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Lightning Fatalities and Injuries in Bangladesh from 1990 through 2017

Ronald L. Holle
Holle Meteorology & Photography
Oro Valley, Arizona, United States
rholle@earthlink.net

Ashraf Dewan
Curtin University
Bentley, Australia

Shajia Mohammad
Dept. of Geography and Environment
University of Dhaka, Bangladesh

Md. Razimul Karim
Center for Environmental and Geographic Information Services
Dhaka, Bangladesh

Md. Faruk Hosain
School of Environmental and Life Sciences
University of Newcastle, Australia

***Abstract*—National summaries of lightning-related deaths and injuries are very difficult to obtain in many developing countries. For Bangladesh, Dewan et al. [2017] identified 3,086 fatalities and 2,382 injuries from 1990 to mid-2016, for annual averages of 114 fatalities and 89 injuries over the entire period. This paper updates Dewan et al. (2017) with another 18 months of recent data through 2017. The latest eight years have a fatality rate of 2.08 per million people per year and injury rate of 1.7. The rural attribution is 93%, the majority of deaths occur to males, and farming is the major activity. An increase since the late 2000s in part results from greatly improved communications leading to better media reporting of casualties because of a major increase in cellular telephone usage. The totals from 2010 to 2017 of 260 fatalities and 211 injuries per year may be considered as the current estimate.**

Keywords—Bangladesh, lightning fatalities, data collection.

I. INTRODUCTION

A. Global lightning occurrence

The occurrence of lightning occurs across the globe is steadily becoming better known by the use of a variety of sensors [Nag et al., 2015]. Extensive global lightning climatologies have been completed with data from the Global Lightning Dataset GLD360 network [Holle, 2016a] and satellites [Albrecht et al., 2016]. A series of lightning climatologies for the United States have been completed as summarized in Holle et al., 2016]. Numerous other regional and national lightning summaries have been published, including those over Europe [Anderson and Klugmann, 2014] and Japan [Sugita and Matsui, 2014]. A preliminary climatology of lightning in the Asian Monsoon including Bangladesh was published recently by Nag et al. [2017].

B. *Global lightning casualties*

However, the number and more specific aspects of lightning casualties in many lesser-developed countries are not well known. Estimates of the number of global lightning deaths per year range from 6,000 to 24,000 and are most frequent in developing regions [Cardoso et al., 2014; Gomes and Ab Kadir, 2011; Holle and López, 2003]. A summary of 23 national-scale publications on lightning fatalities [Holle, 2016a] was extended [Holle 2016c] to total 4,176 deaths per year in 26 nations in recent years. However, this total is known to be too low by an unknown amount since lightning deaths and injuries are not tallied in many countries, especially in regions where labor-intensive agriculture continues to dominate society [Holle, 2016b] and people live and work in structures that are not lightning-safe, such as schools [Holle and Cooper, 2016].

The situation in developed nations is entirely different with regard to lightning exposure. Relatively few people are involved in labor-intensive agriculture, and buildings such as dwellings are substantially safe from lightning due to their higher quality of construction. In addition, metal-topped vehicles are usually readily available for protection from lightning [Holle, 2009, 2016c].

C. *Bangladesh lightning casualties*

Bangladesh has an estimated population of 164 million and a density of 1,237 people m^2 [BBS, 2016; Fig. 1]. There has been a decrease in the rural population from a 1990 value of 80% to a 2015 percentage of 70% [Biswas et al., 2016].

The largest losses of life and damages in Bangladesh are due to floods and tropical cyclones. As a result, less likely to be reported are more localized incidents such as those from thunderstorms including lightning, as well as hail and tornadoes. No government agency in Bangladesh collected data about lightning casualties until 89 people were killed on 12 and 13 May 2016 [Holle and Islam, 2017].

Three previous studies provided some information about Bangladesh lightning casualties [Gomes et al., 2006; Ono and Schmidlin, 2011; and Mashreky et al., 2012]. However, none of there were comprehensive national studies over multiple years. As a result, Dewan et al. [2017] undertook a multiyear study of all lightning reports beginning in 1990 and ending in the middle of 2016. Due to the importance of updating the important results in the last few years, the present paper will primarily focus on providing an update to Dewan et al. [2017]. It will explore whether the recent media-driven increase in lightning deaths and injuries attributed to changes in media reporting has continued beyond that found in the previous publication.

II. Data and Methods

Details of the data collection are provided in Dewan et al. [2017]. In brief, data were compiled from a substantially labor-intensive project from newspapers, civil surgeon offices, national disaster reports, district police, and other historical sources from 1990 through June 2016. Nevertheless, newspapers were the main data source, and data were obtained by scanning each issue during the period. Underreporting, especially of injuries, is a well-identified problem in lightning casualty data collection [Cherington et al., 1999; Elsom, 2001; Holle et al., 2005; Dlamini, 2009; Trengove and Jandrell, 2015]. The result is that lightning may not be perceived as large a risk as is the actual situation such that steps are not made to address the issue.

The resulting database from 1990 through mid-2016 reported in Dewan et al. [2017] contained 5,469 casualties. Additional fatalities and injuries were collected for the last half of 2016 and all of 2017.

III. Updated Inter-annual Distribution

The most important update to Dewan et al. [2017] is to extend the inter-annual distribution of fatalities and injuries through the end of 2017 (Fig. 1). The trend of many more casualties starting in 2010 has indeed continued. The decadal totals are as follows:

- 1990-1999: 30 deaths and 22 injuries per year,
- 2000-2009: 106 deaths and 72 injuries per year,
- 2010-2017: 260 deaths and 211 injuries per year.

Dewan et al. [2017] consider two major factors that resulted in this large increase in lightning casualties:

- Potentially the most important factor is that reporting of lightning casualties was due to an increase in cellular phone subscribers in the country by 47% in less than five years, from 87 million in January 2012 to 128 million in July 2016, a growth of 10% per year (http://www.btrc.gov.bd/content/mobile-phone-subscribers-bangladesh-july-2016). As a result, lightning casualties that had been occurring in prior years, but unreported, are now reaching the media and data gathering systems.
- Bangladesh increased in population from 107 million in 1990 to 163 million in 2016, a 52% change in a growth at the rate of 2% per year. As a result, more people are exposed to the threat of lightning.

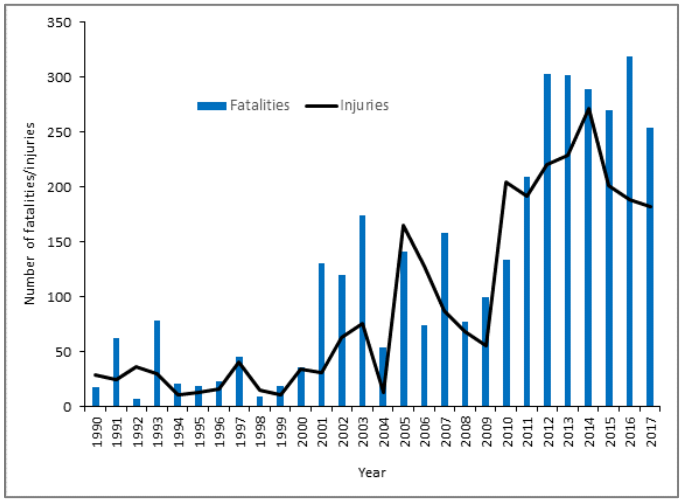

Fig. 1. Number of lightning-related fatalities and injuries in Bangladesh from 1990 through 2017 [updated from Dewan et al., 2017].

This concentration in more recent years is evident in Table I that lists the top ten totals of 17 or more fatalities on one day [Dewan et al., 2017]. Many of them have been reported since 2011, such as the two days in May 2016 when Holle and Islam [2017] found that agricultural exposure was the primary activity. These events almost certainly had taken place in earlier years, but were not reported widely. Similarly, Tilev-Tanriover et al. [2015] in Turkey found a similar increase in recent years that was attributed to population growth and reporting improvements. In contrast, a relatively modest one percent increase in lightning per two years is estimated due to warming temperatures [Romps et al., 2014].

For all of Bangladesh, the lightning fatality rates can be examined in more detail, since injuries are typically less reliably reported than fatalities [Dewan et al., 2017; Cherington et al., 1990]. The following is found when divided into two groups, one for the entire period, and the other for the last seven years:

- 1990 through 2017 0.99 deaths per million per year,
- 2010 through 2017 2.08 deaths per million per year.

IV. Demographic Features of 1990-June 2016 Dataset

A. *Spatial distribution of lightning-related fatalities*

The map of lightning fatality rates by district in Fig. 2 shows a very wide range from 0.20 to 4.47 per million people per year. Details are provided in Dewan et al. [2017]. A subsequent study is planned to address the regional differences by combining population, lightning frequency, and crop-related agriculture activity through the year. Similar maps of population density, lightning injuries, and fatality rate density are in Dewan et al. [2017].

TABLE I. Top Ten Days in Chronological Order with Large Numbers of Lightning-related Fatalities Since 1990 [Dewan et al., 2017].

Day, month and year	Number of fatalities
02 June 1991	27
31 May 1993	31
03 June 2007	21
05 June 2007	23
21 May 2011	17
23 May 2011	24
06 May 2013	25
02 May 2015	19
12 May 2016	51
13 May 2016	38

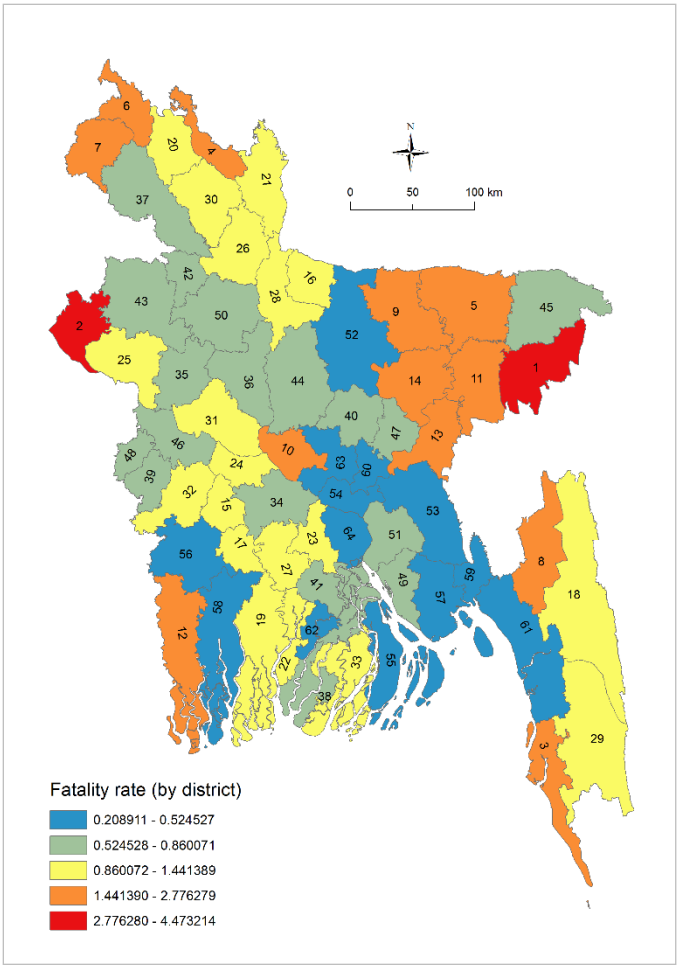

Fig. 2. Lightning fatility rate per million people per year by district. Fatality ranks by district are numbered [Dewan et al., 2017].

B. *Urban versus rural population*

The Bangladesh rural population decreased somewhat from 80% in 1990 to 70% in 2015 [Biswas et al., 2016]. However, the actual number of residents in rural scenarios was relatively unchanged due to the growth in population. The dataset from 1990 through mid-2016 found that 1,497 (93%) fatalities were in rural areas while only 108 were in urban scenarios. A similar rural percentage of 91% in Bangladesh lightning events was found by Biswas et al. [2016]. Other studies have found similar rural dominance of lightning fatalities such as Brazil [Cardoso et al., 2014], China [Zhang et al., 2011], Southeast Asia [Gomes and Ab Kadir, 2011], and globally [Holle, 2016a]. Labor-intensive agriculture is one of the main factors in such rural dominance [Holle, 2016b]. Other factors include structures such as schools that are not lightning-safe [Holle and Cooper, 2016], few readily available fully enclosed metal-topped vehicles, and inadequate understanding of lightning [Gomes and Ab Kadir, 2011; Raga et al., 2014].

C. Time of day of fatalities

The time of day of fatalities in Fig. 3 shows a dominance of daytime events. There is one maximum in late morning (1000 LST) and another in the more typical mid-afternoon period (1400 LST). There is usually a distinct minimum in lightning around 1000 LST [Holle, 2014] but the morning fatality maximum in Fig. 3 is unusual. There is also an indication of such a morning maximum in this region using GLD360 lightning data by Nag et al. [2017] that needs to be examined in more detail.

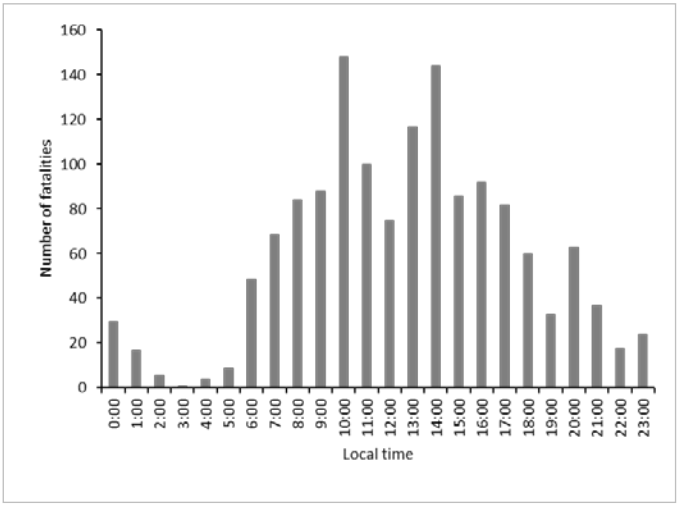

Fig. 3. Number of lightning-related fatalities in Bangladesh according to local time [Dewan et al., 2017].

D. Seasonal distribution of fatalities

Table II indicates the spread of lightning fatalities through the year. The pre-monsoon season has more fatalities (1,916) than any other season, while winter has the fewest (45). A somewhat different pattern was sound by Nag et al. [2017] with GLD360 lightning data that indicated more monsoon lightning than in the pre-monsoon season. It is possible that agricultural activity is more frequent during this period, so the planned fatality-lightning-crop study may assist in understanding this pre-monsoon tendency for more lightning fatalities.

TABLE II. SEASONAL DISTRIBUTION OF LIGHTNING-RELATED FATALITIES FOR BANGLADESH FROM 1990 THROUGH JUNE 2016.

Season	Months	Fatalities
Pre-monsoon	March to May	1,916
Monsoon	June to September	998
Post-monsoon	October-November	127
Winter	December-February	45

E. Fatalities per incident

One person was killed by lightning in half of the events (Fig. 4). Another 31% of the incidents involved two people. The other 19% of the events had more than two deaths each. The top ten recent multiple-deaths days are listed in Table I but these are not all at the same time and place. Instead, the media grouped separate events when lightning was widely distributed on the same day such as on 12-13 May 2016 [Holle and Islam, 2017]. This Bangladesh tendency for many deaths in the same incident is in strong contrast to 78% of Swaziland cases with single fatalities [Dlamini, 2009] and 91% in the United States [Curran et al., 2000].

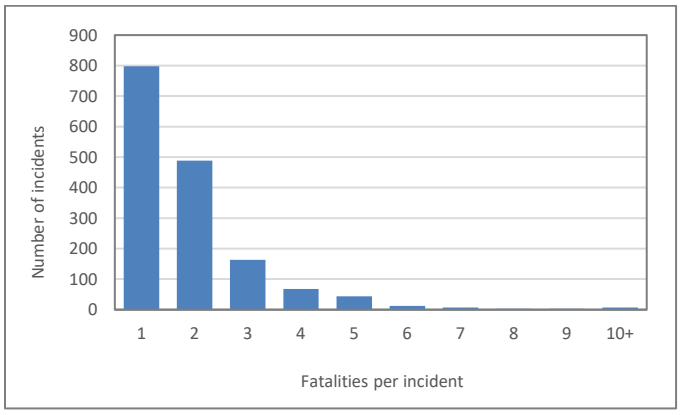

Fig. 4. Number of lightning-related fatalities in Bangladesh per incident [Dewan et al., 2017].

F. Gender

Gender is not always reported for fatalities, but those with reliable data indicate 73% male, 17% children, and 9% females (Fig. 5). Children in Bangladesh are defined as 18 years old or younger. A higher ratio of male population deaths from lightning has consistently been found such as 73% in the United Kingdom [Elsom, 2001], 79% in Mexico [Raga et al., 2014], and 79% from 2006-2015 in the United States [Jensenius, 2016], among many other studies globally.

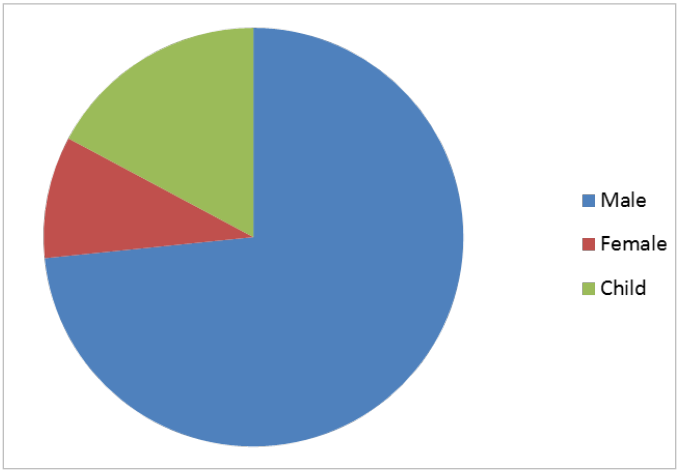

Fig. 5. Gender of lightning-related fatalities in Bangladesh [Dewan et al., 2017].

G. Age

Age and gender are known for many of the deaths (Fig. 6a). A total of 69% of the males killed by lightning were between 10 and 39, and the same female ages had a similar 73% portion. Contiguous is a secondary peak from the ages of 40 to 49, but there are more men than women in all age groups. Badoux et al. [2016] attributed more male deaths to greater risk-taking by young males. Outdoor work by males in rural Bangladesh was emphasized by Dlamini [2009], Raga et al. [2014], and Singh and Singh [2015].

Population by age group is taken into account in Fig. 6b. There is a shift in the maximum for males to the 30 to 39 age range, as well as a larger relative frequency over 60 than the number of fatalities in Fig. 6a. For females, there is also an indication of more deaths per population over age 50 than indicated by fatalities.

H. Socio-economic conditions and activities

Table III shows the activity reflecting socio-economic conditions at the time of lightning deaths when such information is known. Farming is the largest activity (40%), and another 24% occur inside houses. Houses in rural Bangladesh are often make of bamboo, thatch, and mud that are not lightning-safe [Hafiz, 2000; Mohiuddin and Latif, 2013]. Table III shows another 11% of fatalities while returning home (typically by foot) or walking around homesteads and courtyards. Various other factors account for 9% of the deaths, and an additional 8% are water-related activities.

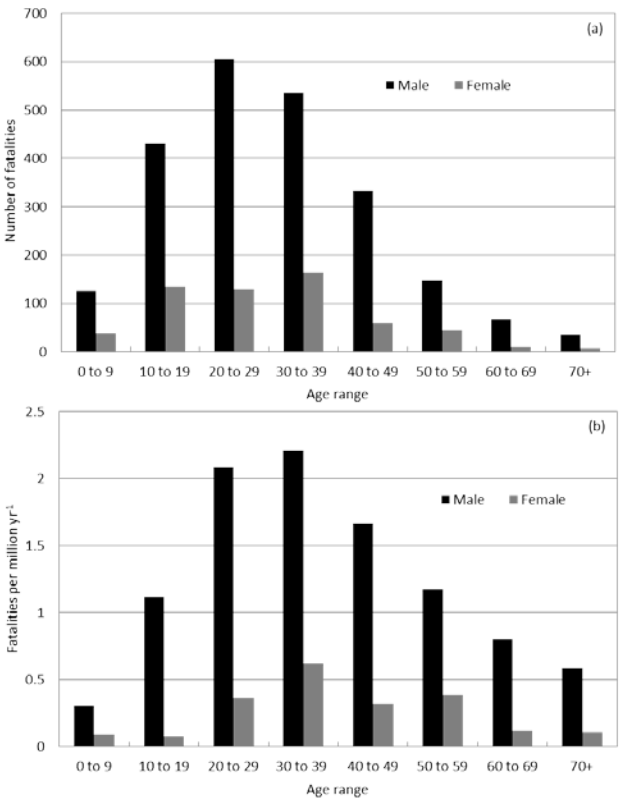

Fig. 6. Age distribution by gender of (a) lightning-related fatalities, and (b) population-weighted fatalities per year [Dewan et al., 2017].

TABLE III. ACTIVITIES AND LOCATIONS OF BANGLADESH FATALITIES DUE TO LIGHTNING.

Activity and location	Percent
Outdoors	
Farming	40
Returning home/walking around home	11
Others	9
Water	8
Herding animals	4
Playing on fields	2
Transport	2
Under tree	1
Indoors	
Inside house	24
School classroom	1

V. CONCLUSIONS

This study expanded Dewan et al. [2017] and documented lightning-related deaths and injuries in Bangladesh from 1990 through 2017. The analysis revealed annual averages of 260 fatalities and 211 injuries from 2010 through 2017. The results for these latest years are a fatality rate of 2.08 and injury rate of 1.7 per million people per year. Fatalities have increased to a much larger annual total since 2010. Part of the upward trend is attributed to a major increase in cellular telephone usage that resulted in better media coverage of lightning deaths and injuries.

As found in Dewan et al. [2017] for 1990 through mid-2016, 93% of fatalities occurred in rural regions. Most lightning fatalities occurred between 0600 LST and 2000 LST when agricultural activities overlap the occurrence of lightning. The largest number of casualties were during the pre-monsoon season, although there is somewhat more lightning during the monsoon season. Males were killed more often than females, and agriculture is the major cause of lightning deaths. Additional fatalities occurred often inside dwellings, returning home or walking around homesteads, and water-related situations.

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