

A Detailed Analysis of Lightning Deaths in the United States from 2006 through 2015

John S. Jensenius, Jr.

National Weather Service

National Oceanic and Atmospheric Administration

Gray, Maine, USA

John.Jensenius@noaa.gov

Abstract— Lightning fatality data were examined from 2006 through 2015. While male victims dominated the fatality statistics, distinct patterns emerged in terms of the age, gender, and activity of the victims. The majority of victims were male aged 10 to 60. About two thirds of the victims were enjoying outdoor leisure activities before being struck, with water-related activities topping the list. Of the water-related activities, fishing ranked highest with boating and beach activities also contributing significantly to the water-related deaths. Among the sports activities, soccer ranked highest, followed by golf and running. Males dominated every category and sub-category of age and activity examined.

Keywords—lightning; lightning safety; lightning fatalities

I. INTRODUCTION

The National Weather Service (NWS) is responsible for documenting weather-related casualties in the United States in a publication called Storm Data. This documented information can then be used to study weather-related incidents in order to find ways to minimize the impacts from weather. Storm Data is typically available two to three months after the end of each month. While Storm Data remains the official source of weather-related casualties, in 2006, the NWS created an online database of lightning fatalities in the U.S. to provide scientists, the media, and the public more detailed and up-to-date information on lightning fatalities [Roeder and Jensenius, 2012]. For this study, the detailed information in this database was used to study the demographics and activities of recent lightning fatalities in the U.S.

A similar study was conducted by Curran, et al. [1997] for the period from 1959 through 1994 based on information in Storm Data. The current analysis provides an update to some of the information in the original study, but with the benefit of having more detailed information about the activities of the lightning victims.

This study does not examine the geographic distribution of lightning fatalities. Geographic information for the most recent

10-year period is available for actual deaths per state and for per capita per state on NOAA's Lightning Safety Web Site [Holle, 2015].

II. METHODOLOGY

Lightning fatality data from 2006 to 2015 were examined and categorized based on gender, age, month, day-of-week, and activity. While the data were easily categorized by age, gender, month, and day-of-week, activity presented more of a challenge. To obtain the most pertinent results, the victims' activities were divided into a series of cascading categories, sub-categories, and tertiary categories. The category and sub-categories assigned to each victim were based on the activity that the put the victim at risk, rather than what the victim was doing at the time of the fatal lightning strike. For example, if a person had been fishing, but was walking to a car when struck, the fatality was categorized as fishing, rather than walking.

For this study, the fatality data were stratified into four main categories: work-related activities, leisure activities, daily routine activities, and unknown.

A. Work-related Activities

A lightning fatality was categorized as work related if the victim was involved in an activity that provided a significant portion of his/her income. Examples include roofing, farming/ranching, lawn/garden care, construction, the military, barge workers, and other. Note that fatalities which occurred when traveling to or from work were categorized as daily/weekly routine, rather than work. Also, lawn care, landscaping and gardening activities were only included in this category if the victim was employed to do the work. Other lawn care and gardening victims were categorized as either daily/weekly routine or leisure, depending on the situation.

B. Daily or Weekly Routine

A lightning fatality was categorized as daily/weekly routine if the activity was done on a regular basis and not work or leisure related. Many of these activities might be considered

daily or weekly chores. This category also included young victims who were working/doing chores for their parents. Activities might include yard work, taking out the trash, feeding or walking domestic animals, traveling or walking to or from work, talking on the phone, taking laundry off a clothes line, etc.

C. Leisure

A lightning fatality was categorized as leisure if the victim had been involved with any sort of leisure activity. Sub-categories of leisure activities included water-related activities; sports-related activities; camping; riding (ATV's or bikes); social gatherings such as picnics; walking; playing; and relaxing outside the home. Also, the sub-category of water-related activities was further divided into fishing, boating, swimming, and beach activities. In addition, the sub-category of sports-related activities was further divided into soccer, golf, baseball, football, and running.

D. Unknown

In some cases, the victim's activity prior to the fatal strike could not be determined from the available information. The activity of these victims fell into the unknown category.

III. RESULTS

Results from this study are presented in graphical and textual format. The number of cases that went into each category and subcategory are given in the graphic showing the results. No attempt was made to determine the statistical significance of any of the findings as the data samples were necessarily small.

A. Gender

Fig. 1 shows the overall ratio of male to female deaths. About 79% of the victims during the study period were male. The predominance of male victims is fairly consistent from year to year. Male percentages for individual years within the study period ranged from 62% male in 2015 to 89% male in 2007 and 2012.

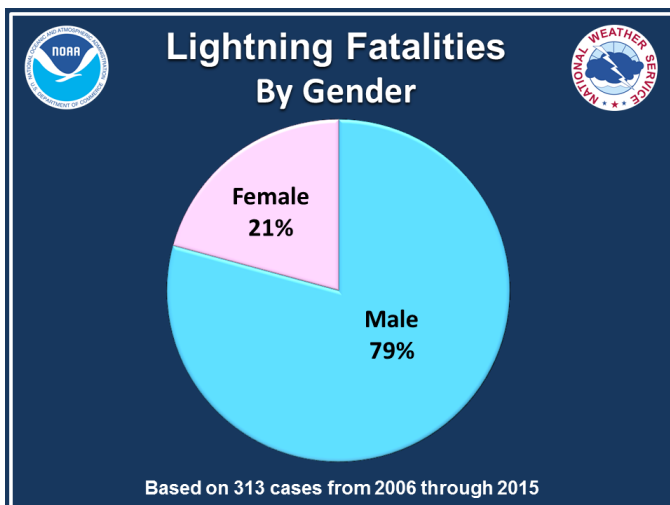


Fig. 1. Ratio of male to female lightning fatalities 2006-2015

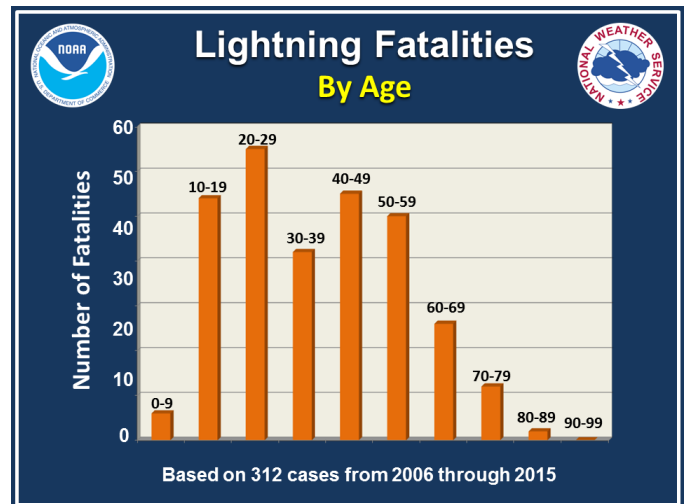


Fig. 2. Number of lightning fatalities from 2006 through 2015 by age category

B. Age

Fig. 2 shows a summary of the age categories of the victims. The greatest number of fatalities occurred between the ages of 10 and 60, with somewhat fewer in the 30-39 age category. While there is no conclusive evidence why this minimum should occur, possible hypotheses include that parents in this age category with young children are either more cautious when thunderstorms are in the area, or parental duties limit the amount of time they spend participating in vulnerable activities. Fig. 3 is similar to Fig. 2, except that the fatalities are given independently for both male and female victims.

C. Month

Fig. 4 shows a stratification of lightning fatalities by month. More than 70% of the lightning fatalities occur in June, July, or August. These months not only have the greatest amount of lightning activity in the U.S., but they are also the months

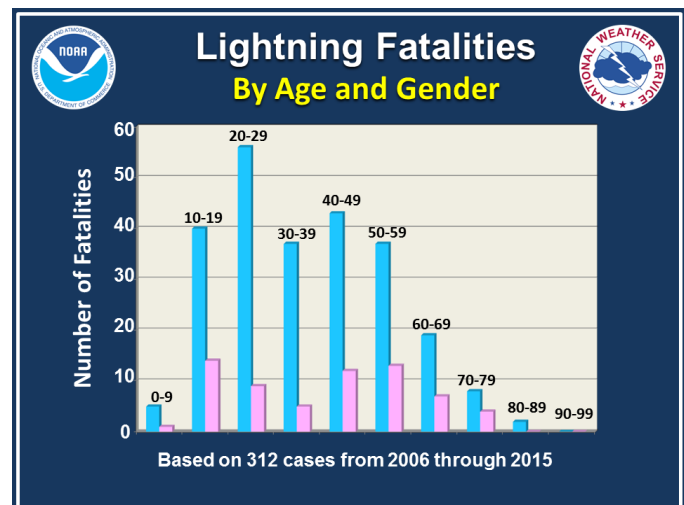


Fig. 3. Number of fatalities from 2006 through 2015

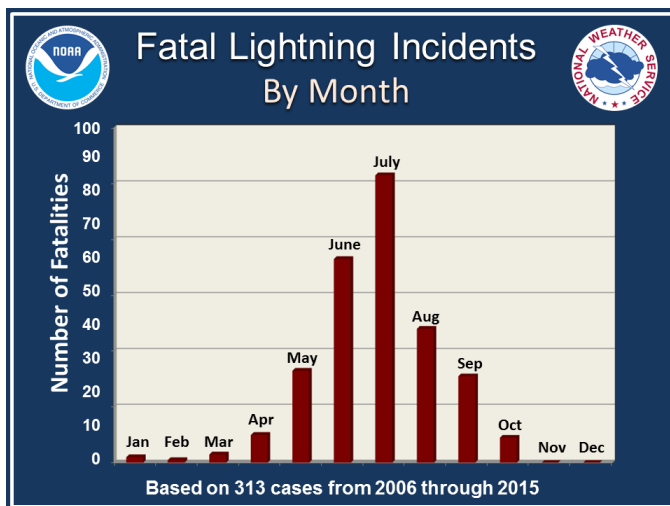


Fig. 4. Number of lightning fatalities from 2006 through 2015 by month.

when people spend more time outside enjoying a variety of recreational and leisure activities.

D. Day of the Week

Fig. 5 shows a stratification of lightning fatalities by the day of the week. While all days of the week see a significant number of fatalities, the weekend days, particularly Saturday, have the greatest number of fatalities. Presumably, this is because people spend more time outside and are involved in activities that make them more vulnerable to being struck by lightning.

E. Activities

Fig. 6 shows the overall breakdown of lightning fatalities into the four primary categories. Of the 313 lightning deaths between 2006 and 2015, leisure activities were responsible for 201, almost two-thirds (64%) of the deaths. During the period, there were 49 fatalities (16%) related to routine daily or weekly

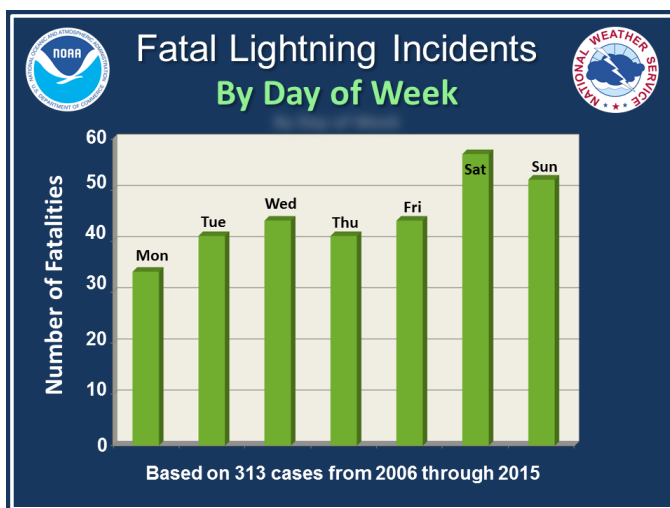


Fig. 5. Number of lightning fatalities from 2006 through 2013 by day of week.

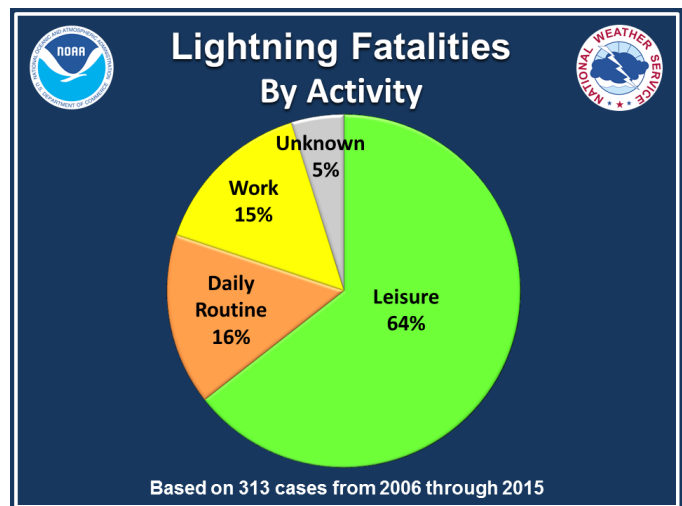


Fig. 6. Percent of lightning deaths by activity.

activities, and 47 fatalities (15%) related to work. Fig. 7 and Fig. 8 show similar charts for male (248 cases) and female (65 cases) victims, respectively. In both cases, leisure activities contributed to the majority of deaths. However, compared with males, females had a smaller percentage of deaths in the leisure and work categories and a larger percentage of deaths in the daily routine category.

1) Leisure-related Deaths

Leisure activities contributed to 64% of the overall deaths from lightning. Fig. 9 shows the overall breakdown of leisure-related deaths. Water-related activities contributed to 35% of leisure-related fatalities. Water-related activities include fishing, boating, swimming, or just relaxing at a beach or lake. Sports-related activities contributed another 15%. Sports-related fatalities include soccer, golf, running, baseball, and football. Other activities that contributed to the deaths in the leisure category included camping (8%); riding bikes,

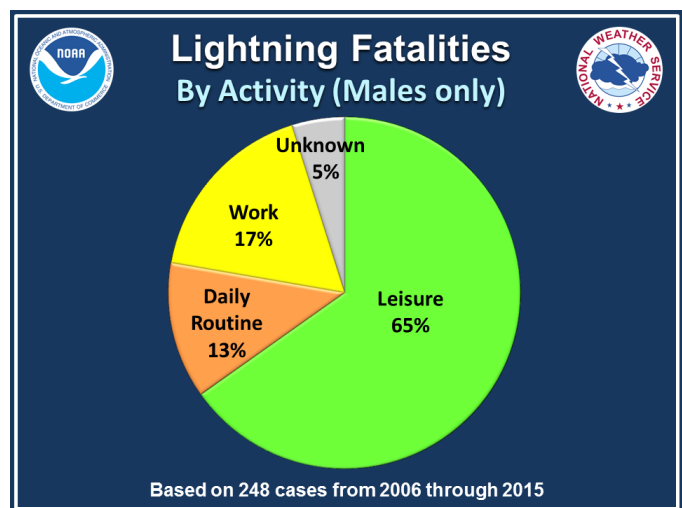


Fig. 7. Percent of lightning deaths by activity – males only.

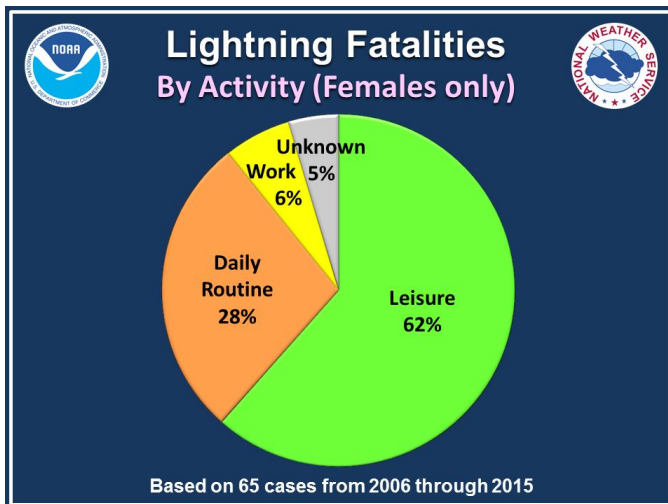


Fig. 8. Percent of deaths by activity -- females only.

motorcycles and ATVs (7%); social gatherings (5%); walking (5%); relaxing outside the home (3%); tourism (2%); children's play (2%); and "other" (9%). The "other" category included: hunting, horseback riding, building a tree house, taking a work break, picking berries, watching a car race, watching a fire, watching a swollen river, getting a book out of a vehicle, waiting in a parking lot, walking to a car from a local park, and getting better cell phone reception.

Fig. 10 shows the gender breakdown for the leisure activities. About 80% of the victims involved in leisure activities were male.

a) Water-related Lightning Deaths

Fig. 11 shows the breakdown of water-related fatalities. Fishing contributed to almost half (46%) of the water-related deaths with boating (power boats, canoes, sailboats, tubes) adding another 20%. About 25% of the victims were involved

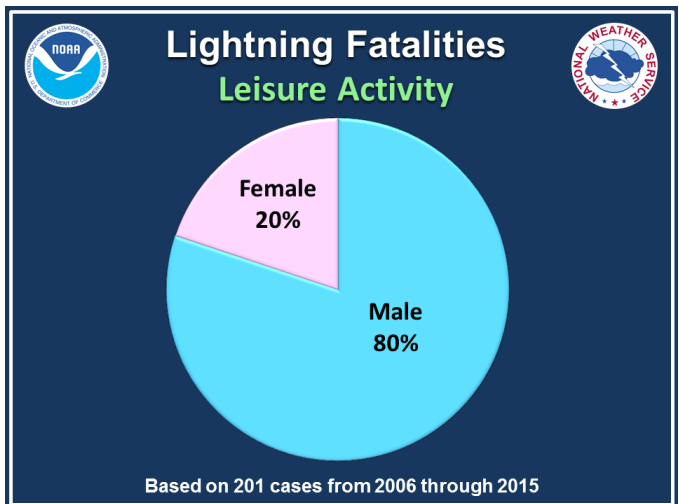


Fig. 10. Ratio of male to female deaths for leisure-related activities.

in beach-related activities, while about 8% of the victims had been swimming. The gender breakdown for water-related activities (not shown) was similar to the overall gender ratio with about 80% of the water related fatalities being male.

Fig. 12 shows the gender ratios for the fishing, boating and beach categories. While the overall number of cases in each category was relatively small, males dominated each of the water-related activities, especially fishing.

b) Sports-related Deaths

Fig. 13 shows the breakdown of sports-related fatalities. Soccer contributed most to the sports-related deaths (40%), followed by golf (27%), running (17%), baseball (10%), football (3%), and disc golf (3%). Fig. 14 shows that the vast majority of the victims in those sports-related deaths were male.

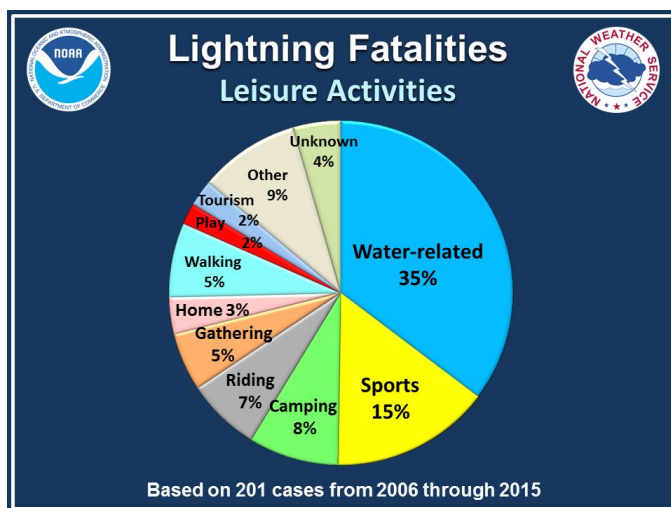


Fig. 9. Percent of deaths by sub-category for leisure-related activities.

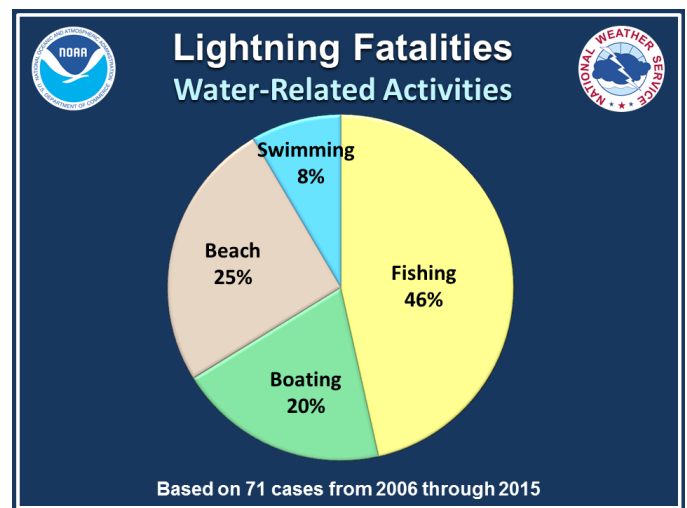


Fig. 11. Percent of deaths by specific activity for water-related deaths sub-category.

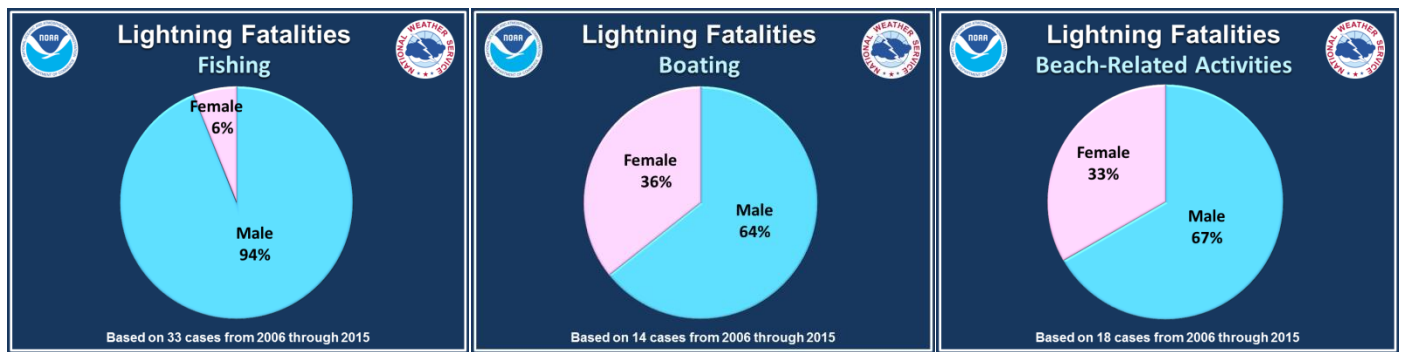


Fig. 12. Ratio of male to female deaths for fishing-, boating-, and beach-related deaths.

2) Daily Routine-related Deaths

Activities that would be considered part of the victim's daily or weekly routine contributed to 16% of the overall deaths from lightning. Fig. 15 shows the breakdown of those deaths. Victims that were walking to, walking from, or waiting for a vehicle contributed to 16% of the daily routine-related fatalities; victims walking to or from a home accounted for 22% of the fatalities; and yard work (excluding mowing) accounted for another 18%. Other daily routine-related fatalities included mowing the lawn (8%), taking out the trash (4%), checking/feeding animals (10%), farm chores (4%), and traveling to/from work on a motorcycle (4%). The "Other" category contributed 12% which included lowering the blinds on a window, talking on a corded phone, taking laundry off the clothes line, and working on a vehicle.

Fig. 16 shows the ratio of male to female deaths for the daily-routine category. Overall, males contributed most of the daily routine-related deaths (63%), however, females had a much higher contribution in this category than any other category. Of note, about half of the 11 deaths walking to or from the home were female and both victims that were taking out the trash were female.

3) Work-related Deaths

Work-related activities contributed to 15% of the total lightning fatalities. Fig. 17 shows the breakdown of the work-related deaths. Farming/ranching-related activities contributed most (34%) to the work-related deaths. Other activities included roofing (15%), construction (11%), lawn care (9%), military work (4%), barge work (4%), and other (23%). Included in the other category were deaths related to loading and washing trucks, surveying, door-to-door sales, logging, mail delivery, tornado rescue, utility repair, building maintenance, working at an amusement park, and working on a billboard.

Fig. 18 shows the gender ratio for the work-related category. About 91% of the fatalities were male. Only the sub-category of the military had more female deaths (2) than male deaths (0).

F. Actual Number of Deaths by Activity

Table 1 lists the 12 activities that contributed most to lightning deaths in the U.S. These 12 activities accounted for 171 (55%) of the 313 lightning deaths from 2006 to 2015. Fishing was, by far, the most deadly activity, accounting for about 11% of the lightning deaths. It was followed by beach activities, camping, farming/ranching,

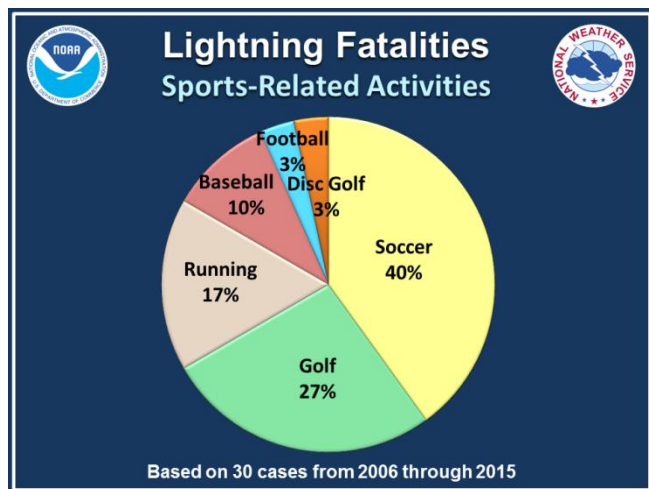


Fig. 13. Percent of deaths by specific activity for sports-related sub-category.

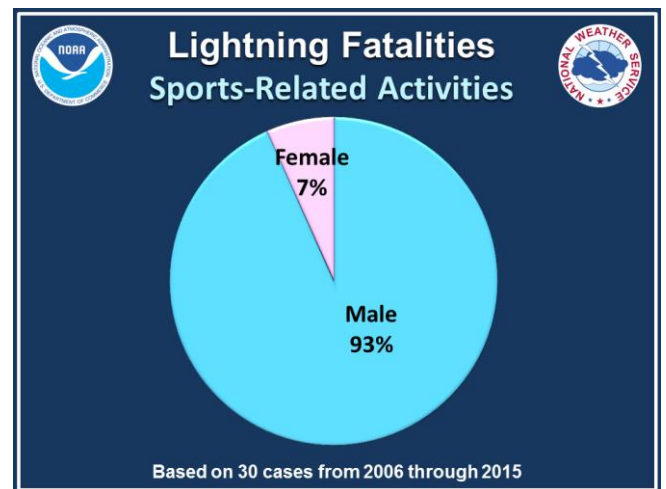


Fig. 14. Ratio of male to female deaths for the sports-related category.

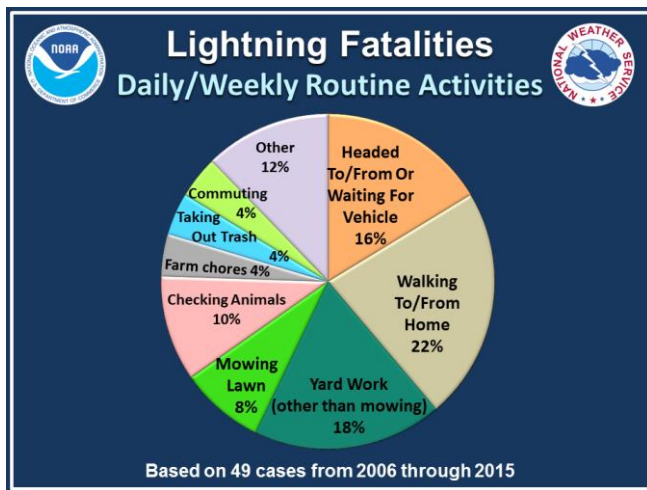


Fig. 15. Percent of deaths by specific activity for daily/weekly routine activities sub-category.

boating, riding, soccer, social gatherings, walking to or from the home, and yard work. Walking to/from a vehicle, and golf all tied for 11th place on the list.

IV. FACTORS THAT CONTRIBUTE TO LIGHTNING FATALITIES

In order to understand why these deadly activities rank the way they do, the various factors that contribute to lightning fatalities need to be examined. These factors include the willingness to cancel or postpone activities, the ability to be aware of an approaching or developing storm, the vulnerability of the actual activity, and the ability to get to a safe place quickly.

A. Willingness to cancel or postpone activities

In the busy life schedules of today's society, very few people like to alter their plans. Although many outdoor activities are cancelled in advance due to threat of a steady rain, few are cancelled in advance due to the threat of a potentially deadly thunderstorm. For outdoor activities,

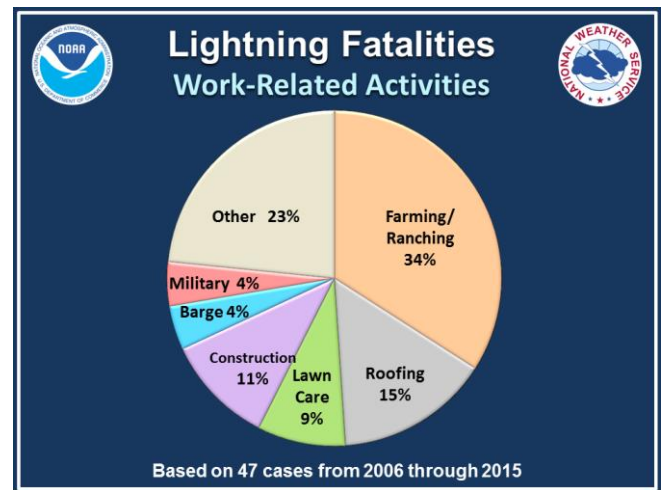


Fig. 17. Percent of deaths by specific activity for work-related activities sub-category.

there is a balance between safety and convenience. People who don't alter outdoor plans when thunderstorms are forecast (or occurring) are unnecessarily putting themselves at risk of being struck by lightning. For any activity where a safe shelter is not readily available, there is no safe alternative but to cancel or postpone the activity in advance if thunderstorms are forecast.

B. Being aware of approaching or developing storms

Certain activities limit a person's ability to monitor conditions. In particular, any background noise may limit a person's ability to hear distant thunder from an approaching or nearby storm. Mountains, trees, or buildings may impair a person's view of the horizon and limit the ability to watch for signs of developing storms. Recent advances in cell phone technology and the availability of lightning notification services may help provide advance warning in these situations.

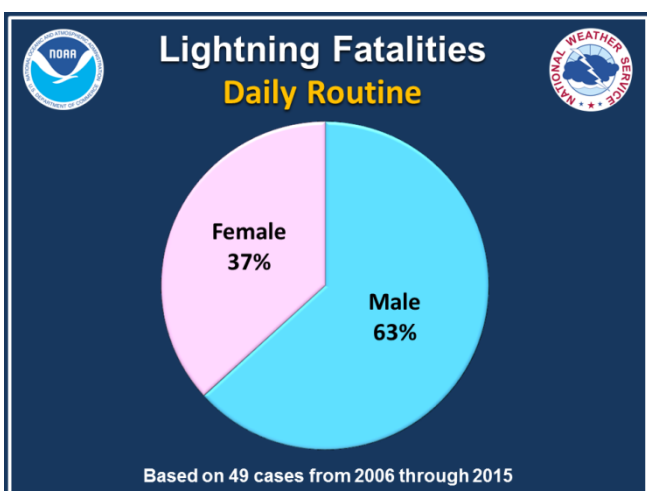


Fig. 16. Ratio of male to female deaths for daily/weekly routine sub-category

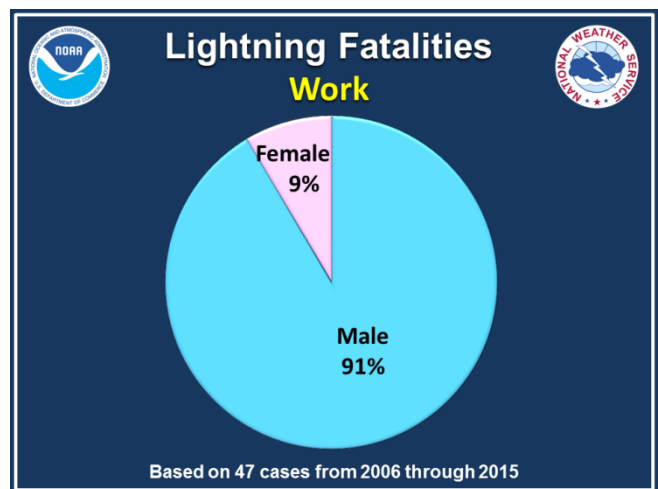


Fig. 18. Ratio of male to female deaths for work-related sub-category..

C. Vulnerability of the activity

Being outdoors any time a thunderstorm is in the area is dangerous. However, some activities cause people to be more vulnerable to a lightning strike, and, in particular, a direct lightning strike. Direct strikes are a greater threat to people in open areas such as sports fields or on the water.

D. Ability and willingness to get to a safe place quickly

The inability and unwillingness to get to a safe place in a timely manner both contribute to many lightning fatalities. Many people wait far too long to start heading to safety, and that puts them in a dangerous and potentially deadly situation. In fact, a number of lightning victims in this study were seeking safety when they were struck – the problem is that they just didn't start soon enough. In some cases, people decide to wait to see if the conditions improve rather than heading toward safety immediately. It's important to note that some activities require a considerable amount of time to get to a safe place. In those instances, it is imperative that people in charge or involved in the activities monitor conditions and head to safety immediately at the first signs of a developing storm.

V. DISCUSSION

Based on the statistics for gender, the vast majority of lightning victims are male. Possible explanations for this finding are that males are unaware of all the dangers associated with lightning, are more likely to be in vulnerable situations, are unwilling to be inconvenienced by the threat of lightning, are in situations that make it difficult to get to a safe place in a timely manner, don't react quickly to the lightning threat, or any combination of these explanations. In short, because of their behavior, males are at a higher risk of being struck and, consequently, are struck and killed by lightning more often than females.

The data also showed that leisure-related activities are the greatest source of lightning fatalities. In particular, the combination of fishing and boating activities account for 15% of all lightning deaths. These activities are especially dangerous because fishermen and boaters are likely out in the open and more vulnerable to a direct lightning strike; the background noise of a motor or water may limit their ability to hear thunder; and they may need extra time to get to a safe place. In these cases, the key is to monitor weather conditions closely and react to any developing threat quickly. While many of the fishing and boating victims realized that a dangerous situation was developing and were heading toward safety, they just didn't react soon enough to avoid being struck.

Beach-related activities were the second greatest contributor to lightning deaths. In some cases, the sounds of the surf may have masked the sound of thunder which could have provided an earlier awareness that thunderstorms were developing or approaching. In other cases, due to a lack of situational awareness, victims had walked or run along the beach and may have been far from safety when the storm approached.

TABLE I. THE TWELVE ACTIVITIES THAT CONTRIBUTE MOST TO LIGHTNING DEATHS

Activity	# of Deaths (%)
Fishing	33 (11%)
Beach	18 (6%)
Camping	17 (5%)
Farming or ranching	16 (5%)
Boating	14 (4%)
Riding bike, motorcycle, or ATV	14 (4%)
Soccer	12 (4%)
Social gathering	11 (4%)
Walking to/from home	11 (4%)
Yard work	9 (3%)
Walking to/from or waiting for vehicle	8 (3%)
Golf	8 (3%)
Total	171 (55%)

Camping fatalities also contributed significantly to the lightning death toll. In many cases, the victims were only steps away from a vehicle that could have provided safety. In some of these cases, skies may have been obscured by mountains or trees, and the victims just didn't realize a storm was nearby. In other cases, though, the threat was likely ignored. In a few cases where the fatal incident was in a remote area far from a safe place, there may have been little or nothing the victim could do at that time to be safe. In these cases, canceling or postponing the activity may have been the only course of action that would have provided safety.

Sports-related activities contributed to about 10% of the total lightning deaths, with soccer contributing most to the death toll. For most incidents, safety was nearby in the form of a building or vehicle. Many victims failed to react quickly to the imminent danger. A few of the running victims were some distance from safety and should have listened to the forecast and chosen a route that would have allowed them to get to a safe place sooner.

For most farming or ranching victims, there was typically a vehicle or building nearby. In these cases, the victims either didn't recognize the warning signs soon enough or didn't act promptly to get to a safe place.

There also were a number of people killed while riding in open vehicles including bicycles, motorcycles, and all-terrain vehicles. As with many other activities, situational awareness, and not venturing too far from a safe shelter are key to staying safe. Some victims may have been a long distance from safety when the storm approached. Although most people are aware that the rubberized tires on these vehicles do not protect a person from lightning, there are likely some people that continue to believe this myth.

Finally, there were quite a few people killed around their home, business, or neighborhood. Most of these victims were only steps from safety. In fact, some even walked outside just before being struck. Others were doing outdoor

chores or relaxing outside the home. In these cases, the key to safety is just to go inside and not take chances. It's important for people to remember that they should go inside immediately if they hear thunder or the sky looks threatening, and then wait at least 30 minutes after the last lightning or thunder before returning back outside.

VI. CONCLUSIONS

This paper examined and analyzed lightning fatalities in the U.S. from 2006 through 2015. The common belief that golfers are responsible for the greatest number of lightning deaths was shown to be a myth. During this 10-year period, fishermen accounted for more than four times as many fatalities as golfers, while camping and boating each accounted for almost twice as many deaths as golf did. The key to being safe in a thunderstorm is to get to a safe place before the lightning threat becomes significant. Activities such as fishing, boating, and camping may require that those involved in these activities be particularly wary of developing and approaching storms so that they can get to a safe place quickly. When planning an activity, if a safe shelter is not readily available and thunderstorms are forecast, the only safe solution is to cancel or postpone the activity.

For many of the lightning victims, safe shelters were available; however, the victims simply did not act soon enough to get to safety before they were struck. In order to reduce the number of lightning deaths, the public must continue to be made aware of the dangers of lightning, and also why it is so important to act quickly to avoid the lightning threat. To protect the public, the National Weather Service and NOAA have an ongoing effort to reduce lightning deaths, highlighted by the NOAA Lightning Safety Web Site and an annual national Lightning Safety Awareness Week. The broadcast and print media also play an important role in getting information out to the public. The results of this study will hopefully provide new material that will help reduce lightning casualties.

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