

# A Follow-up Study of a Large Group of Children Struck by Lightning

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**Abstract**— On 11 November 1994, 26 preadolescent girls, 2 adult supervisors and seven dogs were sleeping in a tent in rural South Africa when it was hit by lightning. Four of the girls and four of the dogs were killed. What follows is a nineteen year follow-up study of the survivors. Of the 22 surviving young women, 11 responded. Clinical and psychological symptoms are reported in this paper which adds to the body of literature on the long-term after effects of lightning strike on survivors. A brief discussion on posttraumatic stress disorder symptomatology is provided.

**Keywords**- lightning injury, burns, lightning burns, cataract, macula, eye injury, psychological injury, chronic pain, follow-up study, clinical symptom, posttraumatic stress disorder.

## I. INTRODUCTION

A prior paper [1] reported an incident on November 11, 1994, in which 26 preadolescent girls, 2 adult supervisors and seven dogs were sleeping in a tent in a rural area near Nylstroom in the Northern Province of South Africa. Four lightning flashes occurred in the vicinity between 2:00 am and 2:30 am. All were single stroke negative discharges, ranging from -33 to -67 kA. Four of the girls and four of the dogs were

killed (Fig. 1). The adults reported no injuries. No follow-up studies have been done to date on such a large group of people, especially children.

The initial report concentrated on physical signs such as burns, cataracts and macular holes, skull fractures, and tympanic membrane rupture and did not collect information about pain, weakness, or more subjective clinical findings. The original study was unique because it was one of the first case-studies illustrating the damaging effects of the so-called fifth mechanism of lightning injury, although a number of mechanism including sideflash and ground current may have contributed to the injuries [2-4]. This current study investigates the long term problems that the surviving girls continue to experience as a consequence of the 1994 lightning incident including neuropsychological issues and chronic pain [5-8].

The dangers of upward streamers have been relatively well-documented [2, 4]. Injury may occur when a victim serves as the conduit for one of the usually multiple upward leaders induced by a downward stepped leader and its field. Upward streamers occur even when there is no attachment between them.

While one might think that these upward streamers are weak in energy compared to the full lightning strike, they may carry several hundreds of amperes of current which can be transmitted through or around the victim. Upward streamer injury is probably a much underestimated mechanism of injury, and may account for as much as 10% to 15% of injury cases [9, 10].

There are up to 100 lightning-related fatalities annually in South Africa [11], and it is probable that there are at least 4 or 5 times as many survivors of lightning strike presenting for clinical treatment [12]. With the relatively high mortality and morbidity associated with lightning in South Africa, there was a need for a follow-up study on lightning strike victims. In addition, although the complications and long term sequelae of lightning injury have been described there have been no long

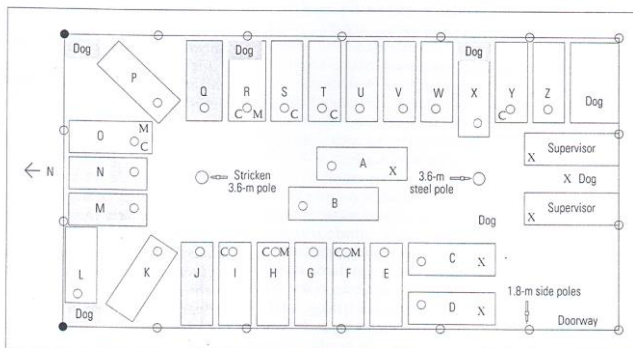


Figure 1. Figure showing the relative positions of the girls in the 10 X 5m tent from original report [1]. Circle = head, X = fatally injured, M = macular hole, C = cataract

term follow-up studies done with lightning survivors to delineate the frequency of the sequelae [5, 7, 8, 13].

## II. METHODS

### A. Sample

The present study examined self-report responses to an on-line survey collected from survivors of the 1994 lightning strike. Of the 22 surviving young women, contact details could be obtained for only 11 survivors. These were contacted directly by the researchers with a response rate of 82% (9). One of the survivors volunteered to attempt recruiting more respondents by using a social media network that some of the survivors used to keep in touch [14]. This yielded one additional response (N = 10) (Table I). The study was approved by institutions in both the United States (University of Illinois at Chicago's Institutional Review Board) and South Africa (University of Pretoria's Ethics and Integrity Committee). The data was collected with the permission and assistance of the current headmistress of the primary school the girls attended at the time of the incident.

### B. Measure

A three-part questionnaire based on the previous study [1] and pertaining to immediate symptoms following the lightning strike, persisting symptoms, and subjective experience (including recalled location in the tent) was administered online. Certain items only relevant to immediate symptoms (e.g., loss of consciousness) were eliminated from the portion of the questionnaire pertaining to persisting symptoms.

### C. Analyses

Frequencies of immediate and current symptoms were calculated.

## III. RESULTS

Three participants reported loss of consciousness at the time of the lightning strike, and six reported current scars. Participants were asked to recall their position in the tent at the time of the lightning strike to compare reports of the initial injuries reported in the previous study [1] with participants' recollections of their injuries nearly twenty years later. Five girls were quite sure of their positions (H, L, R, W, X) and some gave details to correct the diagram (Fig. 2) that was

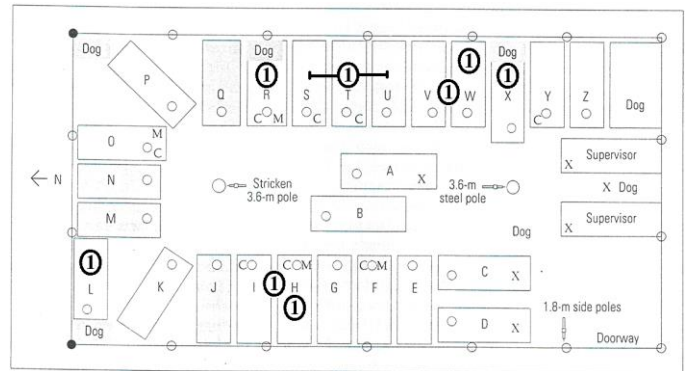


Figure 2. Recalled Positions in the Tent

reported in the original study [1]. Three gave approximate positions (HI, S-U, VW) where they could have been located. The remaining two participants were unsure of their position in the tent.

One participant reported no initial symptoms and no current or chronic symptoms. Responses of the other 9 participants are presented in Tables II and III.

## IV. DISCUSSION

While this is admittedly a small study and the results may not be generalizable to a larger population, it is among the first long-term follow-up studies to be done. Of the subjects who could be contacted, there was a very high response rate. This study showed a relatively large number of chronic symptoms reported including eye and ear problems as well as a relatively high number of cognitive and emotional problems.

Persistent otologic symptoms are reported in the literature [15-17]. This is important to note as lightning injury survivors are well-documented to experience chronic symptomatology [5-8, 13]. What needs to be considered is that five of the girls reported continuing changes in vision including one where it was not documented in the original report. Ocular pathology post-lightning strike is relatively well documented in the literature [18-20].

Many of the changes reported long term are consistent with posttraumatic stress disorder (PTSD). PTSD is defined as significant distress or functional impairment in response to a traumatic event in the form of a specific set of symptoms: re-experiencing; avoidance; negative cognitions and mood; and heightened arousal [21].

The results of studies that examine long-term outcomes of PTSD as a result of trauma experienced in childhood or adolescence have been variable, and the population studied has been heterogeneous in factors such as demographics, type of trauma, and treatment history. However, in studies involving those who experienced a disaster in childhood or adolescence, ongoing PTSD or PTSD-related symptomatology (i.e., fear, depression, etc.) has been shown to persist, sometimes for many years following the event [22]. In a study of schoolchildren involved in a cruise ship collision, 26% met DSM-IV criteria for PTSD five years following the disaster,

TABLE I. DEMOGRAPHIC INFORMATION

	Frequency	Percent
<b>Age</b>	30.4 (M)	0.4 (SD)
<b>Race</b>		
Caucasian	7	70
African	1	10
Indian	1	10
Chinese	1	10

TABLE II. REPORTED INITIAL AND CURRENT/CHRONIC PHYSICAL SYMPTOMS

Physical Symptoms	Initial Symptoms	Chronic/Current Symptoms
Deafness - Both Ears	1	1
Ringing/Noises in Right Ear	1	0
Ringing/Noises in Both Ears	1	0
<i>Pain/Burning/Stiffness</i>		
Right Ear/Face/Neck	1	0
Right Arm/Shoulder	2	1
Left Arm/Shoulder	1	1
Right Chest	1	0
Right Leg	1	1
Left Leg	2	1
Back	0	2
All Over	3	0
<i>Numbness/Tingling</i>		
Right Leg	1	1
Left Leg	1	1
All Over	2	0
<i>Weakness</i>		
Right Leg	3	0
Left Leg	3	0
All Over	2	0
Changes in Vision	4	5
Headache	2	0
Palpitations/Racing Heart	2	1
Breathing Difficulty	1	0
Giddiness/Dizziness/Incoordination	2	0
Loss of Balance	4	1

and 34% of those continued to meet criteria up to 8 years following the shipwreck [22]. In a study of child and adolescent survivors of the Buffalo Creek dam collapse disaster, approximately 25% met PTSD criteria 14 years later [23], which is generally consistent with the National Comorbidity Survey that demonstrated approximately one third of those diagnosed with PTSD fail to recover after many years [24]. Additionally, there has been evidence that levels of

TABLE III. REPORTED INITIAL AND CURRENT/CHRONIC COGNITIVE AND EMOTIONAL SYMPTOMS

Cognitive/Emotional Changes	Initial Symptoms	Chronic Current Symptoms
Memory Loss/Forgetfulness	4	1
Poor Concentration	1	1
Confusion/Disorientation	5	0
Difficulty following through	0	2
Irritability	0	2
Restlessness	0	1
Temper Outbursts	0	1
Mood Swings	0	2
Crying/Easily Upset	4	2
Emotional Upset - Shaking	2	0
Depression	0	3
Anxiety/Tension	0	3
Troubling thoughts, difficult to keep out of mind	0	1
Feelings of guilt	0	2
Increased suspiciousness of others	0	1

depression related to chronic PTSD sustained in adolescence can increase over time [25].

The sample in the present study is generally consistent with previous findings, with 30% of participants reporting persistent depression and anxiety. Also consistent with previous studies, 20% of participants reported persisting irritability, mood swings, emotional reactivity, and feelings of guilt.

The fact that the girls still keep in contact with one another via social media demonstrates the impact the 1994 lightning incident had on their respective lives. Given the rapid changes in the communication landscape brought about by participative Internet use and social media, it is important to develop a better understanding of these technologies and their impact on health communication [14].

Although none of the girls reported knowledge or membership in any support groups for lightning survivors, these groups have been described in the literature [26].

## V. CONCLUSION

The importance of such a study cannot be understated and there is a need for more of these kinds of studies. There is a paucity of data on the long-term after effects of lightning strike

on survivors. What is more, the long-term dangers of the fifth mechanism of lightning injury have also not been reported upon in the literature.

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