



A Comparison of Lightning Human Fatalities Between Malaysia and United States

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Abstract: This study analyzed and compared the lightning related casualties in Malaysia and United States. United States as a developed country is reported with 0.3 deaths per million per year after 1970 comparing to lesser-developed areas such as Malaysia with an annual lightning fatality rate of 6 deaths per million. The comparison and analysis were made based on the rural-urban setting and the six types of activities locations defined as agriculture, indoors, outdoors, recreation, small structures (i.e. vehicle, open-sided shelter, shed) and sports. The results for the both countries were discussed in terms of their differences and similarities.

Keywords: *Lightning fatalities, Injuries, Human fatalities*

I. INTRODUCTION

Malaysia as a country located in tropical areas is reported with very high lightning density in the world [1]. Malaysia has recorded a high number of lightning accidents which lead to death, injury, and property damage and service disruption. It has been reported that casualties associated with lightning are high in Malaysia both due to lack of awareness and misconceptions spread by vendors that sell unscientific systems and techniques [2]. Even though, in this case the effect of Malaysia being a tropical country with very high lightning density should not be overlooked as a reason of reporting high in terms of lightning fatalities. This high rate of lightning accidents in Malaysia as like in the other lesser-developed countries, indicates the emergence of education and awareness on lightning safety programs to reduce the human casualties due to lightning. Thus, there is a need to accept that lightning is a threat and that there are solutions to reduce lightning's human and material impacts. In this matter, the lower rate of lightning casualties in more developed countries like United States indicates that these steps have been taken into account a long time ago. In United States, lightning kills more people than tornadoes, hurricanes, or high winds on average each year [3, 4]. Although, a large reduction in the lightning death rate and total number of mortalities over the last century in the United States has been recorded [5, 6]. It is reported that a rate of less than 0.3 deaths per million people appears in more developed countries such as United States. Other areas were supposed to have an annual lightning fatality rate

of 6 deaths per million, and this rate was considered relevant to a large portion of the world's population [7]. In this paper, the researcher compares Malaysia as a lesser developed country with U.S. as a developed country in terms of their rate of lightning casualty. The rational of this comparison is to consider on the area of difference in their lightning casualties reports.

II. CAUSES OF DECLINE IN LIGHTNING CASUALTIES IN A DEVELOPED COUNTRY LIKE U.S.

As stated previously, the effects of lightning are reported to differ significantly between more developed regions, and lesser-developed countries such as Malaysia. United States as a developed country was reported with 0.3 deaths per million per year after 1970, showing a great reduce from about a century ago [8, 9]. The country lightning fatality rate per million was reported to be highest at 6.3 in 1901 and in the beginning of 20th century the annual rate reached 0.6 deaths per million. In this sense, it has been hypothesized factors contributing to this significant decline in U.S. annual lightning fatality rate from 1901 to 1970 onward. The following factors were apparent in a comparison of U.S lightning fatalities in the 1890s with those in the 1990s [6]:

- Large substantial buildings commonly inhabited by people, provide significant protection to people inside them
- Climatological forecasts and warning systems significantly upgraded
- Increased people awareness of the lightning hazard and lightning safety through education, preparation, and detection
- Medical care improved and emergency infrastructures prevented many of lightning victims from resulting in deaths
- Other climatic and socioeconomic changes may have also resulted in change
- Frequent access to protection provided by fully enclosed metal-topped vehicles [7]

However, in this matter it is not apparent which factors of human behavior, location or activity are most important to improve standards for lightning safety through education. In contrast, in many lesser-developed areas rate of lightning casualties may be steady or slowly diminishing caused by urbanization and many other reasons.

Concluding this part, Malaysia as a country with lightning fatality rate higher than 6 deaths per million, needs to fully focus on the above mentioned reasons in the way of improving country's lightning safety system.

III. A COMPARISON OF LIGHTNING RELATED CASUALTIES BETWEEN MALAYSIA AND U.S.

First, in order to show how similar lightning occurrences in U.S. and Malaysia are, a comparison is made in terms of their annual number of thunderstorm days as shown in Figures 1, 2, respectively.

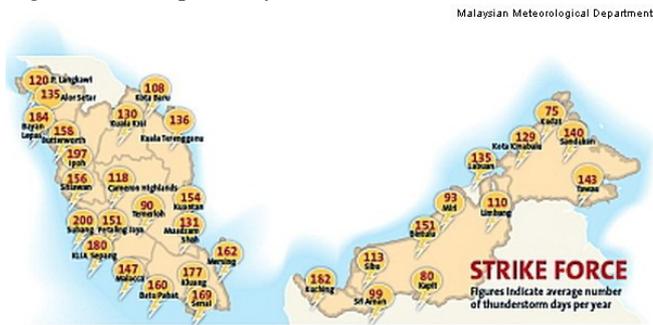


Figure1. Average number of thunderstorm days per year in Malaysia [20]

As can be seen in Figure 1, in Malaysia the highest density is in the Selangor state with 200 days per year.

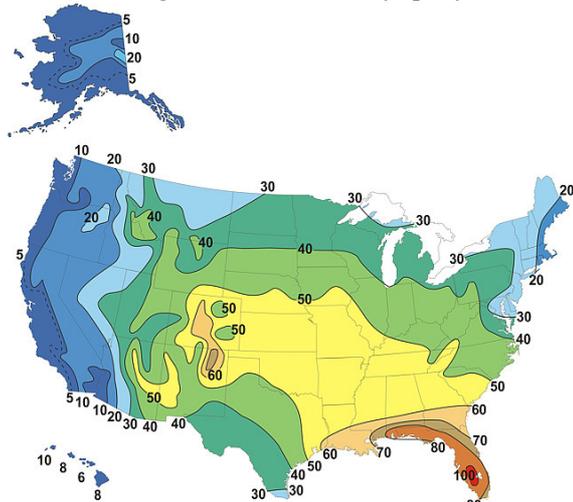


Figure2. Average number of thunderstorm days per year in U.S (Data from U.S. National Weather Service, NOAA)

According to the Figure above, in U.S. the most frequent occurrence is in the southeastern states, with Florida having the highest number 'thunder' days (80 to 100+ days per year).

As can be seen the highest occurrence in Selangor state of Malaysia (200 days per year) is approximately two times greater than lightning density in southeastern states of U.S (80 to 100+ days per year).

The number of lightning accidents in Malaysia has been decreased during the last years. Figure 3 shows the distribution of lightning injuries and deaths in Malaysia (2008- 2015). Although the number of lightning deaths have had a fluctuation during the years of 2009 to 2012, but starting from 2012, a diminishing trend can be seen in the number of fatalities (by the time of this study). Based on the Figure 3, the lightning injuries in 2012 have had the highest rate. In this case, the spike in injuries rate in 2012 may need to be treated as outlier. There might be specific reasons associated with this observation which needs to be more investigated. According to data available to the study, the large number of victims in the year 2012 were due to a few large groups with injuries (a few groups of students were camping in a field struck by lightning). Despite the spike in year of 2012, the population-weighted rate of lightning injuries is steady or slowly decreasing from 2013 to 2015 (by the time of this study).

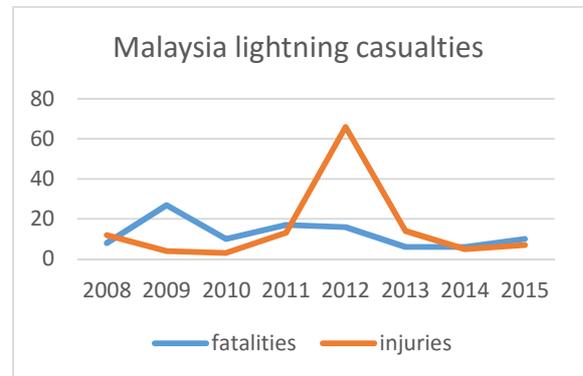


Figure3. Annual lightning casualties in Malaysia (2008-2015)

The number of lightning accidents in the U.S. has declined distinctly from a maximum of over 400 deaths per year early in the 20th century to less than 30 deaths annually in recent years [3, 5, 6, 10]. According to a recent statistics in this matter, as can be seen in Figure 4 the number of fatalities in U.S. during the years of 2008 to 2014 is less than average 40 deaths per year. Although, as Figure 4 shows the number of lightning related injuries is much higher than deaths, still a significant declining trend is evident.

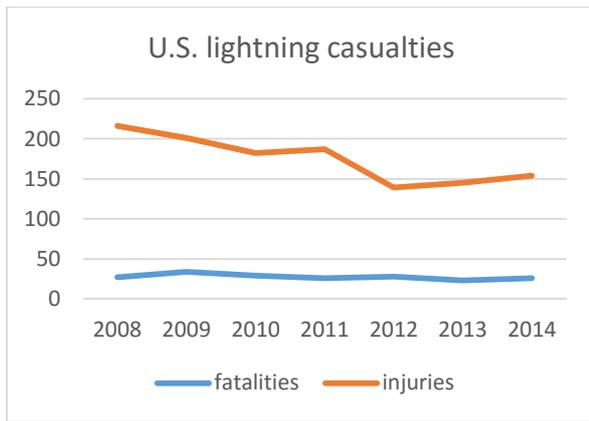


Figure4. Annual lightning casualties in United States (2008-2014), Data from U.S. National Weather Service, NOAA

IV. CLASSIFICATIONS OF LIGHTNING INCIDENTS

- Rural-urban setting

As mentioned earlier, in U.S, a significant decrease has been documented in lightning death over the last century by López and Holle (1998). This significant decline was likely parallel to the reduction in the proportion of the U.S. population living in rural areas [6]. According to U.S. Census Bureau, the U.S population living in the rural situations has been decreased from 65% in 1890s to 25% in 1990. Thus, based on the U.S. population shift from rural areas, a considerable shift from rural to urban situations of lightning fatalities was derived [5, 6].

In Malaysia, in terms of Rural- Urban settings, a trend similar to the U.S. has been documented as the Malaysia population living in the rural parts has been reduced from 50% in 1990 to 28% in 2010 [11]. Despite the fact that Malaysia rural population has been significantly decreased, contrasting to the recent years in U.S., still most lightning fatalities in Malaysia occurred in rural settings. According to Malaysian data from governmental website of Kilat [19], in 2012 the most lightning fatalities occurred in rural parts and from 2014 onward, still fatalities occurred in rural setting were higher than urban areas.

It needs to be mentioned that, the fact as the rural/urban setting has not been specifically recognized in past reports,

the occurred cases were categorized into rural or urban setting when possible, without reference to other material.

- Activity and location

Identifying the specific location for each victim is unknown in many of the cases and remaining are more likely in “open field, ballparks, playgrounds, etc.” [3, 6, 12]. In this report, activities and locations were identified and categorized for each casualty, based on the groupings recognized in the past research and the data available to this study from [19]. Past studies have stressed on location and define it such as in an open field. Similarly, it is essential to understand what activity the person was doing when killed by lightning strike, for instance playing baseball. It is because, the activity individuals are involved in during the thunderstorm determined generally by social norms and roles, have a significant impact on the fatality patterns in a country. The risk profile of a construction is also affected by issues such as the dimensions and relative location of the building, consist of unnecessary items nearby the building, and the lightning parameters [13, 14].

Accordingly, it is likely that a large number of fatalities in rural settings is due to the kind of structure and the poorly grounded buildings. The structures in rural parts are regularly built in open unprotected zones such as ridge lines and hill sides which increase the possibility of direct lightning strikes to the constructions [15]. In modern structures, fatalities by lightning strikes can only occur while an individual is in direct contact with power, telephone or plumbing that passes the current due to the lightning into the structure [6]. Thus, it needs to extract as much information as possible from the data to achieve a clear understanding of the mortalities by making separate groupings of both activity and location. For instance, a death or injured case might have “camping” as activity and “under a tree” as location. Doing so, locations and activity are coded to six classes (according to past reports): indoors, outdoors, agriculture, sports, recreation, small structures [6].

These six classes apply to both location and activity as defined in Table 1[6, 16]. Agriculture is recognized as a separate type because most lightning fatalities are recorded to occur in rural setting in the world and similarly in Malaysia [1, 17].

Table 1. Types of activities, locations

Type	Description of locations and activities
Indoors	The event take place inside a building most often a house
Outdoors	The case take place in a wide variety of locations where the fatality is outside a structure but the circumstance is not related to recreation, agriculture, sports or small structures
Agriculture	The event occur in a farm or ranch, the agricultural setting is more large than a garden in the backyard of a home, It usually is where the income of a lightning victim and related family involved agriculture
Recreation	Such events involve any entertaining activity, these cases occur outside but not include group sports events
Sports	The event take place during a group sporting event including a team situation, If only one or a few people are fishing, for instance, the situation is recreation
Small structures	The case occur when the victim is in vehicle, open-sided shelter, shed, or other small isolated structure, it does not contain large structures such as homes, office buildings, or stores.

The types of lightning incidents in terms of the activities and locations involved, in Malaysia and U.S. is compared in the following parts.

Table 2. Types of activities, locations of Malaysia Lightning incidents, 2008-2015

Type	Agriculture	Indoors	Outdoors	Recreation	Small structures	Sports	Total
Fatalities	12	6	56	13	1	12	100
Injuries	8	13	74	7	0	22	124
Total events	20	19	130	20	1	34	224
Percentage	8.92%	8.48%	58.03%	8.92%	0.44%	15.17%	100

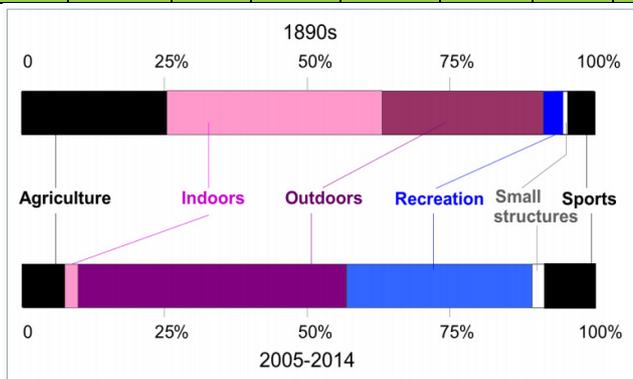


Figure 5. Types of U.S. lightning incidents’ activities, locations [6, 18]

As can be seen in Table 2, in Malaysia the highest portion of casualties occurred in outdoor areas and the second highest group is belonged to sports activities followed by agriculture, indoors and recreation activities with approximately the same portion. Whereas, share of the small structure is not much substantial.

In U.S. as reported by Holle, during the years of 2005 to 2014, similar to Malaysia the highest portion of lightning

related casualties were occurred in outdoors activities (Figure 5). However, contrasting to Malaysia, the second large category is placed for recreation activities, followed by sports and agricultural types. Indoors and small structures have the smallest portion among the all types.

Outdoor locations has the highest portion of casualties in both U.S and Malaysia. Past studies show that outdoors locations often include individuals situated under or near a tree [6, 12]. The Malaysia results show that the second highest type in terms of lightning hazards was sport activities. Research show that the most frequent sport activities have been playing baseball, golf, soccer and attending in tents and open fields.

As can be seen in both Malaysia and U.S. reports, indoors related casualties have the small portion among the activities. It is likely due to better-grounded constructions now than before. In recent years, with the setting up of power, plumbing, and telephones, a lightning strike to a building has a path to ground that significantly decreases the effect on the house and its residents [7].

Among the all categories only small-structure activity or location has the minimum portion in both U.S and Malaysia reports. In this case, research show casualties more likely occur near or inside a vehicle. The above results for both countries show that still there are casualties occur in agricultural, recreational activities. Most agricultural casualties occur in farms, barns and for recreation it involve the category of water, which consist of fishing and on water craft of all types.

V. CONCLUSION

The impacts of lightning in terms of fatality and injury rate seems to vary between developed countries like U.S and lesser developed regions such as Malaysia. Even though, the effect of Malaysia being a tropical country with very high lightning density (as mentioned and compared with U.S. in part III) should not be overlooked as a reason of reporting high in terms of lightning fatalities. Nevertheless, as mentioned earlier in developed countries such as U.S. there mentioned factors contributing to this significant decline and they have had a more basic programs to reduce the rate of lightning related casualties. In many lesser-developed countries as in Malaysia, the population-weighted rate of lightning casualties may be steady or slowly decreasing. This can be due to urbanization and many other factors. Lightning related fatality and injury reports of Malaysia were compared with those of United States. The methods were used to subdivide features of casualties including, rural- urban setting and six activities locations as, agriculture, indoors, outdoors, recreation, small structures and sports. The lightning casualties’ reports of the Malaysia and U.S. were compared in terms of the differences and

similarities. Results show that in terms of rural-urban setting, contrasting to the U.S still most lightning fatalities in Malaysia occurred in rural areas. Moreover, similarities were also found in this comparison including, the highest portion of lightning related casualties occurred during outdoors activities and locations such as individuals situated under or near a tree. This result indicate the necessity of continued education regarding the lightning risk of being in the area of trees.

Indoors related casualties have the small portion among the activities and small-structure activity or location has the minimum portion in both U.S and Malaysia.

In this sense according to the above results, specifically for Malaysia it is recommended that lightning avoidance education programs should place more stress on behavior in outdoor and sports activities and recreation situations, including the danger of seeking safety under trees and being in or near water. Also, not doing sport activities such as golf, soccer, attending in tents and not open fields during the lightning. In conclusion, the risk of lightning hazard leading to fatalities calls attention to the need for technological advancement, proper technical practices and engineering, distribution of knowledge and improving public awareness with respect to lightning protection in the country.

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