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LIGHTNING IN NEPAL: UNDERSTANDING THE RISK, HEALTH IMPACT, AND SCOPE FOR EARLY WARNING

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ABSTRACT

Background: Lightning is a recurring hazard in Nepal, particularly in the periods before and during the monsoon. This paper examines how existing records of lightning events, deaths, injuries and human exposure might inform prevention efforts at local level. **Objective:** This paper reviews published evidence on lightning occurrence and health effects in Nepal and sets out a practical framework for assessing risk, conducting a community survey and planning early-warning actions. **Methods:** The proposed retrospective analysis would use national disaster records, meteorological information and published studies. Variables for review include the date and location of incidents, deaths and injuries, circumstances of exposure, occupation, weather conditions and access to safe shelter. A proposed Lightning Risk Score brings together information on the hazard, exposure and shelter access. **Results:** Existing studies document a substantial lightning burden in Nepal, with differences across locations and study periods. One analysis covering 1971–2019 recorded 2,501 fatality events, 1,927 deaths and 20,569 affected people, and estimated a national fatality rate of 1.77 per million people per year. A separate analysis reported 1,050 deaths in its Himalayan-region dataset for 2011–2021. The figures come from different datasets and definitions, so they should not be treated as directly comparable. **Conclusion:** The evidence points to a need for Nepal to complement post-event response with prevention based on local risk. Priorities include improving records, making safety information more accessible, identifying safe shelters, issuing targeted warnings and testing the proposed Lightning Risk Score before any practical use.

KEYWORDS: Lightning; thunderstorm; Nepal; injury; mortality; early warning; disaster risk reduction; occupational exposure; public health.

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Figure 1: Illustrative depiction of a lightning-producing thunderstorm over mountainous terrain. This image is illustrative and is not presented as field photography.

1. INTRODUCTION

Lightning is an electrical discharge associated with charged thunderclouds. It matters for public health because a strike can cause serious injury or death, while the chance of being harmed also depends on where people are, what they are doing and whether they can get to shelter.

In Nepal, lightning is an important hazard that can receive less attention than it warrants. Harm can occur through a direct strike, a side flash, ground current or contact with an object struck by lightning. People who survive may still experience cardiac, neurological, hearing, vision or burn-related complications.

Nepal's terrain varies sharply from the Terai to the hills and Himalayan areas, making the country a useful setting for examining lightning risk. Published studies report regional differences in lightning activity and in its effects on people. Areas with frequent lightning do not necessarily have the highest number of human casualties.

For prevention, mapping lightning activity is only part of the task. It is also necessary to understand where people are when storms develop and whether they can reach shelter in time. NASA's assessment similarly highlights the value of considering lightning density alongside terrain, population and socioeconomic vulnerability.[4]

2. Rationale and Need for the Study

Long-term records show that lightning has caused substantial loss of life in Nepal. In an analysis covering 1971–2019, Adhikari recorded 2,501 fatality events, 1,927 deaths and 20,569 affected people. The estimated national fatality rate was 1.77 deaths per million people per year.[1]

A separate study based on Ministry of Home Affairs/Disaster Risk Reduction portal data reported 1,050 lightning deaths in its Himalayan-region dataset for 2011–2021, with clear variation from month to month.[2] These findings do not necessarily conflict: the studies cover different periods and use different datasets and reporting systems.

Research also shows that lightning risk is influenced by location, communication infrastructure, outdoor activities and other factors that affect people's exposure. This supports the need for a framework focused on prevention.[1,3,4]

3. AIM AND OBJECTIVES

3.1 Aim

To describe the public-health burden and patterns of exposure to lightning in Nepal, and to develop a practical, evidence-based framework for community risk assessment and early warning.

3.2 Specific objectives

- To describe the temporal and geographical distribution of lightning-related deaths and injuries using available secondary data.
- To identify populations and occupations with greater outdoor exposure during thunderstorms.

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- To assess awareness of lightning safety, early-warning messages and safe-shelter practices using a proposed community survey instrument.
- To develop and pilot a Lightning Risk Score that combines hazard, exposure and shelter-access variables.
- To propose community-level early-warning and risk-reduction measures for high-risk areas.

4. Conceptual Framework

The proposed framework looks at lightning risk through three connected factors: hazard, exposure and vulnerability. Hazard refers to the likelihood or intensity of storms that produce lightning. Exposure concerns where people are and what they are doing when lightning occurs. Vulnerability includes factors such as awareness, occupation, mobility, the safety of buildings and access to shelter.

Component	Examples of variables	Potential data source
Hazard	Lightning activity, thunderstorm occurrence, rainfall, season, time of day	Meteorological/lightning networks; disaster records
Exposure	Outdoor work, farming, construction, travel, sports, livestock herding	Community survey; incident reports
Vulnerability	Age, occupation, awareness, warning access, shelter distance	Community survey; local records
Response capacity	Warning dissemination, evacuation time, first-aid knowledge	Survey; health facilities; local authorities

5. METHODOLOGY

5.1 Study design

A retrospective descriptive study using secondary data is proposed, alongside a cross-sectional survey in selected communities. The secondary-data analysis would draw on published research and administrative records. The survey section provides a proposed questionnaire and sampling plan; it does not report results from a survey that has already been carried out.

5.2 Study setting

The study would cover Nepal, with results grouped where possible by ecological region (Terai, hills and mountain/Himalayan areas), province and district. District comparisons should use consistent administrative boundaries or clearly explain any boundary changes.

5.3 Study population

The secondary-data component would include recorded lightning incidents and affected people. For the proposed survey, participants would be adults who live or work in selected high-exposure communities. Outdoor workers, including farmers, construction workers, livestock herders and field labourers, should be included.

5.4 Inclusion and exclusion criteria

- Include documented lightning incidents with a recorded date and location, where available.
- Include community participants aged 18 years or older who provide informed consent.
- Include outdoor workers and residents of selected high-exposure communities.
- Exclude duplicate incident records and records with too little information to establish whether lightning was involved, following a predefined data-cleaning process.

5.5 Variables

Domain	Variables
Demographic	Age, sex, occupation, residence, education
Event	Date, month, time, district, ecological region
Exposure	Indoor/outdoor, farming, construction, travel, water exposure, elevated/open area
Outcome	Death, injury, burn, neurological symptoms, cardiac symptoms, auditory/visual symptoms
Protection	Warning received, warning source, shelter available, estimated shelter distance
Knowledge	Recognizes thunder as warning, knows safe shelter, avoids trees/open fields/water, knows first aid

6. Proposed Community Survey Instrument

This questionnaire is intended for field use after institutional approval has been obtained and participants have given informed consent. It does not contain responses from completed interviews.

No.	Survey question	Response format
1	Have you ever experienced a thunderstorm with lightning in your community?	Yes / No
2	During thunderstorms, are you usually indoors or outdoors?	Mostly indoor / Mostly outdoor / Both
3	What is your main occupation?	Farmer / Student / Construction / Household / Other
4	How quickly can you reach a fully enclosed building during a storm?	<5 min / 5–10 min / >10 min / No safe shelter
5	Do you know that thunder indicates possible lightning danger?	Yes / No
6	Where would you seek shelter?	Building / Hard-top vehicle / Tree / Open shelter / Other
7	Do you avoid isolated trees during lightning?	Always / Sometimes / Never
8	Do you avoid open fields, high ground and water during storms?	Always / Sometimes / Never
9	Have you ever received an official weather/lightning warning?	Yes / No / Unsure
10	Which warning channel is most accessible to you?	SMS / App / Radio / TV / Social media / Local authority / Other
11	Have you or a household member ever been injured by lightning?	Yes / No
12	Would you follow a warning advising immediate shelter?	Definitely / Probably / Unsure / Probably not / No
13	Do you know that a lightning victim can be touched safely?	Yes / No
14	Do you know basic CPR/first aid?	Yes / No
15	What is the main barrier to seeking shelter?	Distance / No shelter / Work duties / Lack of warning / Other

7. Proposed Survey Data-Collection and Analysis Plan

A multistage sampling approach could be used. First, select districts based on published information about lightning impacts and hazards. Next, choose municipalities or communities within those districts. Finally, select households or occupational groups systematically or consecutively, depending on the conditions in the field.

Analysis	Suggested method	Output
Descriptive	Frequencies, percentages, mean/median as appropriate	Participant profile and safety practices
Knowledge score	Sum of predefined correct safety responses	Low / moderate / high knowledge
Exposure score	Weighted outdoor-exposure items	Low / moderate / high exposure
Shelter access	Time-to-shelter categories	Accessibility profile
Association	Chi-square/Fisher exact test; logistic regression where appropriate	Factors associated with unsafe practices
Risk mapping	GIS linkage of survey and incident data	Community/district risk map

8. Secondary-Data Survey Table: Published Evidence

The table below summarizes findings from published sources; it is not a dataset collected through a new survey.

Study/data period	Key measure	Reported finding	Reference
1971–2019	Lightning fatality events	2,501 events	[1]
1971–2019	Deaths	1,927 deaths	[1]
1971–2019	Affected people	20,569 people	[1]
1971–2019	Countrywide fatality rate	1.77 deaths/million/year	[1]
2019	Deaths	94 deaths; highest reported annual total in that study's series	[1]
2011–2021	Deaths in Himalayan-region	1,050 deaths	[2]

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	dataset		
2016–2020	Lightning strokes detected	>1 million strokes/year reported by GLD360 analysis	[3]

9. Proposed Lightning Risk Score

The Lightning Risk Score is proposed as a framework for research. It has not been validated as a clinical or meteorological prediction tool, so it should be tested against recorded incidents before being used in practice.

Domain	Example indicator	Suggested points
Hazard	Active thunderstorm/lightning alert	0–3
Recent lightning	High recent lightning activity in locality	0–2
Exposure	Outdoor work/activity during storm	0–3
Terrain	Open/high/elevated location	0–2
Shelter	>10 minutes to safe enclosed shelter	0–3
Warning access	No reliable warning channel	0–2
Knowledge	Poor lightning safety knowledge	0–2

For illustration, scores of 0–4 indicate lower risk, 5–9 moderate risk and 10 or above high risk. These cut-offs need to be calibrated using validation data and should not be treated as established clinical thresholds.

10. Health Effects of Lightning Exposure

Lightning exposure can cause health problems immediately or later. It may involve a direct strike, contact injury, a side flash, ground current or blast effects. Possible consequences include cardiac arrest, neurological injury, burns, blunt trauma, and injuries to the eyes or ears.[5]

Alongside prevention, public-health planning should include prompt first aid and clear routes to medical care. The CDC notes that lightning victims do not retain an electrical charge and can be touched safely. If a person is not breathing or has no pulse, CPR should be started when appropriate and by rescuers who can provide it.[5]

11. Lightning Safety Recommendations

- When thunder is heard or lightning is observed, move into a fully enclosed building or hard-top vehicle.
- Do not use isolated trees, open shelters, exposed ridges or open fields as protection.
- Avoid water, plumbing contact and corded electrical equipment during thunderstorms.
- Outdoor workers should have a predetermined stop-work and shelter plan.
- Communities should identify safe shelters before the thunderstorm season.
- Warnings should provide the hazard, affected area, expected timing and the specific action people should take.
- Schools, workplaces and community groups should include lightning drills and first-aid education.

These recommendations align with public-health guidance from the CDC: if you hear thunder, lightning is close enough to be dangerous, so you should seek safe shelter.[5]

12. Early-Warning System Proposed for Nepal

Stage	Action	Responsible/partner institutions
Detection	Monitor lightning and thunderstorm activity	Meteorological and lightning-monitoring agencies
Risk assessment	Combine hazard with population/exposure information	Disaster-risk and local government teams
Alert	Issue concise, location-specific warning	Government/local authorities
Last-mile delivery	SMS, apps, radio, sirens, local networks	Telecom operators; local authorities; community groups
Protective action	Stop outdoor work and move to shelter	Households, schools, employers
All-clear	Issue safe-return message after danger passes	Authorities/weather services
Evaluation	Review false alarms, missed events and casualties	Research/monitoring team

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The World Meteorological Organization recommends that warning messages explain the hazard, identify the affected area, say how soon people need to act and how severe the situation may be, communicate the level of certainty, and give clear instructions.[6]

13. RESULTS: Evidence Synthesis

The studies reviewed show that lightning is a significant hazard in Nepal. In the 1971–2019 analysis, the national fatality rate was 1.77 per million people per year, while district rates ranged from 0.10 to 4.83 per million. The study reported particularly high rates in Dolakha, Okhaldhunga, Ramechhap, Nuwakot and Makwanpur.[1]

Research published in 2021–2022 also points to strong seasonal and geographical differences. Studies report more lightning activity at lower and middle elevations than in the highest Himalayan areas, and identify the pre-monsoon and monsoon months as important periods for prevention.[2–4]

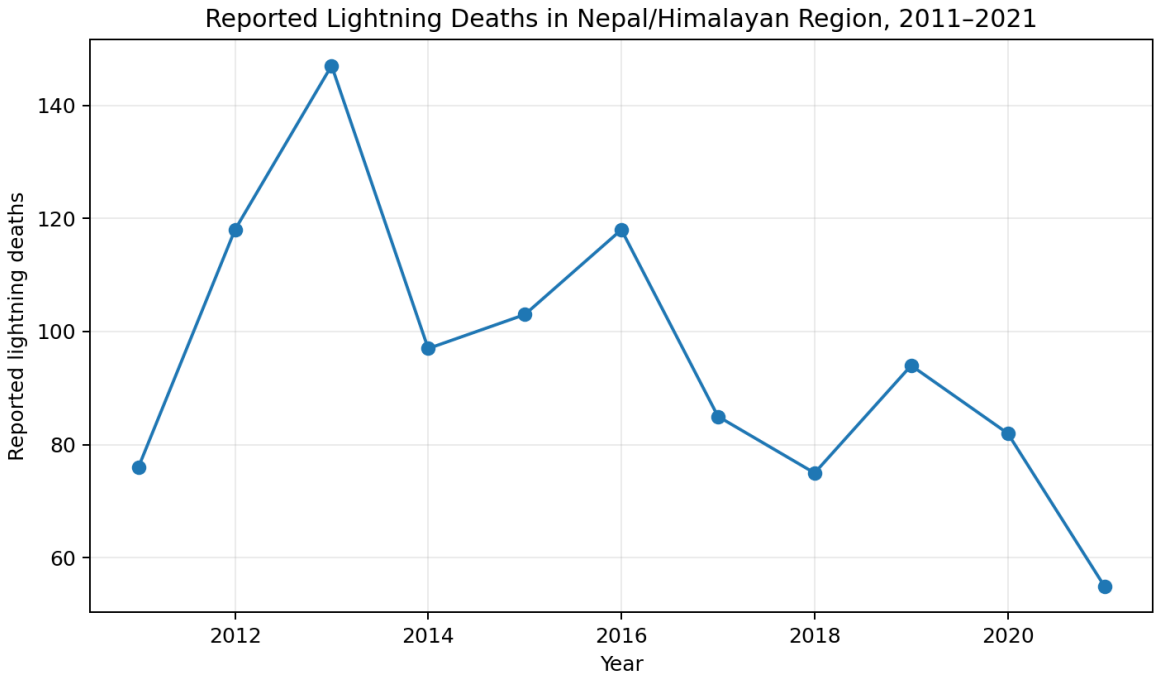

Figure 2: Reported lightning deaths, 2011–2021, reproduced from the annual values reported in Adhikari (2022). This is a secondary-data visualization, not a new national estimate.

14. DISCUSSION

The studies reviewed here suggest that lightning risk in Nepal cannot be explained by weather patterns alone. Terrain affects where thunderstorms develop, while population distribution and outdoor work influence how many people may be exposed when a storm occurs.[3,4]

A district with frequent lightning is not necessarily the place where people face the greatest danger. A useful assessment also needs to consider who is outdoors, how vulnerable they are and how long it would take them to reach an enclosed shelter. These factors support the proposed Lightning Risk Score and the broader aim of moving from response after an incident to prevention beforehand.

The available records also need to be interpreted carefully. Adhikari noted that an increase in reported events may partly reflect improvements in communication and data collection, rather than a real increase in lightning activity.[1] Comparing disaster records with meteorological and lightning-network data would help clarify this issue.

Warnings are more useful when they tell people what action to take. A general message that a thunderstorm is possible may not be enough for someone working outdoors. Where possible, an alert should identify the affected area, give an expected time window and clearly advise people to stop outdoor activity and move to safe, enclosed shelter.

15. Strengths

- Integrates epidemiological, meteorological and exposure perspectives.
- Separates published evidence from proposed primary-survey work.
- Provides a practical survey instrument for future field research.
- Introduces a testable risk-scoring framework rather than claiming an already validated model.
- Links early warning to specific protective actions.

16. Limitations

- Secondary disaster records may contain under-reporting, duplicate records or inconsistent definitions.

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- Published studies cover different periods, administrative boundaries and data sources. Their estimates should not be combined unless the data have first been made comparable.
- The proposed survey table does not contain completed participant responses and should not be presented as original survey findings.
- The proposed Lightning Risk Score is conceptual and must be tested against observed outcomes before it can be used.
- District-level figures may hide important differences between individual communities and households.

17. Ethical Considerations for Future Survey Work

- Obtain institutional ethical approval before collecting primary data.
- Obtain informed consent from all participants.
- Do not collect unnecessary personally identifying information.
- Store data securely and report results in aggregate.
- Provide participants with basic lightning-safety information after survey completion.
- Apply additional safeguards when working with vulnerable participants, and obtain the required permissions from schools or workplaces.

18. Recommendations

- Establish a standardized national lightning injury and mortality surveillance protocol.
- Integrate lightning-detection data with district-level population and exposure information.
- Develop location-specific, action-oriented warning messages.
- Expand public education before and during the pre-monsoon and monsoon periods.
- Identify and improve access to safe community shelters in high-risk outdoor-work areas.
- Train community health workers, teachers and local volunteers to provide lightning first aid and respond to emergencies.
- Evaluate the proposed Lightning Risk Score prospectively before operational deployment.
- Publish annual reports on lightning risk to track changes over time and assess prevention efforts.

19. CONCLUSION

Lightning remains a serious public-health concern in Nepal, and some of the resulting deaths and injuries may be prevented. The studies reviewed in this paper show substantial impacts, differences between locations and a clear seasonal pattern. Better prevention will require more than information about where lightning occurs: planners also need to know who is exposed and whether safe shelter is within reach.

Taken together, the evidence supports stronger lightning surveillance, public education and community-level warning systems, particularly in areas where people are frequently exposed outdoors. The proposed Lightning Risk Score is a starting point for further study, not a validated prediction tool; it should be assessed against observed incidents before being used operationally.

19. Statements for Manuscript Submission

Author contributions: Arishti Singh contributed to the study concept and manuscript preparation. Shivangi Singh contributed to the study concept, review of the literature, development of the survey framework and manuscript preparation, and serves as the corresponding author.

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Conflict of interest: The authors declare no conflict of interest.

Data availability: This manuscript draws on published and secondary evidence and includes a proposed survey instrument. It does not claim to contain an unpublished primary survey dataset. Any future primary data should be collected, cleaned and stored in line with institutional requirements.

Ethical approval: This manuscript does not report new survey data from human participants. Any future field survey using the proposed questionnaire should receive institutional ethical approval, and informed consent must be obtained before data collection.

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Appendix A. Proposed Field Survey Form
Participant code: _____ Date: _____ District/Municipality: _____
Consent obtained: Yes / No Interviewer code: _____

Section	Item	Response
A	Age	_____ years
A	Sex	Male / Female / Other / Prefer not to say
A	Occupation	_____
B	Typical outdoor hours during storm season	<1 / 1–3 / 4–6 / >6
B	Typical distance to safe shelter	<5 min / 5–10 min / >10 min / None
C	Heard thunder as a warning sign?	Yes / No
C	Would avoid isolated trees?	Yes / No
C	Would leave open field/high ground?	Yes / No
C	Would avoid water during storm?	Yes / No
C	Knows lightning victim can be touched safely?	Yes / No
D	Received warning in past season?	Yes / No / Unsure
D	Preferred warning channel	SMS / App / Radio / TV / Local authority / Other
E	Household lightning injury history	Yes / No
E	If yes, outcome	Death / Injury / Burn / Neurological / Other

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