Weatherwise

ISSN: 0043-1672 (Print) 1940-1310 (Online) Journal homepage: www.tandfonline.com/journals/vwws20

Reducing Lightning Mass Casualty Incidents: How One Non-Profit is Saving Lives in Africa Using Lessons from the U.S. Experience

Walter Lyons

To cite this article: Walter Lyons (2025) Reducing Lightning Mass Casualty Incidents: How One Non-Profit is Saving Lives in Africa Using Lessons from the U.S. Experience, Weatherwise, 78:6, 48-57, DOI: 10.1080/00431672.2025.2563459

To link to this article: https://doi.org/10.1080/00431672.2025.2563459

Reducing Lightning Mass Casualty Incidents

How One Non-Profit is Saving Lives in Africa Using Lessons from the U.S. Experience

by Walter Lyons

TOM A. WARNER

Lightning has blazed through Earth's skies for eons. As *homo sapiens* evolved in and then dispersed from Africa, they were both awed by its majesty and terrified of its powers to kill and destroy. Estimates put the annual global death toll due to lightning strikes in the tens of thousands. Some nations, like the United States and China, have succeeded in reducing mortality rates due to lightning strikes drastically, thanks to technological advances, best practices, and public-safety campaigns. But developing nations face a tougher battle, with cultural beliefs, lack of resources, and lack of knowledge combining to keep mass casualty incidents due to lightning at an unfortunate high. Africa is one continent where lightning strikes have had particularly tragic consequences. Now a small non-profit organization, the African Centres for Lightning Education Networks (ACLENet), is working to help address the problem in rural Africa to great success and hopes its work can be replicated in rural areas around the globe.

Ancient Cultural Beliefs Surrounding Lightning

Ancient civilizations understood little of the best practices we have today for reducing lightning injury. Seeking to understand the danger, our ancestors conjured hundreds of deities whose whims and anger "explained" lightning's rampages. In 3500 BCE Mesopotamia, the god Adad controlled the heavenly bolts. Then came Zeus (Greece), Jupiter (Rome), Thor (Norse), Donar (Germanic tribes), Indra (India), the Thunderbird (Native Americans), Raijin (Japan), Kadlu (Inuits), and Shango (Yoruba of West Africa).

Throughout history, humans have sought to protect themselves from lightning. Derek Elsom's fascinating book, *Lightning: Nature and Culture*, details humans coping with this capricious and terrifying threat. Medieval Europeans hid knives and scissors during storms, lest their sharpness invite a strike. The Norse and Celts planted holly

ISTOCK/DARKO MLINAREVIC

Zeus, king of the gods, god of the sky, lightning, thunder, law, and order.

trees by dwelling doors. In rural southern Africa, the village shaman or "heaven herder" was tasked with standing on a hill in dark clothing while waving sticks to divert the heavenly flames, a practice that lingers today.

From the 8th- through 18th-century Europe, church bells tolled to disrupt approaching lightning. Standing in a belfry holding a wet rope was eventually recognized as both ineffective and hazardous. German officials outlawed the practice upon tabulating that between 1750–1785 some 386 church steeples were struck and 103 bellringers killed. Benjamin Franklin's 1752 treatise (which included an equally dangerous kite flying experiment) confirmed lightning was electricity (no divinities required), initiating the era of its scientific investigation. By the mid-1900s, photography helped decipher the structure of flashes. Lightning detection networks (LDN) began proliferating in the 1970s and now monitor the globe. Three-dimensional lightning mapping arrays now chart the fine structure of flashes through the clouds. New geostationary satellite lightning mappers today detect most flashes over continental scales. Prognostic models foretell when storms are likely to produce flashes. Recent theoretical studies may have cracked the mystery of how lightning actually initiates (hint: cosmic rays, strong electric fields, relativistic electrons, photoelectric feedback, and other cool processes are involved). Worldwide, more than 14 million thunderstorms occur annually, flashing 40–50 times every second. Depending on one's lightning event definition, there are at least 2.2 billion lightning strikes every year.

Humans can now enumerate, categorize, and sometimes even predict when these awesome electrical discharges may appear; we no longer need to appease the gods. Yet lightning still kills us mere mortals … and depending on where one lives, at alarming rates. In rural tropical regions, especially sub-Saharan Africa, lightning is perpetrating mass casualty incidents with a frequency just now becoming recognized. In recent decades, science has made it possible to protect life, limb and property from lightning's wrath; no holly trees, church bells, or shamans required. Sadly, this knowledge has yet to reach many parts of world. But one American physician, Dr. Mary Ann Cooper, and her organization, ACLENet, are starting to make a difference.

The U.S. Lightning Experience

In many developed countries like the United States, lightning is now perceived as "under control" in that we can mitigate its most catastrophic impacts and have reduced the annual death toll to a mere fraction of 19th-century levels. But this came only after decades of research and public

ISTOCK/JOSEPHGRUBER

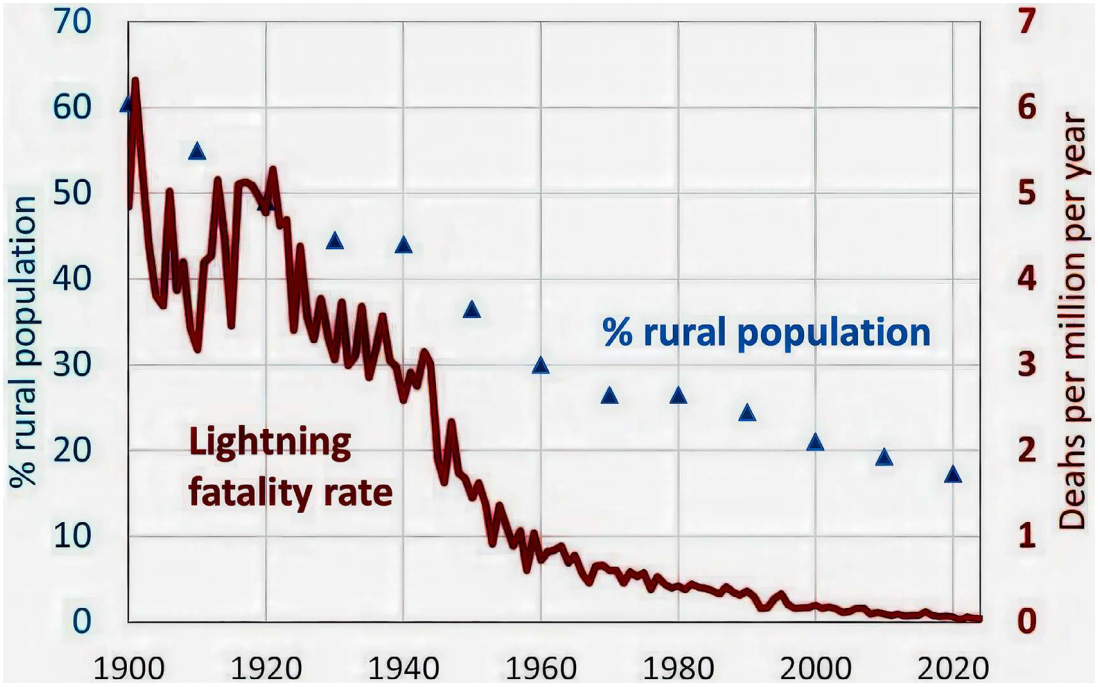
Lightning strikes behind the Washington monument in Washington, D.C.

education by scientists, government agencies, and emergency responders. Greatly assisted by the media, their lightning safety messaging reached much of the population.

Lightning is by far the most common direct weather threat to life that people encounter worldwide—often on a daily basis. Yet it tornados, hurricanes, storm surges, and flash floods that garner the spectacular headlines. Death tolls in the tens, hundreds, or thousands are dutifully tabulated after each of nature's ill moods. In the U.S. experience, where each year approximately 40 million ground targets absorb tens of thousands of amps of current, lightning's historical cumulative death tolls actually have been comparable to other severe weather hazards. However, they often occurred just one at a time—insufficient to make headlines and grab the public's attention—in part because a mass-casualty incident has been (arbitrarily) defined as a single event causing 10 or more fatalities. Because lightning mass-casualty incidents were absent in the United States, tabulating lightning's death toll was never a priority and therefore not very precise.

What factors actually contribute to lightning fatalities, at least as understood in the United States? First is the lightning density (strokes/square kilometer/year), which is moderately high over much of the eastern and especially Gulf Coast regions when compared to global distributions. Second is the density of the population, now at 340 million. More relevant is the rural population and, especially, the percentage working outside, where >99% of deaths occur. It is clear that no place outside is safe from lightning. Encouragingly, simply moving into a modern, fully enclosed structure or a hardtop vehicle provides high levels of protection. Why? In most buildings, the plumbing, wiring and metal components (and a vehicle's metal shell) act as a Faraday cage, directing the lightning currents around the outside, protecting the occupants. Therefore, a third factor is whether a person has timely access to a shelter when a thunderstorm threatens. This implies the fourth factor, whether the person has had the benefit of public safety campaigns teaching them behaviors that lessen their risk. A fifth factor involves access to proper response and medical care after an incident. Immediate first aid and follow-up emergency care are essential, though such care would be unnecessary if victims had taken suitable shelter.

During the 1800s, the United States was largely a rural and agricultural economy. Farmers, fishermen, and lumberjacks worked outside. "Guesstimates" of the annual lightning death toll exceeded 1,000. As data collection improved, these tallies (still underestimating the total) confirmed U.S. lightning fatalities in the 400–500 range by 1900 (population 76 million). During the 20th century, the death rate slowly fell, largely mirroring the decline in exposed agricultural workers, which decreased from 11 million to 1–3 million today, many of whom now labor inside fully protective tractor and combine cabins, along with more substantial farm buildings. Even so, at the onset of the 21st century, 50–60 Americans perished annually.



RONALD HOLLE

The best estimates of the lightning fatality rate per million population in the United States since 1900 plotted verses the percent of the U.S. population classified as rural.

Founded in 2000, the U.S. National Lightning Safety Council focuses on enhancing public safety campaigns fortified by the most up-to-date research (http://LightningSafetyCouncil.org). The public needed to know a lightning strike was not a death sentence: Less than 10% die, though as many as 70% suffer lifelong neurological damage. This has implications for immediate onsite first aid and subsequent medical treatment. Still, the best "medicine" is to avoid being struck. "When thunder roars … go indoors!" became the mantra. If the worst happens, call 911 and assist the apparently "dead" first, as they are likely briefly paralyzed. Be sure their airway is clear.

Even today, lightning myths abound. No, victims are not turned into cartoon-style "crispy critters," nor are they electrically charged; they can be safely touched. Cell phones do not attract lightning, nor will rubber shoes save you (lightning is very unimpressed by their insulating properties). No, it does not have to be raining for lightning to strike; the bolt from the blue is a very real thing as lightning can strike miles from its parent storm. While lightning tends to strike taller objects (including trees), it blindly strikes anywhere and everywhere.

Decades of lightning incident reports revealed the ways in which lightning kills and injures. A key researcher has been Dr. Mary Ann Cooper, a founding member of the National Lightning Safety Council. An internationally known expert in emergency medicine, Cooper has worked for 30 years to understand electrical injury trauma and treatment. From there arose an interest in lightning-induced injuries, which were found to be quite distinct in their nature. Lightning does not "burn" its victims (the current is too brief). Less than a third show any skin markings (often due to vaporized sweat or melting jewelry). Loss of consciousness, cardiac arrest, impaired breathing and brief immobilization (keraunoparalyises) are common in the immediate aftermath. Lightning, moreover, can inflict significant, long-lasting neurological damage. Estimates suggest for every one lightning death, perhaps 10 or more people are injured. Medicine is only slowly evolving to treat these long-term complications, again, avoidable by simply seeking shelter. Dr. Cooper's heroic efforts led to a 2001 American Meteorological Society Special Award "*for outstanding work on the medical effects of lightning … and revolutionized lightning safety worldwide*" and naming as a Fellow of the American Meteorological Society, the only physician ever so honored.

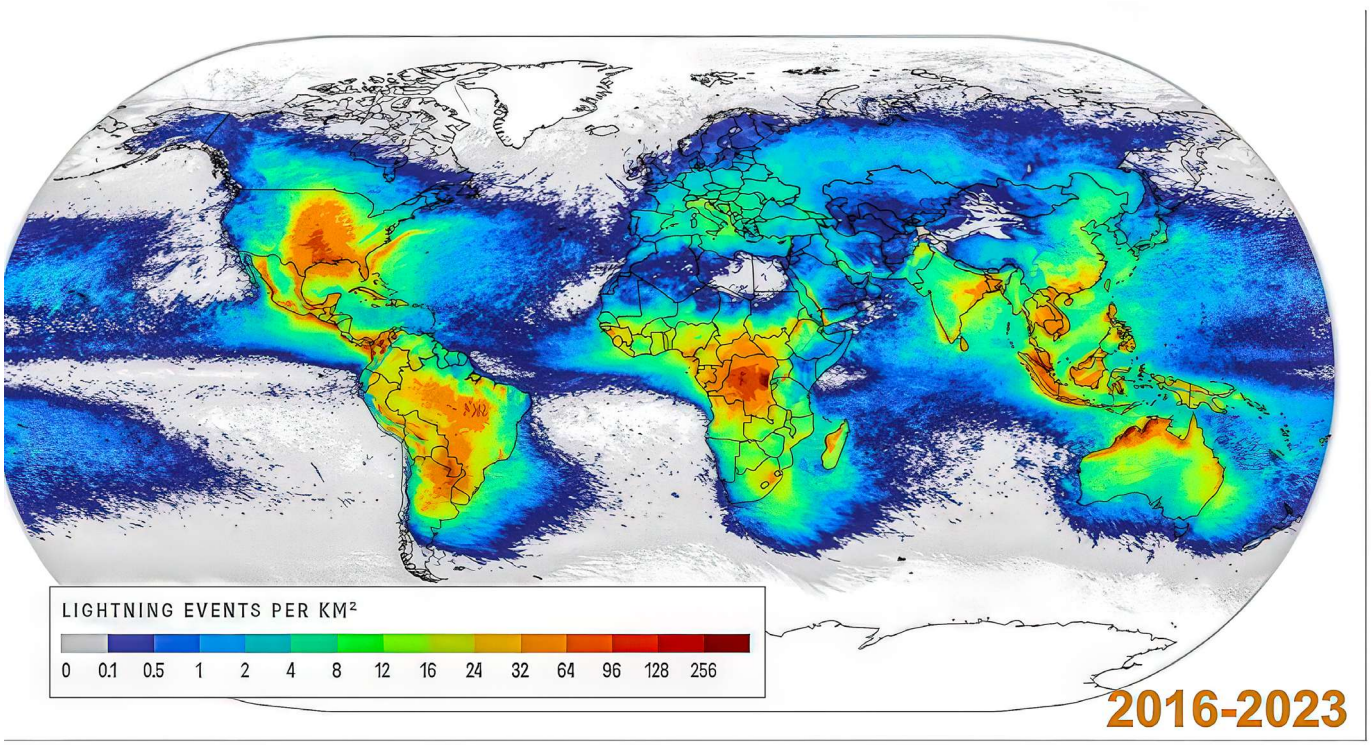
Understanding a lightning stroke's pathway can improve safety guidance. Curiously, a direct strike to a person standing in the open is rare, perhaps 3–5% of the total. As a stepped leader descends from the electrified cloud above, multiple upward streamers rise from grounded objects. One of these will connect with the descending leader, closing the electrical circuit with the brilliant return stroke we perceive as lightning. Unfortunately, being the source of one of these other failed streamers comprises 10–15% of injuries. Carrying metal does not attract lightning, though touching a metal conductor (fence, railing, wired phone, indoor plumbing) is implicated in 5–10% of casualties. The major pathways are side flash and ground currents. As current flows through a tree or metal pole, it often jumps sideways to targets nearby, such as a person sheltering under a tree. Current in the metal roof of an ungrounded structure can flash downwards to occupants inside. When lightning current enters the ground it spreads laterally for great distances, setting up a potential difference in the soil. A standing person experiences current up one leg, through the body, and down the other. (Having four feet on the ground is worse. More than 100,000 farm animals, who can't head indoors, are lost globally each year. In 2016, 323 reindeer were killed by one strike in Norway. In August 2021, 550 sheep were struck dead on a mountain in the nation of Georgia.)

A large crowd exposed to lightning is a recipe for a disaster. Aided by groups such as the National Lightning Safety Council and its predecessors, professional golf (search for Lee Trevino) began clearing courses when lightning threatened. College athletics and major sports leagues began suspending games and directing attendees to shelters. The result is the United State. has avoided a long-overdue lightning mass casualty incident. According to NLSC's John Jensenius, two fatalities from a single flash occur maybe once or twice a year, with three deaths only every decade or two. Since 1959, almost 99% of fatal lightning strikes have taken one or rarely two lives, with the highest known toll being an (unconfirmed) eight deaths. Almost all multiple fatality incidents involved sheltering under trees, a practice Americans have finally begun avoiding.

By 2024, the number of annual lightning-related fatalities in the United States had fallen to 13 (the lowest since the Covid year 2021 tally of 11). This marks a dramatic ~75% decrease over the past quarter century. (Public education campaigns in China appear to have similarly reduced their once alarmingly high lightning death toll over the last decade.) "When thunder roars, go indoors!" is working! Still, since 2000, the United States has suffered over 700 deaths. Victims were typically engaged in outdoor leisure activities: swimming, fishing, boating, hiking, and still, golfing—mostly preventable deaths.

The Global Lightning Threat

But what if there were no indoors? Dr. Cooper, though retired as a distinguished Professor



RONALD HOLLE

The annual global lightning density distribution as compiled over an 8 year period from the Vaisala GLD360 lightning detection network. Lightning totals in portions of sub-Saharan Africa rank among the highest in the world.

Emerita from the University of Illinois in Chicago in 2009, asked that very question when studying the scant data on global lightning casualties. Worldwide verified death totals were steadily rising (due in part to improved reporting.) Notably, however, many of the deaths were not isolated, but included large groups of victims. This leads us to the tropical nations of the developing world, including sub-Saharan Africa and particularly, Uganda—and a second "career" for Dr. Cooper.

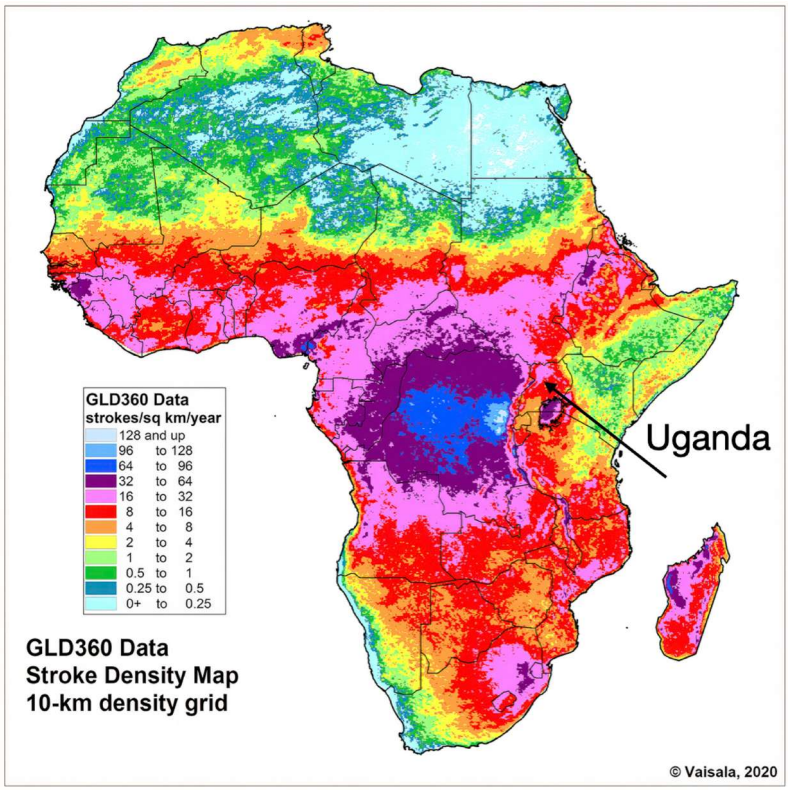
Others working in the space include Ronald L. Holle, who might reasonably be called a "lightning epidemiologist." During a lightning research career with NOAA and companies engaged in lightning detection, he expertly documented the patterns of U.S. lightning strikes and injuries. After retirement, he was frequently asked the same questions about the rest of the world. Various satellite and global LDN datasets now delineate those regions experiencing high lightning densities, including large portions of South America, the Indian subcontinent, China, Oceania, and especially sub-Saharan Africa. The Democratic Republic of the Congo (DRC), population 113 million, may include the planet's largest region of extremely high values. But how many people die from lightning in the DRC? No one knows. Like in the 19th-century United States, tabulating lightning casualties is far down the list of concerns of most developing (and some developed) nations. Documented lightning deaths from the few countries with somewhat reliable records numbered about 4,000 annually (with India alone accounting for more than 2,200/year.) As for the remainder of the planet, Holle made his best projections, by assuming there were six lightning deaths per million (similar to the United States in 1900). The result: About 24,000 deaths and 240,000 additional injuries. This annual toll is greater than many of the more "dreaded" natural disasters that do receive much needed attention. Unlike in North America and Europe where casualties are isolated, more and more reports of mass casualty incidents have emerged. Then the World Meteorological Organization certified a previously unpublicized mass casualty incident in Chinamasa, Zimbabwe, which on December 23, 1975, killed 21 people sheltering in a hut—the deadliest single strike yet documented. (An unconfirmed 2014 report from Zimbabwe claimed 33 killed.)

Since the 1990s, annual global conferences focusing on lightning protection technology for industrial, military, and residential structures could no longer ignore lightning's growing human toll and the likelihood that mass casualty incidents were not a rarity. A 2007 conference in Sri Lanka highlighted the concern. Similar resolutions addressing the problem were issued at a 2011 gathering in Kathmandu, Nepal.

In Kathmandu, Cooper connected with educator Richard Tushemereirwe, then a Senior Presidential Advisor on Science and Technology

for the President of Uganda. A subsequent 2013 conference in Uganda resolved to establish an "African Centre for Lightning and Research." This materialized into ACLENet, co-founded by Cooper and Tushemereirwe in 2014, who were soon joined by an international team of experts in lightning protection, research and education. ACLENet's charter: *to reduce deaths, injuries, and property damage from lightning across Africa.* The non-profit organization was incorporated in both the United States and Uganda and, despite its small size, plays a growing role in addressing some vexing problems.

Why Africa, why Uganda? Africa, with much of its population of 1.54 billion (still 57% rural) dangerously exposed to copious rates of lightning, will by mid-century be home to one in four humans. Uganda provides an excellent test bed as it encompasses the range of issues that must be resolved in Africa, and elsewhere.



RONALD HOLLE

The lightning stroke density map for Africa reveals moderately high levels within Uganda including a significant "hot spot" around Lake Victoria, from the Vaisala GLD360 lightning detection system.

The Ugandan Experience

It took a tragedy to focus the research community on Uganda, a nation of 51 million that is slightly smaller than the state of Michigan, straddling the equator in east Africa. Though adjacent to the DRC, its lightning activity (almost 4 million strokes/year) is more akin to the central United States, though with notable "hot spots" affecting islands in Lake Victoria and its northwest. But similarities with the United States soon fade. The population skews very young (average age 17) and is 70% rural and agricultural. While modern African cities like Kampala and Entebbe in Uganda have many modern, relatively lightning-safe buildings, as many as 90% of the structures in sub-Saharan Africa provide little protection. Open air design and minimal plumbing or wiring precludes the de-facto grounding found in urban structures. Ungrounded metal roofs can side-flash into interiors. Many with earthen floors expose occupants to high ground potential differences. Thatched roofs are commonplace and explosively flammable when struck, often incinerating the momentarily paralyzed occupants unable to flee the flames. Most Ugandans can expect to hear thunder for 200 to 400 hours every year, but when the thunder roars, they may have no safe indoors. In addition, given the historical lack of public safety campaigns, few have a detailed understanding of what measures they could take to save themselves.

This was the background for the disaster at the Runyanya primary school in the Kiryandongo district on June 28, 2011. As children studied inside metal-roofed school buildings, a single strike to a classroom killed eighteen and injured 38, a tragedy initially largely unreported even in Uganda. This was not an isolated event. The same year, a strike injured 79 students in the Oweko school. Eight students perished and "many" were injured in Bushenyi in 2014. At the Palabek Camp for refugees from South Sudan on November 2, 2024, lightning killed 14 and


ISTOCK/WIRESTOCK

Thunderstorm over Dibeng Information Settlement, near Deben, South Africa.

ACLENET

A row of classroom buildings at a Ugandan primary school in which LP systems meeting international safety standards have been installed by ACLENet, creating safe havens for students when lightning threatens the campus. These protected schools serve as demonstrations of LP good practice for school administrators, engineers and government agencies.

hospitalized 34 children who, while attending an outdoor choir practice, sought shelter in a food distribution center. Flashover from the metal roof was believed to be the culprit. Ten students playing soccer near Arua, Uganda, were struck down in 2020. This was reminiscent of a 1998 tragedy in Basanga, DRC, when all 11 members of a visiting soccer team died from a strike, resulting in wild rumors that local witches had cursed the team. This highlights some additional complications. Rural agricultural populations and those without a science education worldwide still cling to ancient spiritual myths and superstitions. Beyond the immediate grief of losing family and friends, schools struck by lightning are believed to be cursed. Attendance at the Runyanya school plummeted by 50%. It is not unheard of that families of lightning victims can be expelled from their village or tribe, discouraging the reporting of incidents. Some persistent myths including cell phone use, wearing red, or talking about it will attract lightning, while covering mirrors and placing rubber tires on roofs deflects the bolt. These are in varying degrees harmless, though the belief that sheltering under the *witgat* tree—falsely claimed never to get struck—is obviously misguided. In many developing nations, such notions remain unchallenged, with citizens not realizing they can, in theory at least, actually protect themselves.

Ugandans were not unaware of lightning's dangers. Some newer schools are adequately protected, but the majority of the 30,000+ campuses (many consisting of multiple small buildings) remain unprotected, or worse, have installed inexpensive and substandard "lightning arrestors" that do not comply with international standards, providing a false sense of security. They often fail, discrediting the notion that a building can be made safe. Uganda, like most of Africa's 54 countries, is not rich and has many needs. Lightning protection systems are expensive. In a nation where lightning claims an estimated 250–500 people annually, children attending school are the most at-risk population. The poor and the rural, especially children, are not expendable. ACLENet's challenge was, and remains, formidable and, as in the United States it may take decades to lessen the toll.

ACLENET

Beyond simply installing hardware, ACLENet staff and volunteers travel the countryside teaching lightning safety to students. Some schools have even formed "lightning clubs" as a way to learn about lightning as a natural phenomenon and introduce them to the world of science.

ACLENet—A Model for Africa and the World

ACLENet's approach to addressing the lightning toll in Africa is to apply what is valid from the developed world's experiences, but tailor the information to the realities of rural Africa. Having only a very small staff in Uganda, but bolstered by volunteers from around the world, ACLENet has undertaken the task of documenting lightning casualties continent-wide. It has compiled more than 1,300 reports from 45 nations (all publicly available online at ACLENet.org), and assessed lightning density patterns for each nation. It investigates lightning mass casualty incidents and shares lessons learned with experts at numerous conferences. The textbook, *Reducing Lightning Injuries Worldwide*, by Cooper and Holle, is free

ACLENET

Dr. Mary Ann Cooper (lower right), the Honorable Hillary Onek (to her right) and ACLENet staff conduct educational outreach on 2025's International Lightning Safety Day not only for students, but teachers, parents and officials, promoting lightning safety and in the process, dispelling unscientific myths that are commonplace in many parts of the world.

online, along with numerous scientific reports and media clippings. Their electronic newsletter, *The African Flash*, is distributed in five languages.

An expert Lightning Protection Working Group has been tasked with designing lightning protection systems suitable for rural Uganda. To date, nine schools have received lightning protection (LP) systems, helping more than 17,000 students. These schools serve as demonstrations of best practices for educators and engineers. The systems are composed of air terminals (aka lightning rods), down conductors, and, critically, proper grounding into the soil around the building.

Showing how to create a safe shelter for students was only the start. Students, teachers, staff, and parents needed to understand that lightning is a natural process from which one can protect oneself. Pamphlets, site visits, school lectures, the formation of student "lightning clubs", and intensive use of social media (including a YouTube channel) spread the word in areas where the cell phone's reach is becoming ubiquitous. Even so, these efforts are not without challenges. English is widespread, but in Uganda alone, one finds over 50 regional languages. Educating the educators, and from there the students and their parents, remains an ongoing focus. After the lightning protection system was installed at Runyanya school, students eagerly returned, with enrollment now more than double pre-disaster levels.

After 10 years of work in Uganda, ACLENet's efforts are starting to get noticed. Government officials, including The Honorable Hillary Onek, Minister for Disaster and Refugees, have recognized the challenge at hand. The First Lady of Uganda, who is also the Minister of Education and Sports, is now championing lightning safety. Having the government mandate school lightning systems—and compliance with international safety standards—is critical. Cooperative

ACLENET

ACLENet installing a lightning protection (LP) system atop a Ugandan school building, including the vertical air terminals (lightning rods), connectors and down conductors to a properly engineered earthing ring about the structure. LP systems do not prevent lightning strikes - they provide a means for the current to flow harmlessly into the ground.

agreements with the Uganda Institution of Professional Engineers have been signed. Hopefully the high import taxes on lightning protection equipment will soon be waived and/or domestic suppliers of qualified lightning protection products will emerge.

June 28, 2025—the anniversary of the Runyanya tragedy—was celebrated in 20 nations as International Lightning Safety Day. More than 500 people gathered at the Palabek Camp for a memorial, including Dr. Mary Ann Cooper, educators, students, parents, government officials and, vitally, press and broadcasters who are increasingly eager to spread the word. Lightning needs to be perceived as the threat it is. UNESCO has undertaken a worldwide educational campaign teaching children to be proactive in the face of natural disasters, and lightning protection is expected to be part of a new booklet coming out.

Like most small, mission-oriented non-profit organizations, ACLENet subsists on individual donations and foundation grants, in addition to the donation of lightning protection equipment by generous businesses. ACLENet typifies how a small group of dedicated people can affect big changes. After 10 years of showing the way, it is hoped similar centers will emerge in other

ACLENET

African nations. Our climate is changing, though researchers disagree whether the "new normal" will have somewhat less or more lightning. Either way, the lightning gods will continue hurling millions of bolts earthwards. Lightning travels at more than 200,000 mph. You can't outrun it—but you can outsmart it. Each year 320 million trees are killed by lightning worldwide. The goal is that our descendants will no longer be sheltering under them, but rather in lightning-safe homes, offices, and schools.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Walter Lyons http://orcid.org/0000-0001-6009-2259

WALTER LYONS is a lightning researcher, a Past President of the American Meteorological Society and serves on the Board of Directors for ACLENet.

The author wishes to thank Ronald Holle, John Jensenius, Daile Zhang, and especially Dr. Mary Ann Cooper for their most valuable insights and assistance. For more information, readers can find the lightning density at their home or any place on the planet by visiting https://interactive-lightning-map.vaisala.com.