Investigation of Lightning Mass Casualty Incident at Mongoyo School, Uganda

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Abstract: **On October 3, 2018, Mongoyo School in Yumbe District, northern Uganda, was struck by lightning at approximately 7:15 am. Three children were killed and dozens more were reported injured and hospitalized, 25 in critical condition. A team of ACLENet staff responded to the scene, examined it for physical evidence of damage and measured the school for lightning protection with plans to raise funds for lightning protection to prevent similar incidents.**

Thirteen months later, ACLENet staff returned to investigate in the effects to the students and teachers in more detail. A questionnaire to guide interviews and nurses were recruited to interview the students 9-11 November 2019. Teacher were interviewed to reconstruct the details of the incident as it occurred. It was confirmed that three children were killed, 73 others injured, and at least 34 admitted to the hospital for one or more days. More than twenty survivors remain out of school to date.

Injuries were consistent with a ground current mechanism of injury with many students only knocked down but others more seriously injured with burns, loss of consciousness, keraunoparalysis, ongoing auditory and visual problems and a few with long term problems suggestive of brain injury, learning disabilities and post-traumatic stress disorder, although these cannot be properly diagnosed using a simple questionnaire.

Keywords: lightning, lightning injury, school, lightning safety, lightning injury prevention, lightning risk assessment, mass casualty incident, neuropathy, post-traumatic stress disorder, lightning in Africa

I. INTRODUCTION

According to news reports, lightning hit Mongoyo Primary School in Yumbe District, northern Uganda, on Wednesday October 3, killing three children and injuring more than 70 others [1, 2]. Initial reports said 53 of those injured and transported to hospitals were released after evaluation and 25 others were admitted. The African Centres for Lightning and Electromagnetics Network (ACLENet) responded, sending a response team to survey the damage and take measurements and photographs of the school for immediate fundraising to install lightning protection.

There have been multiple reports of mass casualty events caused by lightning at schools across Africa [3-7] but ACLENet has not had enough staff and resources to investigate them previously. Thirteen months after the incident, ACLENet staff returned to investigate in more detail 8-12 November 2019 and 21-24 February 2020.

Only one prior study has been reported in the medical literature for a large group of school aged children injured by lightning in Africa [8]. However, the injuries for this 1994 South African incident occurred as the children were in a tent on a school sponsored class trip, not at their school. Reconstructing the incident at Mongoyo school gives us the opportunity not only to begin collecting data on more lightning injuries, but also to attempt to reconstruct the incident in order to provide data to ACLENet's Research Group to determine likely mechanisms of injury to investigate potential solutions and to inform ACLENet's Lightning Protection Working Group in design and installation of lightning protection at schools in Africa.

II. ORIENTATION TO MONGOYO SCHOOL

Mongoyo school is a government founded and assisted primary school located in Olivu Parish, Drajin/Arajam subcounty, Yumbe district, in northwestern Uganda (Fig. 1). It has a registration of approximately 900 students distributed through primary grades P1-P7. Typical Uganda schools are made up of several buildings including kitchen, administration, classroom, each with one or more classrooms and sometimes dormitories (Fig. 2). The buildings where most of the injuries occurred were Block 6 containing the first and second grade classrooms and Block E with a 3rd grade classroom (Fig 2b).

A. Setting and Activity at School

A normal school day begins at 8:00 am at Mongoyo primary school. Prior to that time, school children are engaged in several activities to prepare for the day. Some, according to a set roster, are engaged in cleaning inside and outside of the classrooms. Others, like those in P-7 were engaged in review sessions preparing for regional and national examinations. The morning of 3rd October 2018 looked like any other day at the school except for cumulonimbus clouds in the sky around 7:00 am which suggested it would be a rainy morning. This did not

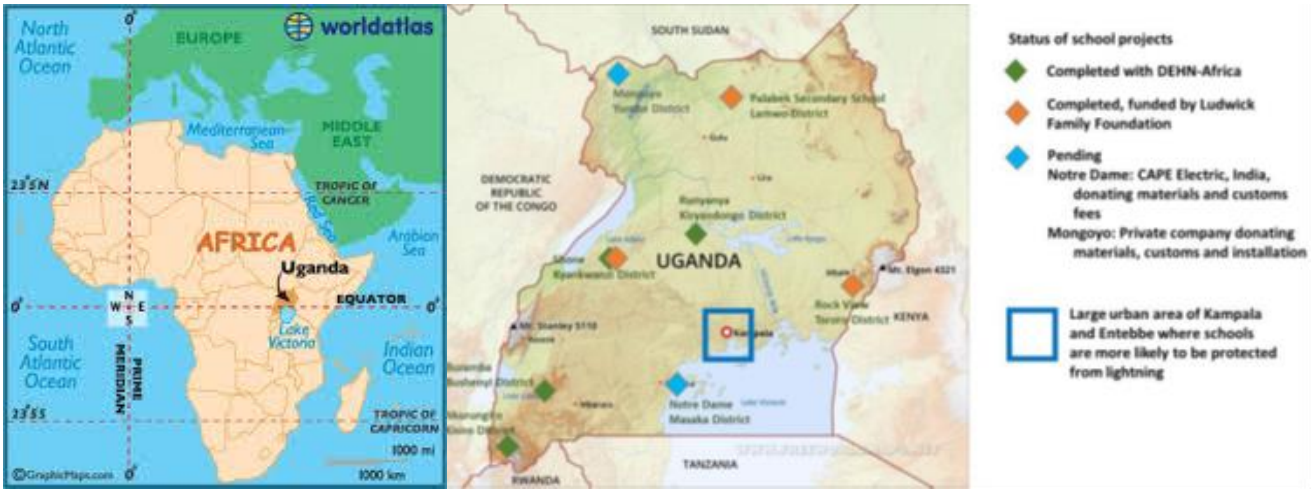

Figure 1. Location of Uganda in Africa and location of Mongoyo school in the far northwest corner of Uganda.

worry anyone, least of all the children who enjoy playing in the rain.

As the children trickled into the school compound, the teacher on duty directed some to clean the compound by sweeping, others to sweep the inside of classrooms, and those in P-7 to join their colleagues in the review session guided by their teacher.

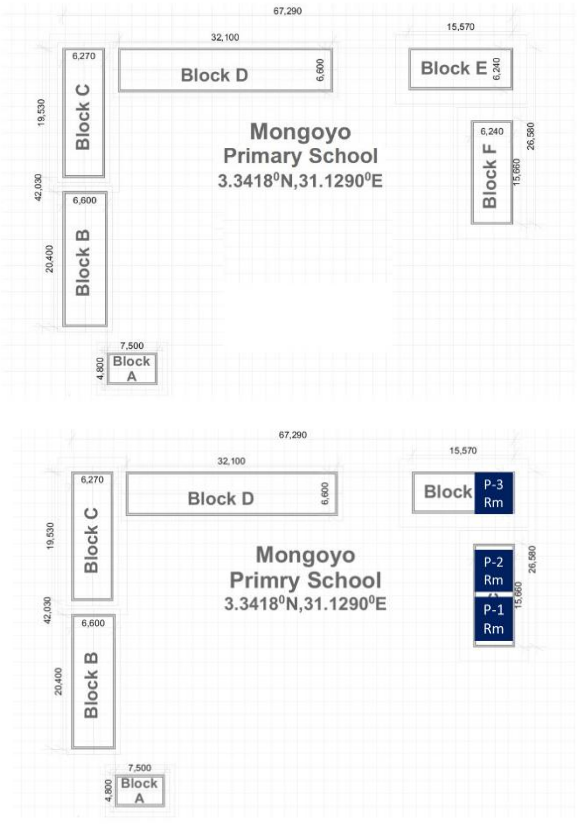

Figure 2. Arrangement of buildings for Mongoyo School.
2a. General school layout, Mongoyo school,
2b. Classrooms P1-3 most affected by lightning indicated.

It began to drizzle at about 7:10 am. Children who had been outside in the compound began moving into the classrooms. A playful mood prevailed in the compound as the younger children in the lower primary classes 1-3 were jumping in the rain. Those who entered the classrooms moved around or sat on windowsills reaching out to play in the rain falling from the roofs as others waited for the teacher to begin the day. It was a hum of disorderly activity.

B. Lightning Strikes

When lightning struck around 7:15 am, children who had been playing were now crying and wailing in alarm, especially those in classroom blocks E and F. Some were running in all directions and others had fallen in the muddy compound because of shock, confusion, or paralysis of body parts (keraunoparalysis [9, 10]).

The P-7 teacher in block C was the first one to respond to the cries of those who were in block F, especially the second-grade classroom between the P-1 classroom in block F and P-3 classroom in block E.

The P-7 teacher stopped on her way to the P-2 classroom to rescue two children who had fallen in the muddy compound, taking then to the verandah of the office, which soon became the gathering place for victims. She was the second teacher to enter the P-2 classroom and recalled that it was filled with a mist-like smoke and a bad strong smell. The smell was pungent and irritating that she described as like that of a car exhaust pipe but stronger with other mixtures. However, there was nothing burning and no report of anything burning during or after the incident.

By this time, many teachers had reached the school yard and were rescuing children by lifting them to some safe place. According to the deputy headteacher, many children ran towards their homes. Some collapsed on the way and were picked from the bush by parents and neighbors who responded to the loud wailing at the school.

Two children who were interviewed corroborated the account of BDL, 13 years old at the time of the strike and a P-3 student inside her classroom. She was momentarily blinded by what looked like red flames of fire all around her. Immediately, she responded by running eastwards while feeling as if her legs were on fire. After a short distance, she fell down unconscious but was later picked up by parents rushing to the school. AA, a 13 year old P-3 student at the time of the strike, remembered black smoke but relates the same behavior of running, feeling his legs on fire, passing out and being rescued by parents.

Three children, two boys and one girl, died instantly, two (EL and MC ages 8 and 7) in P-2 classroom and one (NA) in P-1 classroom. NA was reported to be sitting on the windowsill when the lightning strike threw him through the window into the courtyard behind his classroom.

EL was the son of a teacher at the school. His father related his son was barefoot, thinking that this contributed to his death because lightning current easily entered his body. He relates that his son's tongue was 'kind of stretched out, halfway outside the mouth.' Teacher B also reports a blackened spot on the right side of the head of MC, but otherwise, they report no burns or other marks on the three dead bodies.

III. Methodology

A. Institutional Review Board approval

Although the research proposal was submitted to the Uganda National Commission on Science and Technology for Institutional Review Board approval in February 2019, they did not respond to multiple follow-up contacts. Nevertheless, it was decided to move forward with the study due to the importance of reporting incidents such as this in order to guide prevention efforts

B. Instrument and Consent

A questionnaire to guide interviews and examinations of the children was constructed using the format previously reported by Carte, Anderson, and Cooper for the 1994 South African event so that results would be comparable [8]. In lieu of parents having to leave their fields to sign the consents, the head teacher signed for them, assuming consent if their children were sent to participate.

C. Study Team and Training

A team of four travelled to the school, two nurses recruited from Ugandan public hospitals to do the interviews and two ACLENet staff to coordinate the interviews with parents, teachers and school authorities. The nursing team was trained to administer the questionnaire and complied with the guidelines established. Their notes, written in notebooks, were transcribed and entered in data tables like those used for the South African study [8]. One of the nurse-interviewers was a lightning survivor after an injury sustained while she was giving immunizations at Runyanya School in Kiryandongo District over a decade before. The second was a psychiatric nurse from nearby Apac hospital in northern Uganda.

D. Study Subjects

The study proposed to interview all the survivors who had been assessed at a local hospital after the lightning strike. School officials assisted in contacting parents of the survivors. Nearly all of those still attending Mongoyo Primary School participated in the study. About twenty children were no longer attending Mongoyo school due to medical conditions after the strike or suspicions that the school is cursed. Only four of these came to give interviews.

Student survivors were interviewed individually away from other children in order not to bias answers and were given the opportunity to recall what happened at the incident. One teacher acted as a translator for those who could not express themselves in English. Interviewer guided discussion was used to reconstruct the incident and recall other details.

Other witnesses, especially teachers who were in the school compound at the time of incident were interviewed. Those who handled the bodies of the three dead children were asked about their observations.

E. Time period

Interviews were conducted between 9-11 Nov 2019 and reconfirmations of data done 15-16 Feb 2020.

IV. Results

The results of the directed interviews and guided discussions were categorized into survivors (school children) and witnesses (teachers who helped). These were further divided into survivors who seemed to be struck by lightning current and more seriously injured and those who were nearby in the school compound and seemed only shocked by the light and thunder. Witnesses were divided into those present at time of strike and those who came moments later to help with the overwhelming number of victims (Table 1).

TABLE I. Summary of those interviewed

SURVIVORS		WITNESSES	
Struck by lightning current	Shocked by light and sound	Present at the time of strike	Nearby the school (came moments later)
25	48	2	3

A. Reconstruction of the scene:

When the ACLENet response team first visited the school October 18-19, 2018, they could not find physical damage to any of the classroom buildings, leading the team to suspect a ground strike as the mechanism of injury. Additionally, at least one of the students reported feeling the electrical shock come from the metal legs of his desk. Witnesses said lightning struck just outside the ring of school buildings, close to block F at approximately 7:15 am.

B. Student interviews and data:

A total of 55 interviews with students were done including 4 from those that had not returned to school at Mongoyo after the strike for various reasons. Several teachers were also interviewed but on a more informal basis to reconstruct the timing of the incident and response as noted in Section II of this report.

Individual interviews were carried out by the two nurses trained to the questionnaire. One took the boys (33), the other the girls (20). It is being clarified whether one backdated the ages and grade levels to when the incident occurred since there seems to be a too large range of ages from 7-15 and grades P-1-5. Additional data needs to be clarified including age (3), sex (2) and grade level (5) for others that were not included in the data forms. This data is expected to be recovered in March and available for the final paper

Of the 55 interviewed, it was noted that 24 were admitted for one day and 10 for two days. However, it is likely that this is an undercount because those who remembered more severe injuries often did not have admission information recorded in the data. Complete recovery (with the exception of scars) was reported by the majority of students.

C. Physical signs

Burns were reported in fifteen children, some with more than one area of the body burned - 7 to hands with scars remaining in 4 indicating deeper burns, 3 to the trunk or ribs, and 5 to the lower extremities with one remaining scarred. One reported 'serious' burns to his eye and has some continuing vision problems.

There were no fractures, scrapes, or other tissue damage noted in the interviews nor remembered by the children.

D. Neurological Signs

A large number of children reported feeling hit or shocked by light or sound, some falling or being knocked down. None of these had loss of consiousness, paralysis/weakness or other more serious signs of neurological injury and most recovered without incident. At least seven children reported loss of consciousness, sometimes lasting several hours, one lasting a day or more, some amnesia for how they got to the hospital or other signs of altered consciousness.

Keraunoparalysis is a well described temporary loss of muscle control in one or more extremities that occurs after acute lightning injury [9, 10]. Twelve children noted feelings of paralysis, usually to the lower extremities, that lasted from a few minutes to over two days in one instance. In three, the paralysis/weakness was concurrent with loss of consciousness.

Three noted pain or burning, most of which resolved over a period of hours. Three noted headaches, two with continuing problems.

E. Long term problems

Six children noted continuing problems with hearing, serious enough to hamper their learning. Tympanic membrane (eardrum) rupture is common after lightning [9]. One reported recurrent pus which could be consistent with either usual childhood infections or with disrupted auricular bones. Three reported visual problems, also consistent with lightning [9, 11, 12].

Of more concern, seven children reported problems with memory, concentration, and distraction, problems which are consistent with brain injury, one of the most common sequelae of lightning injury. One child reported ongoing visual and auditory hallucinations, uncommon with lightning and perhaps attributable to other causes including mental illness, but also potentially from brain injury or epileptic foci caused by the initial injury, altho this pupil did not report loss of consciousness. This child also noted sleep difficulties.

Post-lightning injury syndrome (PELIS) can cause significant learning disability in children and cause adults to be unable to return to work after their injury [12]. Of course, it is impossible to diagnose such problems long distance and without proper testing, but children's and teachers' impressions that children are different are still valid. It is hoped that further clarification of the data can pinpoint whether any of these were the four interviewed from those who did not return to the school after the injury.

Of equal concern are the large number of children who reported ongoing fear of rain, dark clouds, thunderstorms, of talking about the incident and even one who feared that they would be hit again. Many of these reported phobic levels of fear hampering them from other activities including playing with friends. Although a diagnosis of post-traumatic stress syndrome cannot be made from these details alone, it is a significant problem for many people after life threatening situations such as lightning injury.

V. Discussion

The mass casualty lightning incident that occurred at Mongoyo in October 2018 is only one of many strikes to schools that are reported nearly every month across Africa [1, 7]. Investigating this incident is the beginning of ACLENet's efforts to begin documenting and cataloging these incidents to

gather data with the hope that it will be useful for research into injury prevention and improving lightning protection for schools across Africa.

A. Limitations

While the results of this study are consistent with the range of injuries reported by adults, there is still a dearth of evidence about injuries to children to see if they are comparable. This study had other limitations that ACLENet intends to address in future studies:

- The interview team needs to be better trained and more consistent in their interviews and approach to the children.
- The questionnaire and guideline for the interviews needs improvement and must be used consistently with all those interviewed. Many details such as admission to the hospital were not consistently documented.
- While this study is limited by what the children/survivors could recollect, that is to be expected, particularly for the time lag of more than a year since the incident occurred and when the study team arrived. More rapid response will be attempted in the future.
- The observations by teachers was limited by lack of specialized knowledge of lightning injuries.

VI. CONCLUSIONS

ACLENet is concerned with preventing deaths and injuries from lightning. Prevention takes many guises, from physical protection of structures to research into behaviors or other things individuals and teachers in school settings can do to prevent injury. Solutions that work in developed countries may not be applicable to developing countries. Only by study of incidents such as this can we learn about the mechanisms of injury, the range of injuries, their care and then begin coordinating response and training for those involved at the time of the incidents.

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