Original Research

Prevention of lightning related adverse effects: knowledge, attitudes and practices among residents in Kiriella Medical Officer of Health area

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Abstract

Background: Lightning is an uncommon but potentially devastating cause of injury in both developed and developing countries. These injuries feature high mortality and significant long-term morbidity, thus prompt preventive and protective measures are essential.

Objective: To describe the knowledge, attitudes and practices on prevention of lightning related adverse effects and associated socio-demographic factors among residents in Kiriella Medical Officer of Health (MOH) area.

Methods: A cross-sectional study was conducted among 510 residents aged 18-64 years and living for a minimum period of one year in Kiriella MOH area. A multi-stage cluster sampling method was used. Data were collected using an interviewer-administered questionnaire on knowledge (score range: 0-21), attitudes (score range: 0-15) and practices (score range: 0-5) on lightning related adverse effects. Odds ratio (OR) was calculated to assess their relationship with socio-demographic factors.

Results: The response rate was 98.4%. There were 301 males (60%). The mean overall knowledge score was 11.8 (SD=1.6) while 12.4% (n=62) scored more than 50% of the total score. Favourable attitudes were reported by 87.5% (n=439) and satisfactory practices by 78.7% (n=395). Good knowledge was significantly associated with younger age (OR=1.8), male sex (OR=4.1), Sinhala ethnicity (OR=5.1) and higher level of education (OR=1.9); and favourable attitudes with younger age (OR=2.0), Sinhala ethnicity (OR=2.1) and higher level of education (OR=1.6). In contrast, satisfactory practices were significantly associated with older age (OR=1.2) and higher level of education (OR=2.1).

Conclusions: Despite having poor knowledge, residents in areas vulnerable to lightning showed favourable attitudes and satisfactory practices. Good knowledge, favourable attitudes and satisfactory practices were determined commonly by the level of education and age. These findings should be considered when targeting them for primary prevention.

Key words: adverse effects, lightning strikes, lightning protection

Introduction

Lightning is a sudden electrostatic discharge that occurs during a thunderstorm (1). It occurs between electrically charged regions of a cloud, between two clouds or between a cloud and the ground (2). The occurrence, distribution and strength of lightning are determined by several factors such as altitude, latitude, predominant wind streams, relative humidity and closeness to streams (1).

The formation of lightning is still not clearly understood. However, ice inside the cloud is thought to be a leading cause for the forceful separation of positive and negative charges within a cloud, leading to the accumulation of negative charges at the bottom of the cloud. Due to its electric charge, this band of negative charges is repelled and approaches the positively charged ground to produce a conductive path, allowing a sudden surge of electrons leading to lightning strike (1). These electrons in fact help humans by providing nitrogen, by separation of the nitrogen atoms in the air (3).

Lightning is not evenly distributed around the world. Democratic Republic of the Congo and USA claim to have the highest reported lightning incidents (4). Yet, about 70% of lightning occurs over land in the tropics where the atmospheric convection is greatest (5). Being an island, Sri Lanka is highly vulnerable to lightning in the afternoon or evening during the two inter-monsoon seasons (April-May and October-November). The 'isokeraunic level', which is the average number of days per year during which thunder could be heard in a given area is more than 180 in the Democratic Republic of the Congo (6). In comparison, it is 80-120 in many parts of the Western coastal belt and South-Western slope of the mid-country hills, indicating that lightning is more common in the districts of Gampaha, Ratnapura and Kalutara (1, 6).

Health effects of lightning range from minor adverse outcomes to fatal events. It may cause headache, sleep disturbances, emotional impairment and fluctuation of blood pressure as well as major consequences related to cardiovascular, neurological and psychological health (7-8). Burns, ocular injuries, rupture of the tympanic membrane and deafness are the commonly encountered acute effects, while the late manifestations are memory loss, poor concentration ability and cataracts. Sudden death and cardiogenic shock are estimated to be 24,000 per year worldwide (9).

Lightning can pose a health hazard to humans during both outdoor and indoor activities. Rapid urbanization and increased use of electrical, electronic and telecommunication equipment have been identified as the leading causes for an increase in lightning strikes in the recent past. More frequent outdoor recreation than earlier has also led to more fatalities. On the other hand, lightning strikes have been less reported outdoors due to agriculture related events (10). Treatment of these injuries is based on acute management using life-saving procedures. Since excellent prognosis can be achieved if breathing is supported, resuscitation should be considered in all such victims (8). This makes lightning injuries in developing countries a more complex task than in countries where these facilities are freely available and lightning-safe structures and vehicles are commoner (4).

Although there is no absolute protection against lightning (11), the risk of lightning is shown to reduce substantially when taking specific precautions (9), such as shelter in a safe enclosed area; avoiding risky places such as tall and isolated objects, water environment and open areas; adopting the crouch position during lightning; and being alert on local weather forecast (2,11). Essential indoor safety measures include avoiding the use of electrical, electronic or telecommunication equipment; and introducing lightning protection equipment such as lightning rod and lightning conductors to decrease the strength of lightning shocks (1).

Gomez et al. (2006) shows that lightning deaths have gradually declined in the developed countries through awareness programmes on lightning related health and safety (12). As such, improving knowledges among the high-risk communities will strengthen primary prevention strategies in public health (6). Other than poor knowledge, myths and beliefs could lead to negative attitudes on safety measures during lightning (13). Thus, the objective of this study was to assess the knowledge, attitudes and practices on lightning related adverse effects and associated socio-demographic factors in a highly vulnerable area, where there had been no studies previously. Findings of this study will help in tailoring programmes to mitigate the lightning incidents and re-design the policies and guidelines on major disasters.

Methods

A community-based cross-sectional study was conducted in Kiriella MOH area. This MOH area is located in the district of Ratnapura and has reported a relatively high number of lightning incidents since 1974 (14). Residents aged 18-64 years who have been living in the area for a minimum period of one year were recruited for the study. Those who were not able to respond due to physical or psychological illness were excluded. Multi-stage cluster sampling technique was used to select the sample considering Grama Niladhari (GN) division as a cluster. From an updated list of GN divisions in Kiriella MOH area, 17 clusters were selected according to probability proportionate to size (PPS). Thereafter, 30 households (cluster size) were selected into each cluster using simple random sampling technique. Finally, from each household, one respondent was selected by simple random sampling. The required sample size was calculated as 510 to detect an estimated proportion of 'good knowledge' of 50% on the prevention of lightning related adverse effects, Z value of 1.96, precision of 5%, design effect of 1.2 and non-response of 10% (15).

Data were collected using a pre-tested interviewer-administered questionnaire. It consisted of sociodemographic characteristics of the respondent, and knowledge, attitudes and practices related to lightning. Knowledge was assessed within four domains: scientific basis for lightning, hazardous behaviour during lightning, adverse effects of lightning and lightning protection. Attitudes were on myths and beliefs. Practices were on preventive activities adopted both indoors and outdoors. The knowledge questionnaire was designed after a thorough literature survey of studies conducted in developed as well as developing countries, and by a panel of experts of consultant community physicians and experts in the Department of Meteorology, Sri Lanka. Prior to data collection, informed written consent was obtained. Data were collected by the principal investigator at the participants' houses.

Data analysis was carried out using Statistical Package for Social Sciences (SPSS) software version 20. In the knowledge component, correct responses were given +1 mark and the 'incorrect' and 'do not know' responses did not carry any marks. All marks were amalgamated into a total knowledge score (score range: 0-21). Scores above the mean (>11.8) were categorized as 'good knowledge' and others as 'limited knowledge'. Responses obtained for attitude questions were scored on a Likert scale ranging from 1-5. Higher scores indicated strong agreement with positively phrased statements, while such scores indicated strong disagreement with negatively phrased statements. If a person responded neutral to all statements, the total attitude score was 15. Taking this as the cut-off, scores above 15 were considered as having 'favourable attitudes' and the others as having 'undesirable attitudes'. Responses on practice were also allocated marks (score range: 0-5) and scores above the mean (>3.0) were categorized as 'satisfactory' and others as 'unsatisfactory'. Bivariate analysis was carried out to assess the relationships of selected socio-demographic variables with good knowledge, favourable attitudes and satisfactory practices, using prevalence odds ratio (OR) with 95% confidence interval (CI).

Results

The study was carried out among 502 residents, giving a response rate of 98.4%. The mean age of respondents was 42 years (SD=12). The majority consisted of males (n=301, 60%) and head of the household (n=263, 52.4%). More than 50% had passed GCE (Ordinary Level) examination but half of the respondents were unskilled labourers (Table 1).

Table 2 describes the knowledge on lightning related adverse effects under four domains. Although a lesser proportion (n=92, 18.3%) knew that thunder is preceded by lightning, the majority knew that watching television (n=464, 92.4%) or using electrical appliances (n=446, 88.8%) during lightning would increase the risk of adverse effects. Almost all knew the danger of seeking shelter under an isolated tree (98%, n=492) and being in an open area (90.6%, n=455). However, 84% (n=420) did not know that having a river bath would increase the risk while 45.4% (n=236) were not aware of the safest body position for protection from lightning. Study participants knew most of the adverse effects of lightning except on cataract (8.7%, n=41). Their mean knowledge score was 11.8 (SD=1.6). Accordingly, 87.6% (n=440) seemed to have limited knowledge.

As shown in Table 3, 46.6% strongly disagreed with lightning as a result of a 'curse made by another'. However, 70.3% agreed that "telecommunication towers" and 53.2% that 'certain trees' attract lightning. 'Favourable attitudes' were demonstrated by 87.5% (n=439).

Satisfactory practices were observed in 78.7% (n=395). However, 68.5% disconnected the television only 'occasionally' or 'never' while 13.2% used corded phones 'always' or 'most often' during lightning (Table 4).

Table 5 shows the associations of socio-demographic factors with good knowledge, favourable attitudes and satisfactory practices. Good knowledge was significantly associated with younger age (OR=1.8), male sex (OR=4.1), being Sinhalese (OR=5.1) and higher level of education (OR=1.9). Favourable attitudes on lightning were significantly associated with younger age (OR=2.0), being Sinhalese (OR=2.1) and higher level of education (OR=1.6), while satisfactory practices were significantly associated with older age (OR=1.2) and higher level of education (OR=2.1).

Table 1. Demographic and socio-economic characteristics of the study participants (N=502)

Characteristic	No.	%
Age group (years)		
18-45	286	57.0
> 45	216	43.0
Sex		
Male	301	60.0
Female	201	40.0
Ethnicity		
Sinhala	475	94.6
Tamil	27	5.4
Current marital status		
Single	50	10.0
Married	443	88.2
Separated/divorced/widowed	9	1.8
Highest educational level		
Primary (Grade 1-5)	76	15.1
Secondary (Grade 6-10)	148	29.5
Passed G.C.E (O/Level)	184	36.7
Passed G.C.E. (A/Level)	85	16.9
Higher education	9	1.8
Current occupation		
Teacher	10	2.0
Skilled/ semi-skilled labourer	81	16.2
Unskilled labourer	248	49.4
Self-employed	31	6.2
Retired from work	12	2.4
Student	16	3.2
Unemployed	104	20.6
Monthly Income		
Less than Rs. 10,000	375	74.7
Rs. 10,001 – 25,000	115	22.9
Rs. 25,001 – 40,000	9	1.8
More than Rs. 40,000	3	0.6

Table 2. Level of knowledge of the study participants on prevention of lightning related adverse effects (N=502)

Knowledge	Correctly answered		Incorrectly answered		Do not know	
	No.	%	No	%	No.	%
Scientific basis for lightning						
Lightning is a natural disaster	198	39.4	251	50.0	53	10.5
An electric current flows from clouds to the earth during lightning	125	24.9	274	54.6	103	20.5
Thunder is preceded by lightning	92	18.3	372	74.1	38	7.6
Hazardous behaviour during lightning						
Watching television	464	92.4	1	0.2	37	7.4
Using electrical appliances	446	88.8	39	7.7	17	3.4
Getting shelter under an isolated tree	492	98.0	9	1.8	1	0.2
Being in an open area	455	90.6	1	0.2	46	9.2
Using corded phone instead of a mobile phone	27	5.4	454	90.4	21	4.2
Using metallic objects	490	97.6	12	2.4	0	0.0
Having a bath in a river	61	12.1	21	4.2	420	83.7
Rowing a boat	256	51.0	125	24.9	121	24.1
Staying in a covered building	476	94.8	13	2.6	13	2.6
Staying inside a closed vehicle	360	71.7	120	23.9	22	4.4
Adverse effects of lightning						
Burn	461	91.8	9	1.8	32	6.4
Loss of hearing	452	90.0	34	6.8	16	3.2
Loss of consciousness	456	90.8	32	6.4	14	2.8
Cataract	41	8.7	437	87.1	24	4.8
Death	449	89.4	41	8.2	12	2.4
Lightning protection						
Crouching is the safest body posture during lightning in an open area	63	12.6	211	42.0	228	45.4
Functioning lightning rod or conductors at home will reduce the lightning risk	23	4.6	450	89.6	29	5.8
Functioning earth wires and earth rods at home will reduce the lightning risk	27	5.4	207	41.2	268	53.4

Table 3. Attitudes of the study participants on prevention of lightning injuries (N=502)

Attitude	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree	
	No.	%	No.	%	No.	%	No.	%	No.	%
It is the result of a curse	19	3.8	39	7.8	48	9.6	162	32.2	234	46.6
Telecommunication towers at tract lightning	66	13.1	353	70.3	36	7.2	33	6.6	14	2.8
I give attention to weather forecasts on thundering	91	18.1	293	58.4	92	18.3	15	3.0	11	2.2
Certain type trees[1] attract lightning	200	39.8	267	53.2	14	2.8	12	2.4	9	1.8
Lightning strikes on sinners	30	6.0	74	14.7	57	11.4	128	25.5	213	42.4

[1]oak, pine, cottonwood

Table 4. Distribution of reported practices related to lightning among the study participants (N=502)

Practices during thundering	Always		Most often		Sometimes		Occasionally		Never	
	No.	%	No.	%	No.	%	No.	%	No.	%
Disconnect television from the plug base	10	2.0	105	20.9	43	8.6	202	40.2	142	28.3
Disconnect the television antenna and throw the wire outside the house	40	8.0	90	17.9	282	56.2	58	11.6	32	6.3
Disconnect other electric appliances (refrigerator, phone charge)	52	10.4	64	12.7	112	22.3	181	36.1	93	18.5
Use corded phone instead of mobile phone	46	9.2	20	4.0	151	30.1	252	50.2	33	6.5
Stay under a tall tree	8	1.6	31	6.2	152	30.3	71	14.1	240	47.8

Table 5. Socio-demographic factors associated with good knowledge, favourable attitudes and satisfactory practices (N=502)

Variable	Prevalence OR[1] (95% CI)		
	Good knowledge	Favourable attitudes	Satisfactory practices
Age (years)			
18-45	**1.8 (1.1-2.1)**	**2.0 (1.3 -3.4)**	**0.8 (0.7-0.9)**
> 45 (reference)	1.0	1.0	1.0
Sex			
Male	**4.1 (2.4-4.9)**	0.8 (0.7- 1.2)	0.9 (0.7-1.1)
Female (reference)	1.0	1.0	1.0
Ethnicity			
Sinhalese	**5.1 (3.6-7.4)**	**2.1 (1.2-2.2)**	1.4 (0.9-1.9)
Others (reference)	1.0	1.0	1.0
Marital status			
Ever married	1.4 (0.9-2.1)	1.7 (0.9-2.7)	1.8 (0.8-2.1)
Others (reference)	1.0	1.0	1.0
Highest level of education			
> GCE (O/L)	**1.9 (1.3-2.1)**	**1.6 (1.3-1.9)**	**2.1 (1.9-2.4)**
< GCE (O/L) (reference)	1.0	1.0	1.0
Current employment			
Employed	1.3 (07-1.8)	1.1 (0.8-1.5)	1.6 (0.7-1.9)
Unemployed (reference)	1.0	1.0	1.0

[1]Odds ratio calculated compared to the reference category; significant associations given in bold letters

Discussion

All lightning related adverse effects are largely preventable. In this study, despite only 12.4% having 'good' knowledge, the majority showed 'favourable' attitudes (87.5%) and 'satisfactory' practices (78.7%) on health hazards and safety related to lightning. Their age and education seemed to determine the most.

Knowledge on science-based facts is essential for the use of improved safety measures. Less than one-fourth of the respondents knew that lightning is due to electric current flowing from clouds to the earth (24.9%) and that lightning precedes thunder (18.3%). The same facts were known by 24% and 60% respectively in another study conducted in Northern Namibia among 500 students in grade eight (16). Both studies highlight the gap in science-based knowledge on lightning which needs to be improved to enhance safety practices and to counter-act myths and beliefs on lightning.

Lightning casualties are mainly determined by the activity and location of individuals during a thunderstorm. Therefore, minimum interactions with the hazardous environment can reduce the vulnerability to lightning. In the current study, almost all identified 'sheltering under a tree' as risky behaviour in contrast to only 12.1% on 'having a river bath during lightning'. However, participants of a study conducted in California reported higher percentages on both aspects (90.9% and 72% respectively) (17). These findings support the need to focus on community awareness campaigns in Sri Lanka on the avoidance of risk factors especially in those working outdoors.

Although no outdoor location is considered safe during a thunderstorm, lightning crouch position is a last minute safety effort that could reduce the risk when no shelter is available. Alarmingly, in spite of the majority comprising unskilled labourers working outdoors, only 12.5% were aware of this fact in the present study. Even in developed countries, the knowledge on crouch position has not been satisfactory, as evident in two studies conducted in California (31.6%) and USA (24%) (17-18).

As much as when outdoors, only a limited proportion seemed to be adopting safety practices when indoors, such as disconnecting electric equipment and not using corded telephones. These unsatisfactory practices add to the potentially high incidence of lightning related adverse effects owing to the geographical terrain and weather pattern in vulnerable districts in Sri Lanka (6).

Compared to mobile phones, the use of corded phones during a storm is extremely dangerous. Even if the fixed phone lines are protected with surge devices, these defences can be overwhelmed during an extreme weather situation during which lightning could hit all nearby power poles. Usually, people speculate that mobile phones pose a risk when used outdoors because lightning is attracted to metal, but mobile phone handsets generally contain an insignificant amount of metal (19). In the current study, only 5.4% recognized the risk of corded phones. Further, telecommunication towers attracting lightning seemed to be a common misconception among communities (83.4%). In concurrence, a study done in 48 communication and broadcasting towers situated in similar and different 'isokeraunic' contours in Sri Lanka reported similarly high figures for the same fact (20).

Lightning rod is a metal rod mounted on a structure and intended to protect the structure from a lightning strike. If lightning hits the structure, it will preferentially strike the rod and be conducted to the ground through a wire, instead of passing through the structure (21). Strikingly, only a few were aware of such lightning rods/ conductors (4.6%), and earth wires/ rods (5.4%) to safeguard themselves from lightning. This finding supports their increased vulnerability to lightning when indoors.

Lee et al (2013) showed significant associations of lightning incidents with higher level of education ($p=0.06$) and occupation ($p=0.001$) (22). In the current study, higher level of education was associated with all three aspects: good knowledge (OR=1.9), favourable attitudes (OR=1.6) and satisfactory practices (OR=2.1). This emphasises that education could increase the responsiveness of vulnerable persons. Younger age was also significantly associated with both good knowledge and favourable attitudes, but it was the older age that was significantly associated with satisfactory practices, highlighting the tendency of taking precautions increasing with age.

Conclusions and Recommendations

The majority have 'limited knowledge' on prevention of lightning related adverse effects. Conducting awareness programmes to address hazardous be-

haviour and practices especially among the vulnerable populations who are older and with less educational attainment is recommended.

Public health implications

Public health inspectors have a major role to play in providing knowledge to further improve attitudes and safety practices among populations towards lightning. For this, they should plan activities targeting the vulnerable communities in advance.

Author Declarations

Competing interests: The authors declare that they have no competing interests.

Ethics approval and consent to participate: Ethics clearance was obtained from the Ethics Review Committee of the Faculty of Medicine, University of Colombo. Written authorization was obtained from the Regional Director of Health Services (RDHS) Ratnapra and Kiriella MOH, and informed written consent from the participants.

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Author contribution: KK was the principal investigator of the study. All authors were involved in conceptualizing and interpretation of data. KK was involved in data collection, and KK and NW in drafting the manuscript. All authors revised it critically for intellectual content and gave final approval.

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