



# The Number of Documented Global Lightning Fatalities

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**Abstract**—A recent publication [1] summarized the lightning fatality rates per million people for 23 published national-scale studies ending in 1979 or later. Additional published studies have since been identified for Burundi, Mongolia, and Sri Lanka. A major difference was found between the low fatality rates in more developed countries and higher fatality rates in lesser-developed countries. There have been several recent estimates of the total number of global annual fatalities that range ranging from 6,000 to 24,000 per year. The present study takes the results from [1] and converts them into the number of deaths. The global total from these 26 studies is determined to be 4,176 fatalities per year, but data from many countries are missing and additional multi-year national-scale studies are needed.

**Keywords**—Lightning fatalities; national lightning fatality rates; global lightning fatalities

## I. INTRODUCTION

A recent publication summarized the lightning fatality rates per million people for 23 published national-scale studies during periods ending in 1979 and later [1]. A major difference was found between low to very low fatality rates in more developed countries and higher fatality rates in lesser-developed countries. That study collected the 23 published national studies and standardized the results to fatality rates per million people by country, by combining fatalities with the population of the countries for the periods when the fatality data were collected. Burundi, Mongolia and Sri Lanka have been added since that publication so that Fig. 1 now shows the latest color-coded map of fatality rates for 26 countries with published national lightning fatality rates that were determined for one or more full years since 1979.

There have been several recent estimates of the total number of global annual lightning fatalities. One estimate is several thousand [2]; another is 6,000 fatalities per year [3]; and the third is 24,000 fatalities per year [4]. At this time, there is no collection of fatality totals into one publication so that the existing estimates can be evaluated. The present paper is intended to provide such a summary based on the limited information that is currently available in the form of publications with fatality data that were collected on a national basis.

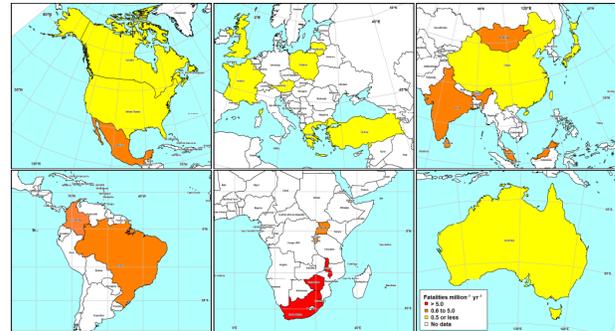


Figure 1. National lightning fatality rates per million people per year by continent. Red shading indicates rates > 5.0 fatalities per million per year, orange is 0.6 to 5.0, and yellow is 0.5 or less. White indicates no national summaries have been published for periods ending in 1979 or later (updated from [1]).

## II. LIST OF NATIONAL ANNUAL FATALITIES

Table 1 lists the annual deaths for the 26 countries that total 4,176 fatalities per year. Following are specific notes:

- Bangladesh: A 2016 multiple-fatality event has led to plans for more complete studies than published in the past, so no prior data are included at this time.
- India: One publication [5] found an average of 1,755 fatalities per year. Another recent publication [6] found only 159 fatalities from another database, which appears to be low. The total from [5] is shown in Table 1. The difference shows the difficulty in collecting national-scale lightning fatality totals.
- Japan: The author received a note from Dr. Nobu Kitigawa, who performed lightning demographic studies. His estimate, though unpublished, is in Table 1.
- Turkey: A major increase in fatalities was determined for the last several years [7]. The increase was due to improved reporting and data collection methods, so the most recent three years of data shown in the publication are used.
- Zimbabwe: Two estimates from a 1990 conference are 100 [8] and 150 fatalities [9]. The periods of record are unknown. The smaller total is used.

TABLE 1. PUBLISHED ANNUAL LIGHTNING FATALITY RATES PER MILLION PEOPLE AND NUMBER OF FATALITIES BY COUNTRY ENDING IN 1979 OR LATER. DATA COLLECTION TYPE A=NATIONAL METEOROLOGICAL AGENCY; B=MEDICAL RECORDS; C=PERSONAL DATA COLLECTION FROM VARIETY OF SOURCES; D=PRINT MEDIA; E=NATURAL HAZARDS DATABASE; F=MIXTURE OF TYPES.

| Continent<br>Country | References                       | Period    | Annual fatality<br>rate per million | Fatalities<br>per year | Data col-<br>lection type |
|----------------------|----------------------------------|-----------|-------------------------------------|------------------------|---------------------------|
| <b>Africa</b>        |                                  |           |                                     |                        |                           |
| Burundi              | [10]                             | 2012-2013 | 2.5                                 | 26                     | C                         |
| Malawi               | [11]                             | 2007-2010 | 84.0                                | 1008                   | F                         |
| South Africa         | [12]                             | 1997-2000 | 6.3                                 | 264                    | B                         |
| Swaziland            | [13]                             | 2000-2007 | 15.5                                | 15                     | F                         |
| Uganda               | [14]                             | 2007-2011 | 0.9                                 | 30                     | F                         |
| Zimbabwe             | [8,9]                            | Unknown   | 14 to 21                            | 100-150                | F                         |
| <b>Asia</b>          |                                  |           |                                     |                        |                           |
| China                | [15]                             | 1997-2009 | 0.3                                 | 360                    | E                         |
| India                | [5]                              | 1967-2012 | 2.0                                 | 1755                   | E                         |
| Japan                | Kitagawa, personal communication | 1990-1997 | >0                                  | 2                      | C                         |
| Malaysia             | [16]                             | 2008-2011 | 0.8                                 | 22                     | F                         |
| Mongolia             | [17]                             | 2004-2013 | 1.5                                 | 5                      | A                         |
| Singapore            | [18]                             | 1970-1979 | 1.5                                 | 3                      | F                         |
| Sri Lanka            | [19]                             | 2003      | 2.6                                 | 49                     | C                         |
| <b>Australia</b>     |                                  |           |                                     |                        |                           |
| Australia            | [20]                             | 1980-1989 | 0.1                                 | 2                      | D                         |
| <b>Europe</b>        |                                  |           |                                     |                        |                           |
| Austria              | [21]                             | 2001-2010 | >0                                  | 1                      | D                         |
| France               | [22]                             | 1990-1995 | 0.2                                 | 11                     | B                         |
| Greece               | [23]                             | 2000-2010 | 0.1                                 | 5                      | F                         |
| Lithuania            | [24]                             | 1994-2003 | 0.1                                 | 2                      | A                         |
| Poland               | [25]                             | 2001-2006 | 0.3                                 | 8                      | F                         |
| Turkey               | [7]                              | 2012-2014 | 0.4                                 | 28                     | F                         |
| U.K.                 | [26]                             | 1988-2012 | >0                                  | 2                      | F                         |
| <b>North America</b> |                                  |           |                                     |                        |                           |
| Canada               | [27]                             | 1990-2004 | 0.2                                 | 9                      | A                         |
| Mexico               | [28]                             | 1979-2011 | 2.7                                 | 230                    | B                         |
| United States        | www.lightningsafety.noaa.gov     | 2006-2015 | 0.1                                 | 31                     | A                         |
| <b>South America</b> |                                  |           |                                     |                        |                           |
| Brazil               | [3]                              | 2000-2009 | 0.8                                 | 132                    | F                         |
| Colombia             | [29]                             | 2000-2009 | 1.8                                 | 76                     | B                         |

Summaries in Table 1 are derived from a variety of sources. The right column indicates the type of data collection. In the order of frequency, the sources are:

- A. Meteorological agencies: Four national studies rely on data collected by meteorological agencies as designated in Table 1 by A, those of Mongolia, Lithuania, Canada, and the United States.
- B. Medical records: Four published national studies rely on medical records, in South Africa, France, Mexico, and Colombia.
- C. Personal data collection: For three country summaries, there was active data collection by the author(s) from a variety of sources in Burundi, Japan, and Sri Lanka.
- D. Print media: The primary data source for publications from Australia and Austria.
- E. National hazards databases: The main source of fatality counts in China and India.
- F. The other 11 national studies used a mixture of these data sources. The Malawi summary not only has much larger totals than elsewhere but the data collection system was unique in that on-site interviews were included.

### III. DISCUSSION

The fatality total from the 26 countries is 4,176. There are many nations missing from this list, and some of them can be expected to have large fatality totals. One national study deserving special emphasis in this regard is that from Malawi [11]. A fatality rate of 84 deaths per million people per year was found, far exceeding the rate in any other country [1]. Their result is 1,008 fatalities per year for this small but populous country. It is unknown if the on-site data collection method was more complete than such a rate is what other countries in the region should report, or if there are special circumstances in the data collection such as including secondary and indirect causes.

Such a high fatality rate in Malawi, when extended to other adjacent countries, indicates that very large numbers of fatalities may be occurring but they are not documented. If a rate approaching 84 per million per year is applied to the other lesser-developed countries in the equatorial region of Africa with no lightning fatality data, then thousands more fatalities are occurring than the present summary is able to indicate.

In addition, there are several countries in Southeast Asia that are not included. It is known that agricultural lightning fatalities frequently occur in these countries [30]. Anecdotal web reports for short periods and portions of these nations lead to the likely conclusion that there are many missing reports around the world.

With regard to injuries, a ratio of ten injuries per fatality was found for the state of Colorado in the United States over a long period [31]. Every available dataset from emergency rooms, medical clinics, and similar organizations was

searched to find this result. Such a 10:1 ratio of injuries to deaths appears to apply in the more developed countries of the world. It is unknown if such a ratio applies in less developed nations where no lightning-safe location is often readily available at work during the day, or at home at night. It appears that more people are killed in multiple-casualty events such as agriculture [30] than occur in the United States, for example, where 90% of all fatalities and injuries are to one person per event [32].

Taking all of these factors into account, it is quite certain that the estimate of several thousand fatalities per year [2] is being surpassed based on the available data totaling 4,176 fatalities from publications describing primarily multi-year national datasets from 26 countries. The next threshold is 6,000 fatalities per year [3] that appears to be attainable based on present data. Finally, it remains unknown if the estimate of 24,000 fatalities per year [4] could be true. It is conceivable, depending on the reliability and extendibility of the Malawi report of an extraordinarily high fatality rate.

Since lightning fatality data continue to be missing for so many countries where large numbers of deaths are expected, another approach could be considered. A recent study indicated how the product of lightning flash density and population could make an estimate of fatalities [33]. This study for the United States had very good results. A similar study is planned for other countries. It is possible that after additional tests, the method could be applied to estimate global lightning fatalities. This may be a way to circumvent the likely long delay until quality national-scale fatality data collection can be made in lesser-developed countries.

### IV. CONCLUSIONS

A summary of published national multi-year lightning fatality studies finds that 4,176 fatalities per year occur in these 26 countries. There are many other populous developing nations where lightning fatality data have not been collected. An especially high lightning fatality rate in Malawi may indicate that rates in less-developed countries are much higher than is reported. Ten injuries occur per fatality in developing countries such as the United States where most lightning deaths and injuries occur to one person at a time [31]. In developing countries, there tend to be frequent multi-casualty events in agriculture [30] so the ratio of injuries per fatality may be different. More information needs to be collected over multiple years on national scales in order to make a better estimate. Nevertheless it appears that the known fatality total is more than one recent estimate of several thousand, is approaching the 6,000 determined from another study, and may be as high as another estimate of 24,000 global fatalities per year.

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