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1. INTRODUCTION

The goal of this study is to consider recent lightning casualties that have occurred during participation in several types of team or group recreation situations. Lightning-related events will be considered relative to the activities and types of precautions taken by casualties, the age and gender of the casualties, and the stage of thunderstorms.

Some terminology used in the tables needs to be identified:

- Events are described as given by the news source. However, some reports are affected by preconceived ideas of the reporters or witnesses. For example, some reports state that metal objects were the cause rather than the effect of the lightning strike to a person.
- The term “shelter” is used in a colloquial sense. Taking shelter under a tree is not safe from the danger of lightning, only from rain. So, when the term “sought shelter” is used, it is taken to say that people went somewhere where they expected to be safe from lightning. The necessary concepts to make a small open structure safe from lightning are in Kithil and Rakov (2001).
- The term “struck” is also used in a colloquial sense. It is not known if a person killed or injured by lightning was directly contacted by the flash, if the current came through the ground, or from another object. Nevertheless, the term is used only to imply that a person was affected in some way by a flash.

One of the topics to consider is the relationship of the casualty to the life cycle of the thunderstorm that produced the lightning. A study in Florida using cloud-to-ground lightning data found that people were killed or injured in the middle of a storm, as well as after and before the storm’s most intense lightning (Holle et al. 1992). Lengyel et al. (2005) also related U.S. lightning casualties to the patterns of cloud-to-ground flashes around them. In both studies, it was often difficult to identify the exact location and time of the casualty event for correspondence with the flashes.

The summary figures and tables for each type of recreation only describe events when the situation is identified by the available information. For example, players may have been actively playing a soccer or golf game. However, unless this activity was stated explicitly in the report, the information was not added since there was no direct mention in the narrative.

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2. DATA

Nearly all of the events summarized in this paper were obtained from NOAA’s monthly publication *Storm Data*, from newspaper accounts, or reports collected by newspapers and broadcast stations that were posted on the web. Some of the cases were also chosen for a study of worldwide lightning casualties by Holle and López (2003). None of the reports included all of the following information: a specific description of the stage of the game or activity, age and gender of all deaths and injuries, and type of league or group involved in the event. For this reason, exact percentages of cases can not be found for many of these categories.

Some of the cases were used in previous lightning casualty demographic studies. Two of the soccer cases from Japan were reported by Kitagawa et al. (2002), and one was in the Florida dataset of Holle et al. (1992). Four baseball cases from Japan were described in Kitagawa et al. (2002). One Florida golf event was in Holle et al. (1992), and one golf case from Japan was in Kitagawa et al. (2002). Two camping events from France were in Gourbière and Lapeyre (2002), one South Africa camping case was in Anderson (2001), and another from Florida was in Holle et al. (1992).

3. SOCCER

Figure 1 and Table 1 describe some of the major activities and behavior during 26 events with 39 deaths and 285 injuries when lightning casualties were involved in soccer. Of these casualties, 91% were from outside the U.S. Most events, especially from outside the U.S., had multiple casualties per event. The two largest tolls occurred when 17 people were killed and 35 injured in Honduras as a crowd stood under a shelter next to the soccer field during heavy rain, and 5 were killed and 100 injured in Malawi at a soccer game.

Relative to the playing of the soccer game, not the thunderstorm, consider the simple diagram in Figure 1. During half of the events, the lightning casualties occurred while the soccer game was being played (13 of 26). Another three events occurred after the soccer game had been stopped due to a thunderstorm. No casualties in this sample occurred before a soccer game began.

Five of the events occurred during heavy rain. Soccer matches tend to continue despite adverse weather conditions, whether there is lightning present or not. Two other events occurred during practice, and several occurred when fans sought safety under trees or an ungrounded structure.

Professional teams were involved in eight soccer-related news stories; this total includes some games postponed or delayed by lightning that did not involve deaths or injuries. Five events involved amateur soccer club teams, four were in youth soccer recreational leagues, three in high school soccer team activities, and two were in the yard of a home.

Males accounted for 91% of the soccer casualties when information was available in the news reports. The gender of the players in the large events was usually mentioned but not of the spectators, so this is a partial sample. Nevertheless, this high ratio of males is similar to other studies around the world during the past century (López et al., 1995).

In terms of age, news stories indicated that more than half (8 of 13) of soccer casualties in the U.S. were between 11 and 15 years old. Two more were between ages 16 and 20. The median was 16 years old, and the range was 12 to 46. These ages of soccer casualties are younger than the general population reported for Colorado by López et al. (1995) and central Florida by Holle et al (1992). Those studies showed that the age range of 26 to 35 had an equal or greater number of casualties than the under-16 category. Ages were only reported for a small portion of the casualties outside the U.S. and could not be summarized. It can be concluded that education and warning of all participants, spectators, and officials need emphasis during youth soccer situations.

In summary, soccer events tend to have multiple lightning casualties during a game that may continue to be played in heavy rain. So, the lightning safety issue involves more than making the players safe from lightning during the game itself. Plans and procedures need to provide safe locations for players and spectators, and time to reach such places. Much more attention needs to be paid to lightning as a threat at soccer matches and practices, since rain itself is not a major threat to soccer matches.

4. BASEBALL AND SOFTBALL

Figure 2 and Table 2 describe 28 cases with 13 deaths and 96 injuries that occurred where the casualties were involved in baseball or softball; most were in the U.S. More than half of the events involved more than one casualty (Table 2). The largest toll at a single event occurred when 20 people were injured in Tennessee (U.S.) when a softball field was struck.

With respect to the playing of the game, more than half of this sample are known to have occurred during the baseball or softball game. Three events occurred before a game began, and three more took place after a game was canceled or suspended. Lightning casualties also occurred during practice in one case, and to a person standing near the field.

Nine events involved amateur baseball or softball teams. Professional baseball teams were the subject of five news stories, including some games that were postponed or delayed by lightning but did not have a casualty. Seven were in youth leagues, five involved high school or college teams, and one was in a park.

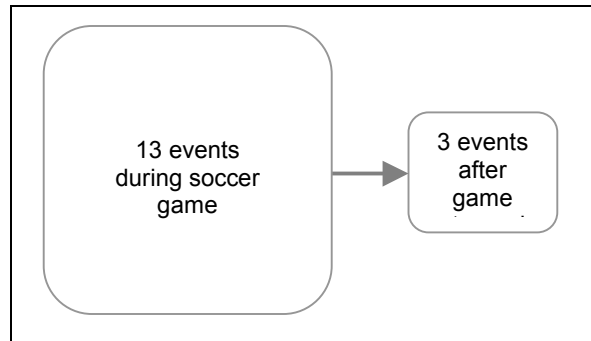


Figure 1. Time relationships of lightning casualties to the game during 26 soccer events in Table 1, sized generally by the number of events.

Table 1. Explicitly mentioned activities of people killed and injured during 26 soccer events. Some events have more than one entry in this list.

Activity	Events
Multiple casualties per event	18
During game	13
During heavy rain/storm	5
After game was stopped	3
Under tree	3
During practice/training	3
Kicking soccer ball in yard	2
Taking shelter from storm	2
Crossing soccer field from pool to car	1
Struck goal post during game	1

Males accounted for 71% of the softball and casualty cases when information was provided. This is a lower than typical ratio, and is influenced by a softball case involving 10 females.

Two thirds (22 of 32) of the baseball and softball casualties were between 11 and 20 years old. The median age was also 16, as for soccer. The range of ages was 7 to 47; three cases involved coaches killed or injured. This baseball and softball age distribution is somewhat older than the soccer events (as found in news reports) in section 3, but more similar to that of the general population of casualties in López et al. (1995) and Holle et al (1992). As with soccer, it can be concluded that education and warning of all participants, spectators, and officials need to be emphasized.

In summary, baseball and softball lightning casualties have occurred during, before, and after a game. Safety needs to involve more than taking care of the players during the game itself. Plans also need to be made for providing lightning safety procedures before and after the game for players and spectators.

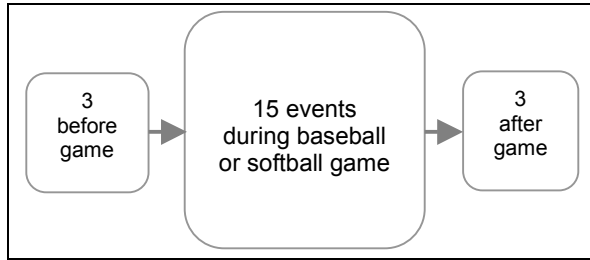


Figure 2. Time relationships of lightning casualties to the game during 28 baseball and softball events in Table 2, sized generally by the number of events.

Table 2. Explicitly mentioned activities of people killed and injured during 28 baseball and softball events. Some events have more than one entry in this list.

Activity	Events
Multiple casualties per event	16
During game	15
After game suspended or canceled	3
Coaching game	3
Prior to game	3
In dugout during thunderstorm	1
During practice	1
Standing near ball field	1

5. GOLF

Figure 3 and Table 3 describe 60 cases with 37 deaths and 117 injuries where the casualties were involved in golf. The largest single toll occurred when 19 people were injured while hitting golf balls off a cliff during a charity event in Colorado in June 2004. All but two of the 60 cases involved amateur golfers who were not part of a school or team event

With respect to the game, Figure 3 shows that half of the events (29 of 60) are known to have involved people on the course playing golf. In another 22 events, casualties had interrupted their game and sought safety under or near trees, small structures, or umbrellas (Table 3). Four additional events involved people running or heading to a safe place because the thunderstorm threat was perceived to have started.

Males accounted for 94% of the golf casualties in the reports. This is somewhat higher than the ratio found in previous studies mentioned earlier.

In terms of age, a large number (20 of 53) were between 31 and 40 years old. The median age is 37, and the range is 15 to 79. This golfers' age distribution is much older than for soccer and baseball-softball deaths and injuries in previous sections, and somewhat older than the lightning victim populations in López et al. (1995) and Holle et al (1992).

From this information, it is apparent that many of the events occurred when adult golfers interrupted their game while on the course, and sought safety under a tree or another type of unsafe structure on the course. Several other people were casualties while working at golf facilities. Two events occurred while people were in the parking lot after play had stopped.

Golf-related lightning education and warning needs to be approached differently than for organized sports. In golf, choices about responding to the lightning threat is made singly or in small groups, often of adults, rather than made by coaches, managers and/or referees.

In summary, there are as many golf casualties from lightning when players sought safety under trees and beneath ungrounded structures as during the playing of the game itself. Players often do not leave the course despite storm indications or warnings. For this reason, installation of safe structures at several locations on a golf course may be the best way to avoid lightning casualties. In addition, this summary shows that golf safety involves a wider range of people than players on the course. Procedures and safe places need to be provided on the golf course, for workers at the facility, and in the parking areas.

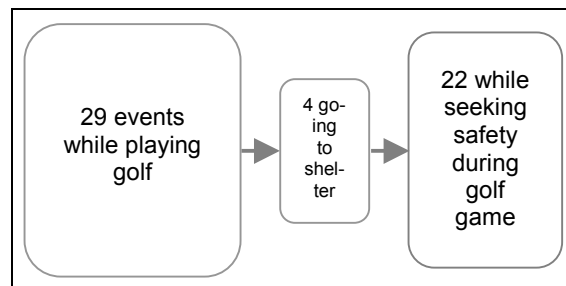


Figure 3. Time relationships of lightning casualties to playing the game and thunderstorms during 60 golf events in Table 3, sized generally by the number of events.

Table 3. Main activities of people killed and injured during 60 golf events. Some events have more than one entry in this list.

Activity	Events
Multiple casualties per event	38
Playing golf	29
Sought safety from thunderstorm	22
Under/next to tree	15
Inside shed/structure	6
Under umbrella	4
Running/heading for shelter	4z
Working at golf course or driving range	3
In parking lot	2
Looking for golf balls	1

6. CAMPING AND TENTS

Table 4 describes 50 cases with 23 deaths and 228 injuries that occurred while lightning casualties were involved in camping and/or activities involving tents. The largest total from a single event occurred when 26 Army personnel were injured inside a tent in Colorado (U.S.) when a tent pole was struck. The next largest occurred in South Africa when four people were killed and 19 injured while schoolgirls and adults were sleeping in a tent (Anderson, 2001).

On the spatial scale, 19 events are known to have occurred to people inside tents (Figure 4). Another three took place while setting up camp, and four events involved people sitting outside the tent. Table 4 also lists events when casualties were on a swing set, walking, or riding a bicycle in the campground at the time of the lightning strike. In nearly half of the cases, lightning first struck a nearby tree or pole.

Males accounted for 57% of the camping and tent-related casualties in the reports; the ratio is 76% when the South Africa case is not included. These percentages are lower than found for the other recreation activities in this paper.

More than half of the casualties (27 of 51) were between 11 and 20 years old. This aspect of the age distribution is similar to that of soccer, and baseball and softball, except the spread is larger. The median age was 16, and the range was 2 to 66. These events indicate the need for vigilance for the threat of lightning on the part of adults who are responsible for children.

More than a quarter of the cases involved scout, Civil Air Patrol, and military campgrounds, where lightning casualties were typically teenagers. The frequency of such events occurring in developed campgrounds suggests that many situations can be avoided by taking the precaution of leaving the tent during a thunderstorm, and staying in a nearby bathhouse or other substantial structure, or inside a metal-topped vehicle.

In summary, being in a tent in a campground with trees nearby is especially unsafe from lightning. For camping and tent safety from lightning, campers need to plan ahead and avoid being inside or near tents during storms. Instead, campers should go to a substantial grounded structure or metal-topped vehicle. Such plans are especially important at group camping events such as those held by scouting groups and the military.

7. DISCUSSION

Recreation-related deaths and injuries from lightning have been a major topic for safety and education efforts in the last decade. In particular, the use of the 30-30 rule has been recommended for recreation events involving groups of people (Holle et al., 1999). The first 30 applies to a 30-second flash-to-bang time for going to a safe place at the start of a storm; this time relates to a distance of 6 mi/9.7 km. That is, count the number of seconds from the time a flash is seen until its thunder is heard. The second 30 refers to waiting 30 minutes after the last lightning and/or thunder.

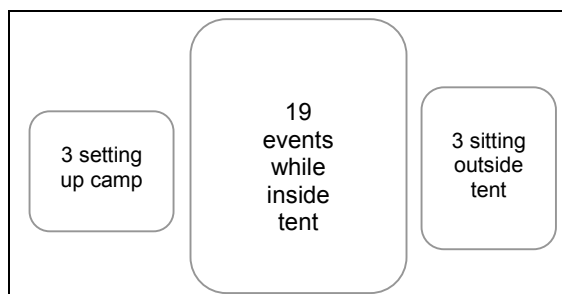


Figure 4. Spatial relationships of lightning casualties in camping and tents during 50 events in Table 4, sized generally by the number of events.

Table 4. Main activities of people killed and injured during 50 camping and tent events. Some events have more than one entry in this list.

Activity	Events
Multiple casualties per event	32
Inside tent	19
Flash struck tent pole and/or nearby tree	19
Scout/Military/Civil Air Patrol camp	14
Sitting outside tent	3
Setting up camp	3
Under tarp or damaged tent in storm	3
Walking through campsite	2
Dismantling tent due to tornado warning	1
On swing set in campground	1
Resting on rubber mattress in tent	1
Riding bicycle in campground	1
Running to shelter	1
Sitting in metal chairs under tree	1

The tradeoffs involved in the choice of these distances and times are described in Holle et al. (2003). This rule has been included in lightning safety policy statements by the American Meteorological Society (2003) and the National Weather Association at www.nwas.org/links/lightning.html.

In the U.S., the 30-30 recommendation has been endorsed by the National Collegiate Athletic Association (NCAA) and is included in the annual updates of their Sports Medicine Handbook such as Bennett et al. (1998). This example has led other local and recreational sports leagues to adopt the rule. Application of this rule has resulted in several nationally-televised football contests being postponed or canceled in the last few years. Following such rules would reduce but not completely eliminate the cases shown in this study (Lengyel et al., 2005).

Gender results are summarized in Table 5 from previous sections. A male ratio of 80 to 85% is typical of other studies (López et al., 1995). However, the 94% ratio for golf is higher than any subset found in previous studies. The lower rate for baseball-softball is partially due to a softball case involving a team with 10 females. The camping-tent ratio is also low, although less so when the 23-female case from South Africa is excluded.

Age distributions are summarized in Table 6. Three of the recreation activities have a median of 16 and most frequent 10-year age range of 11-20. Golf has a different age spread than the other activities, and typically involves an older population. Lightning education issues for soccer, baseball-softball, and camping-tents should target adults and the younger population under their supervision. Golf, however, involves a more mature population that is mainly responsible for its own safety.

Table 5. Gender of lightning casualties according to type of recreation activity.

Recreation type	% male
Soccer	91
Baseball and softball	71
Golf	94
Camping and tents <i>Without S. Africa case</i>	57 76

Table 6. Age distribution of lightning casualties according to type of recreation activity.

Recreation type	Median	Range	Most frequent
Soccer	16	12-46	11-20
Baseball and softball	16	7-47	11-20
Golf	37	15-79	31-40
Camping and tents	16	2-66	11-20

8. SUMMARY

Reports of lightning-caused deaths and injuries were summarized for the categories of soccer, baseball and softball, golf, and camping and tents. Each type of recreation has a different profile of activity of casualties and relationship to storms. However, a common theme is that in all situations, more attention needs to be paid to planning ahead. The result is that safe locations can be reached in sufficient time, and people can stay at these safe locations during the threat of lightning. The situations of relevance include participants and spectators at all phases of each type of recreation, including practice, around the field of play, and in the

campground, before, during, and after a thunderstorm. In all recreation categories except golf, casualties are often in the age range of 11 to 20. When events involve children and young adults during team sports or group camping situations, people in a supervisory role need to be responsible for them.

Soccer events tended to have multiple lightning casualties during a game that continued during rainfall. Most casualties were male participants with a median age of 16. Plans and procedures need to be made for providing safe places for players and spectators, and time to reach them.

Baseball and softball events had lightning casualties during, before, or after a game. Many casualties were male participants with a median age of 16. Plans need to be made for lightning safety procedures to be followed before and after the game for players and spectators.

Golf events have nearly as many casualties when players seek safety under trees and unsafe structures as during the game. Golf casualties were usually male, and most often in the age range of 31 to 40. Plans need to include procedures and safe places on the course, for workers at the facility, and in parking areas. Many players don't leave a course despite warnings, so it appears appropriate to provide safe structures on the golf course itself.

A tent in a campground with trees nearby is very unsafe. Females were lightning casualties more often in camping and tent events than in the other three recreation categories in this paper, but males were still more frequent. The median age was 16, but the spread was large and included five children between 2 and 9. Campers need to avoid being in or near tents during storms, and go instead to a substantial structure or metal-topped vehicle. Such plans are especially important at events held by scout and military-oriented groups.

In many or most of these situations, adults are responsible for the safety of children and young adults. This environment involves teams, site managers, or another group structure with supervision through a chain of command. Such a responsibility results in the need for the lightning threat to be monitored, decisions made about how to respond to the threat situation, and information given to participants in recreation in time to reach a safe place.

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