons except the Southern Hemisphere (SH) summer. Similarly, over Africa, NH events dominate all seasons except 88% of events are in the SH during its summer season. The time of year, hemisphere, and continent are also explored. While it is gratifying to find that seasons and locations of known 2021 reports match expectations, it is also frustrating to find so few casualties with this method. A very substantial effort is needed to determine the actual number of global lightning casualties.**

Keywords—Lightning fatalities, lightning injuries, lightning incidents, Google, India

I. Introduction

At present, there is no comprehensive summary of lightning deaths and injuries around the world in near real time. In order to address this lack of knowledge, the goal of this study is to determine how much can be learned about lightning casualties worldwide from surveying a year of online news reports. In this study, a review of hourly Google Alerts was made for calendar year 2021. The goal was to determine how many lightning deaths and injuries were reported through a global search for the word "Lightning".

II. Prior Estimates of Global Lightning Casualties

An estimate of 24,000 lightning deaths and 240,000 injuries was proposed in [1, 2]. The fatality total was based on multiplying an annual rate of six deaths per million people *times* a population of four billion people in developing countries at high risk from lightning. The review in [2] listed lightning fatalities in 23 national-scale publications for multiple years ending in 1979 and later.

Table I provides an update to [2]. Publications from several countries have been added and others were adjusted to periods that all started in 1980 or later, except for Singapore starting in 1970. Using this publication-based method, the recurring average is 3,806 deaths per year from 30 nations based on references [3] through [32].

The rate of ten lightning injuries to one lightning death was found in the U.S. state of Colorado [33]. It is diffucult to obtain fatality data for a nation over a period of several years, so most researchers are aware that their database is not adequate to compile a firm estimate of lightning injuries. As a result, although some of the studies in Table I have injury data, only the fatality data are included here.

TABLE I. Published National Summaries of Lightning Fatalities Starting in 1990 or Later, Updated from [2]

Continent [nations]	Annual fatalities	Period of record	Reference
Africa [5]	**460**		
Burundi	26	2012-2013	Nibigira and Gomes [3]
South Africa	264	1997-2000	Blumenthal [4]
Eswatini	15	2000-2007	Dlamini [5]
Uganda	30	2007-2011	Mary and Gomes [6]
Zimbabwe	100-150	2004-2013	Chitauro [7]; Van Olst [8]
Asia [9]	**2,828**		
Bangladesh	251	2010-2015	Dewan et al [9]
China	179	2009-2018	Yin et al. [10]
India	2,234	2001-2014	Selvi and Rajapandian [11]
Japan	8	1995-2015	Fujiba [12]
Malaysia	22	2008-2011	Ab Kadir et al. [13]
Mongolia	5	2003-2015	Doljinsuren & Gomes [14]
Nepal	103	2011-2020	Sharma et al. [15]
Singapore	3	1970-1979	Pakiam et al. [16]
Sri Lanka	23	2010-2019	Edirisinghe & Maduranga [17]
Australia [1]	**2**	1980-1989	Coates et al [18]
Europe [9]	**103**		
Austria	1	2001-2010	Kompacher et al. [19]
Czechia	1	2000-2019	Brazdil et al. [20]
France	11	1986-1995	Gourbière [21]
Greece	5	2000-2010	Peppas et al. [22]
Lithuania	2	1994-2003	Galvonaite [23]
Poland	8	2001-2006	Loboda [24]
Romania	45	1999-2015	Antonescu & Carbunaru [25]
Turkey	28	2012-2014	Tilev-Tanriover [26]
U.K	2	1988-2012	Elsom and Webb [27]
N. America [4]	**257**		
Canada	3	1990-2004	Mills et al. [28]
Jamaica	1	2005-2021	Holle et al. [29]
Mexico	230	1997-2001	Raga et al. [30]
United States	23	2013-2022	Natl. Ltg. Safety Council
S. America [2]	**156**		
Brazil	79	2000-2009	Cardoso et al. [31]
Colombia	76	2000-2009	Navarrete-Aldana et al. [32]
30 nations	**3,806 deaths**	**Range of 1970-2022**	

Some issues should be noted in the list shown in Table I, as follows:

- When there is a choice of time period, the later years are shown.
- In developed nations, the numbers are often decreasing, while in developing nations, the counts are often increasing.
- The South Africa fatality total is based on an extrapolation of the rate from one large region to the entire country.

This list of fatalities by nation in Table I is weighted by population in the map in Fig. 1; this is updated from the analogous figure in [2]. Note that the highest rates are in Africa, and intermediate rates are in other lesser developed nations. The lowest rates are in developed countries.

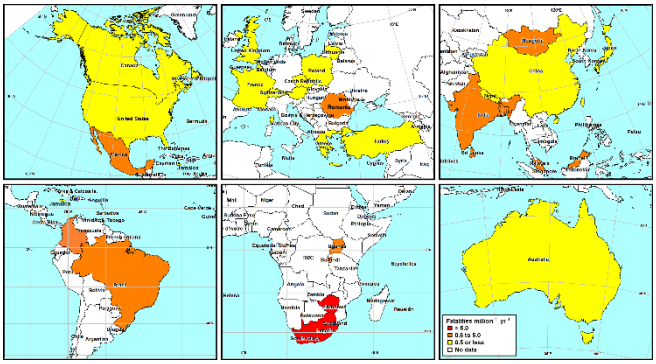

Fig. 1. Lightning fatality rates per million people per year for 30 nations with published summaries from Table I; updated from [2].

III. 2021 Global Casualty Data

One calendar year of lightning-related deaths and injuries are reviewed using hourly online search results from Google Alerts for the English word "Lightning." Some additional cases were found through the African Centres for Lightning and Electromagnetics that occasionally receives translated reports from the French, Portuguese, Spanish, and Kinyarwanda languages, and some other news sources for Africa. A total of 505 incidents were found during 2021 that includes 765 deaths and 560 injuries from 46 nations (Table II). Nearly half (248) of the reports are from India.

TABLE II. Summary of Results from This Study

Primary data source	**Google Alerts on "Lightning"**
Period of study	01 January through 31 December 2021
Events	505
Events from India	248
Deaths	765
Injuries	560
Total casualties	1325
Nations	46

Definitions are as follows:

1. Event / incident: One or more person was killed or injured by lightning.
2. Fatality / death: A person was killed by lightning.
3. Injury: A person was injured by lightning.
4. Casualties: The sum of fatalities and injuries.

IV. Events Reported by Continent and Nation

The reports usually had the correct month, although there was some ambiguity at the start or end of a month. The number of people killed and injured was often clear, but sometimes several events were grouped into one report and decisions needed to be made to separate the incidents. Gender and age of the casualties were reported in many cases but are not tabulated here since the reports are from varying situations and locations, such that meaningful conclusions cannot be made. Gender, age, as well as activity, location, and time of day need to be examined separately by country [3 - 32]. The data collected are summarized in Table III. Note that farming and dwelling events were tracked since they were so frequent.

TABLE III. Data Collected for This Study

Parameter	**Measure**
Time	Half months; combined into seasons
Location	Nations; attributed to continents
Events	Number
Deaths per event	Number
Injuries per event	Number
Deaths and injuries per event	Numbers
Dwelling events, deaths, and injuries	Numbers
Farming events, deaths, and injuries	Numbers

Table IV provides a list of the calendar year 2021 events from the hourly Google Alerts and other occasional sources by continent and country. Israel is listed in Europe since there are no adjacent nations with entries. The Indian subcontinent dominates the database with 320 of the 505 incidents (63%), while there were none reported from South America in 2021.

V. Casualties Per Event

There is a bias toward incidents with multiple injuries and deaths (Fig. 2); only 42% of the incidents involve one person. In contrast in the U.S., 93% of fatal lightning incidents involve only one person [34]. Another 24% of the events have two casualties; the rest have more than two. The largest 2021 event involved 24 critically injured Indian tea garden workers in September. In fact, only 212 of the 1325 casualties are to a single person (16%) while 450 of the 1325 casualties are in events involving one or two people (34%). Said another way, 34% of the events have more than two people killed or injured. Such a proportion shows a major reporting gap since an unkown but large number of single-person events are not reaching the Google Alert reporting system and in fact are not reported to anyone outside of the immediate vicinity of the incident. The dataset indicates a ratio of 1.4 deaths per injury.

TABLE IV. LOCATIONS OF REPORTED LIGHTNING INCIDENTS IN 2021

(Sub)Continent	Incidents	Nations
Africa	**86**	
Angola	9	
Cameroon	3	
DRC	2	
Ghana	3	
Guinea	5	
Côte d'Ivoire	1	
Kenya	4	
Malawi	7	
Mali	1	**19**
Morocco	1	
Namibia	4	
Nigeria	4	
Rwanda	7	
Senegal	4	
South Africa	10	
Tanzania	4	
Uganda	7	
Zambia	2	
Zimbabwe	8	
Asia	**28**	
Cambodia	9	
Hong Kong	2	
Malaysia	3	**6**
Philippines	10	
Taiwan	1	
Thailand	3	
Australasia	**6**	
Australia	5	**2**
Fiji	1	
Europe	**12**	
Germany	1	
Israel	1	
Netherlands	1	
Norway	1	**8**
Spain	1	
Turkey	1	
Ukraine	1	
U.K.	5	
Indian subcontinent	**320**	
Bangladesh	58	
India	248	
Kashmir	2	**6**
Nepal	4	
Pakistan	8	
Sri Lanka	1	
North America	**53**	
Canada	3	
Costa Rica	1	**5**
El Salvador	1	
Mexico	2	
United States	46	
South America	0	0
Total	**505 incidents**	**46**

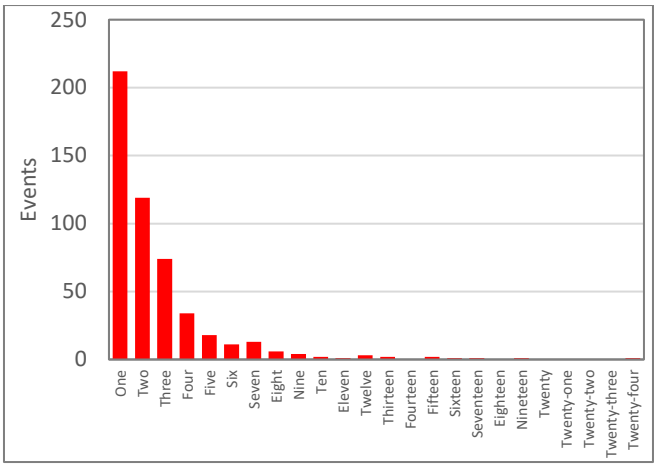

Fig. 2. Number of casualties per event.

VI. CASUALTIES BY TIME AND HEMISPHERE

Over the globe, the largest number of lightning casualty events occur from April through October as shown by half months in Fig. 3. This result is to be expected since the Indian subcontinent accounts for more than half of the events in the Northern Hemisphere (NH). Southern Hemisphere (SH) events are mainly from November through March when they often exceed those in the NH.

Combining both hemispheres, the largest number of lightning casualty events and casualties are in the June-July-August (JJA) season (Fig. 4). This result is due to the Indian subcontinent accounting for more than half of the events.

Of the 505 events, 88% (443) are from the NH and 12% (62) from the SH. NH events dominate during all seasons except the SH summer of December-January-February (DJF) when 65% of the small number of global events occur there (Fig. 5).

Over Africa (Fig. 6), SH events exceed those in the NH in all seasons except JJA. In fact, 95% of the continent's events during its summer season of DJF are in the SH.

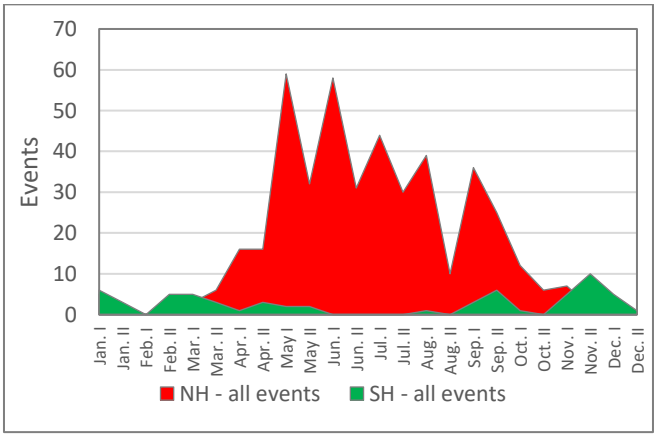

Fig. 3. Number of events by half month for NH and SH.

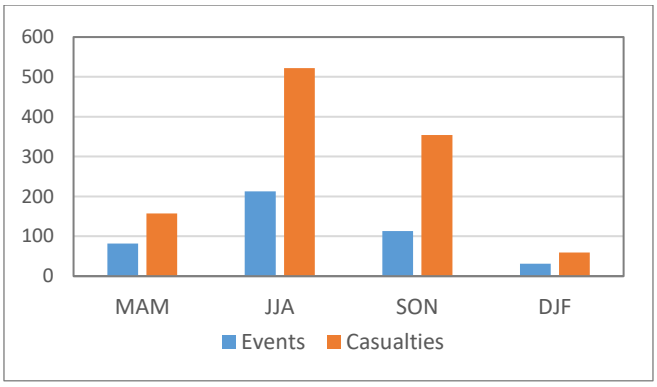

Fig. 4. Number of events and casualties by season over both hemispheres. MAM=March-April-May; JJA=June-July-August; SON=September-October-November, and DJF=December-January-February.

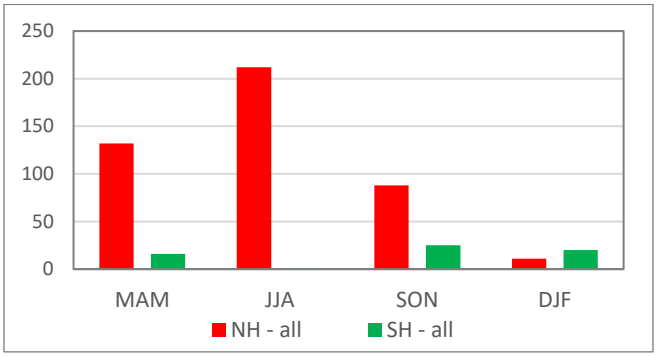

Fig. 5. Number of events by hemisphere for the world.

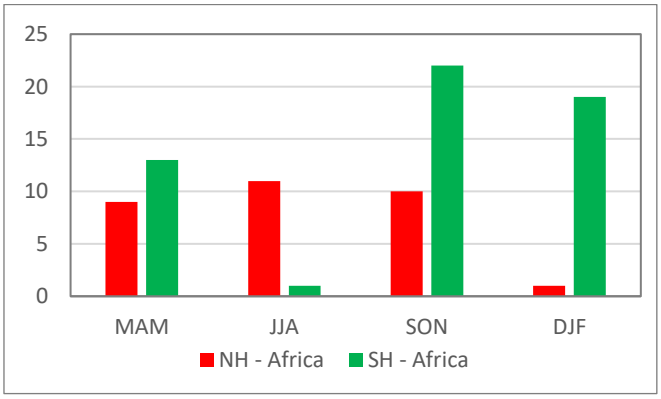

Fig. 6. Number of events by hemisphere for Africa.

VII. Casualties in Farming and Dwellings

Two activities and locations were common enough in the dataset to track separately. These incidents specifically mention the two situations in the narratives of the incidents. However, it is very likely that additional farming and dwelling activities and locations took place but not were not specifically mentioned in addition to the following:

1. **Farming** accounts for 35% of the events. There are 125 incidents, 185 deaths, and 143 injuries included in the reports. Fig. 7 shows a tendency for them to occur in the middle months of the year due to the dominance of the NH events, especially in the Indian subcontinent. Lightning casualties during agricultural scenarios are a major source of people killed and injured by lightning in developing nations [35].
2. **Dwellings** account for 8% of the events, comprised of 39 incidents, 62 deaths, and 36 injuries. Fig. 8 shows these incidents to be spread rather widely through the year. Dwelling-associated cases are almost exclusively in developing countries in a similar distribution to lightning-related death and injury events at schools [36, 37, 38].

VIII. Discussion

This survey of hourly English-language Google searches on “Lightning” and a few other sources captured some of the casualty events during 2021. However, the events are dominated by press coverage in India. The cases tend to be multiple-casualty events that indicate a skewed distribution away from single-person events that account for over 90% of lightning casualty events in the U.S. [34], although it is not certain if such a distribution also applies in developing nations.

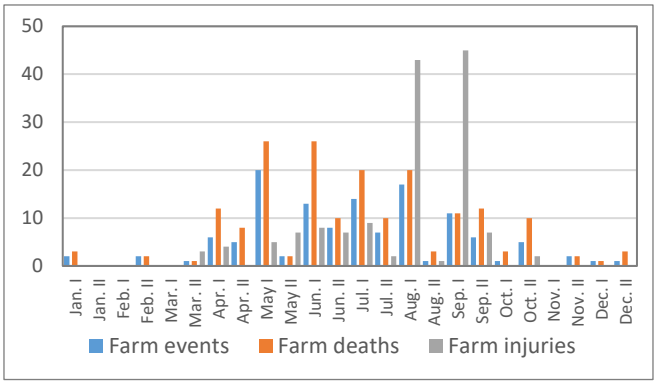

Fig. 7. Farming-related events by half month for all regions.

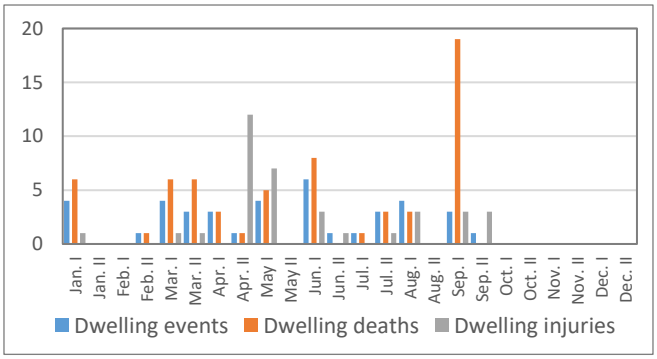

Fig. 8. Dwellling-related events by half month for all regions.

In addition, the countries where the most frequent lightning casualties are likely to occur are not well represented in this 2021 dataaset. For example, data came from only 19 of the 54 countries in Africa. If the rate of 6 deaths per million people per year is applied to all of Africa's population of 1.4 billion, a total of 12,600 deaths is found. If the rate instead is 12 deaths per million per year, the fatality total for Africa alone is 16,800 deaths per year. But we don't really know the rate or the number of people living and working in lightning-unsafe situations. Such speculation leads to the impetus to have more countries develop national-scale multi-year summaries of lightning deaths and injuries.

A prominent example is the Democratic Republic of the Congo (DRC) that has 96 million people, and about half are classified as living in rural situations. If the rate of 6 deaths per million people is applied, the annual death total is about 300, while a rate of 12 per million leads to about 600 deaths per year. However there were only two reports from DRC in the 2021 Google search and ACLENet reports, so their situation is not well known. Unfortunately, the required infrastructure to resolve this gap will not be resolved in the near future, so making estimates from a set of assumptions is the only way to proceed at present.

Another African example should be mentioned for Rwanda. This densely populated developing nation has frequent lightning, however the media mainly uses the Kinyarwanda language. Through ACLENet, Mr. Frank Shumbusho has intermittently sent reports in that language and translated them into English since translation online is not available. Since there are so many languages in Africa, it is nearly impossible to obtain data with this approach for the entire continent.

There is a lack of any reports from China. There were two events indicated for Hong Kong, which has active English-language press coverage. While the number of deaths in China is not especially large [10], it is not known how many reports could be found if a Google-type search in the Chinese language was pursued. One indication that such events are occurring is documented in [40] from more remote areas of the country where groups of people are killed and injured by lightning while collecting tradtional medicinal herbs.

One more situation contributing to undercounting lightning casualties is that a portion of the people in southeast Asia live in lightning-vulnerable dwellings, and some work in labor-intensive outdoor agriculture. These countries often have large flash densities. But the languages are not readily converted to news sources that are included in Google Alerts in English, so the data in Table IV are underreported to a large but unknown extent in this region.

Knowing the number of lightning casualties does not solve the problem. Where do people go when a thunderstorm is present if there are no lightning-safe buildings, vehicles, dwellings, or agricultural workplaces? Without the associated infrastructure to provide such lightning-safe locations, there will be no change in lightning-related deaths and injuries despite advances in warning systems. As a result, the issue of lightning casualty reduction is a long-term process for much of the world [39].

IX. Conclusions

One calendar year of lightning-related deaths and injuries were reviewed using hourly online search results from Google Alerts for the English word "Lightning" along with a few other sources. A total of 505 incidents were found including 765 deaths and 560 injuries from 46 nations; about half are from India. The dataset indicates a ratio of 1.4 deaths per injury. There is a bias toward incidents with multiple injuries and deaths, such that the lack of single casualty events indicates how casualties from this global collection method are greatly underreported.

Most events (88%) are from the Northern Hemisphere (NH). The Indian subcontinent accounts for 320 events (6 nations), followed by Africa with 86 (19). North America has 53 (5), Asia has 28 (6), Europe has 12 (8), and 6 are from Australasia (2); no 2021 reports were received from South America.

Farming is clearly identified in the news reports in 125 events that have 185 deaths and 143 injuries. The largest 2021 event involved 24 critically injured Indian tea garden workers in September. In addition, there are 39 events, 62 deaths, and 36 injuries in and around dwellings. The farming and dwelling categories account for 32% of the 2021 global events.

While it is gratifying to see that seasons and locations of these known 2021 reports generally match what may be expected, it is also frustrating to find only 765 deaths and 465 injuries with this method when it is certain that the casualty total is much larger. A very substantial effort is needed to collect data about the actual number of global total lightning casualties.

Data for 2022 have also been reviewed in less detail to see if the 2021 dataset was typical. No changes in the collection method were made for 2022, and it is readily apparent that the number and spatial distribution of reports for 2022 are similar to 2021. That is, many reports are from India, the events are more likely to be included in a Google search if more than one person was involved, and the seasons are similar. Rather than pursuing the same methodology for another year, attempting to determine the annual global lightning casualty total from Google "Lightning" reports needs to expand beyond the English-language project summarized here.

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