KNOWLEDGE BRIEF
LIGHTNING: DEATH FROM ABOVE

Each second there are 60 lightning flashes worldwide with nearly 1.4 billion flashes per year [1]. The earth experiences around 25 million lightning strike annually. For a 1°C increase in global air temperature, there will be a 12% increase in lightning events [2]. In Bangladesh, 3,273 people died from lightning strikes, about four people a week, between 2010 and 2020 [3]. Bangladesh had 5,757,836 lightning counts with 42.44 events/km2 lightning density in 2021 [4]. With global warming and climate change, lightning events will become particularly deadly in Bangladesh.

Lightning

Lightning and thunder have different sources of energy of their own- electrical and sound energy, respectively. We see lightning as a sudden flash of electricity in the sky that might be straight or forked. Lightning is a quick, visible electrical discharge created from a cloud due to imbalances between a storm cloud and another surface- cloud or ground. Lightning flash is scorching and can heat the surrounding air's temperatures five times hotter than the sun's surface [5]. We hear booming thunder shortly after seeing a lightning flash because this heat causes the area's air to expand and vibrate rapidly. Lightning-related injuries pose a severe threat to global health, as it is one of the major causes of weather-related fatality after hurricanes, tornadoes, and flash floods [6]. Irregular patterns in climate change are forcing more water to evaporate from land surfaces and oceans, raising the potential of more clouds and rainfall and increasing the possibility of more lightning storms. The earth is gradually warming and experiencing more intense lightning events than ever before. Because of its significance, the Government of Bangladesh has added lightning strikes as an official type of disaster since August of 2016 [7].

Lightning Formation Mechanism

Electric discharges from clouds and ground produce lightning. A single lightning strike may heat the air surrounding it to 30,000°C (54,000°F) [8]! The air expands explosively fast due to the enormous temperature and produces a massive explosion, transforming into a loud sound wave known as thunder. Lightning is usually associated with thunderstorms. According to the National Oceanic and Atmospheric Administration (NOAA), the circumstances needed for lightning to be produced are well known, however, the exact reason for its formation has never been identified by scientists. It is recently identified that ice, semi-frozen drops of water, and hail are crucial for lightning to occur. Storms that don't generate a large amount of ice frequently fail to produce lightning.

Moving thunderclouds obtain pools of particles with positive charges that carry with the storm (image 1). A negative charge channel, known as a "stepped leader," will fall from the lowest point of the storm toward the ground. At the same time, particles with positive charges from the ground climb up through taller objects like trees, homes, and telephone poles as the differences in charges increase (image 2).This process happens so quickly, with less than a blink of an eye, it's quite impossible for the human eye to detect by human vision. (image 3). The electrical transmission that occurs when these channels connect with each other is what the human eye sees as lightning. Positive charge builds in the earth and items on the ground when the negative leader hits the ground. Thus, the positive charge meets the negative charge with its channel and produces lightning (image 3) [9].

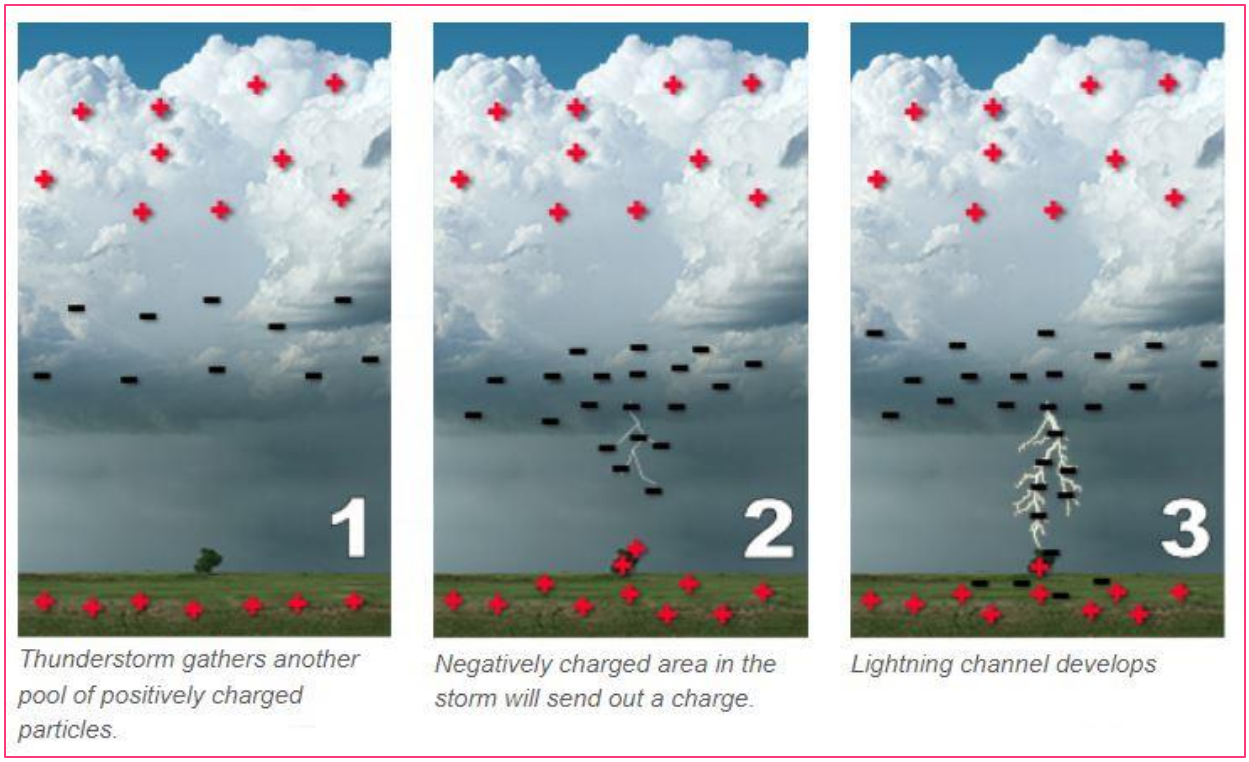

Figure 1: Lightning develops between the cloud and the ground (source: NOAA [8]).

Types of Lightning

The lightning moves through the cloud, which mostly starts inside a thunderstorm. Its existence can be restricted within the clouds, or it travels through the open air and is ultimately crushed into the ground. According to the Royal Meteorological Society, major lightning types are [10]:

a) Cloud-to-Ground (CG) Lightning
   - Negative Cloud-to-Ground Lightning (-CG)
   - Positive Cloud-to-Ground Lightning (+CG)

b) Cloud-to-Air (CA) Lightning
c) Ground-to-Cloud (GC) Lightning
d) Intracloud (IC) Lightning
e) Cloud-to-Cloud (CC) Lightning (or intercloud lightning)

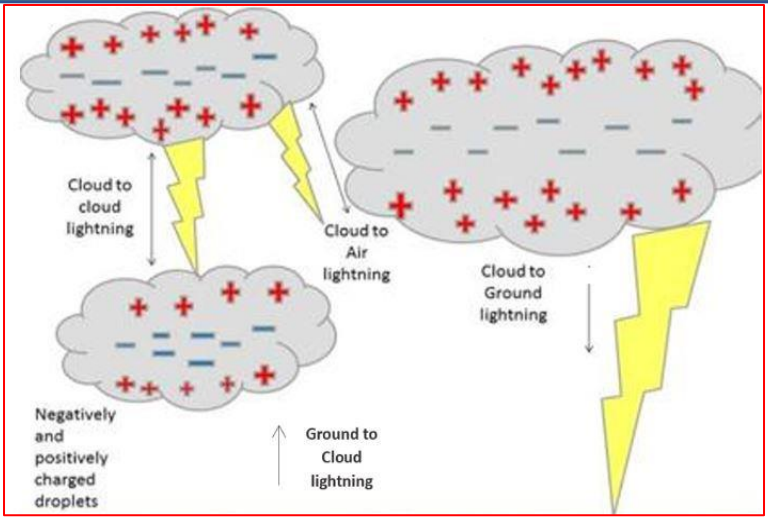

Figure 2: Different form of lightning (Source: Royal Meteorological Society [9]).

Impacts of Lightning Strikes

About 2,000 people are killed annually by lightning strikes worldwide [5]. Hundreds more survive but suffer from long-term problems such as memory loss, dizziness, weakness, paralysis, and other life-altering diseases. Strikes can result in cardiac arrest and severe burns. People who work under the open sky- farmers, fishermen, laborers, and those who fall under poorer communities are more prone to lightning strike fatalities.

Lightning strikes can have various impacts on the environment and human-made structures. Some of the significant impacts include:

- **Fire:** Lightning strikes can ignite fires in forests, grasslands, and other natural areas, as well as in buildings and other structures.
- **Power outages:** Lightning strikes damage power lines and electrical infrastructure, causing power outages and disrupting communications and other services.
- **Injury and death:** Lightning strikes can be deadly to people and animals and cause various injuries, such as burns, cardiac arrest, and neurological damage.
- **Electromagnetic pulse:** A powerful lightning strike can create an electromagnetic pulse (EMP), disrupting electronic devices, and communication systems.
- **Damage to property:** Lightning strikes can damage buildings, electrical equipment, and other structures, causing costly repairs and disruptions.

It's important to note that lightning is a natural phenomenon, and it is impossible to prevent lightning strikes. However, it is possible to reduce the risk of damage and injury by taking appropriate safety measures, such as avoiding outdoor activities during thunderstorms and unplugging electrical devices during a storm.

Lightning in Bangladesh

In many developing countries, calculating the deaths or injuries that occurred due to lightning strikes is immensely difficult. No government agency in Bangladesh collected data about lightning casualties until 89 people were killed on 12 and 13 May 2016 [11]. For Bangladesh, Dewan et al. identified a total of 5,468 casualties comprising 3,086 fatalities and 2,382 injuries from 1990 to mid-2016, with annual averages of 114 fatalities and 89 injuries over the entire time period [12]. Meanwhile, Holle et al. expanded the Dewan's research with another 18 months of recent data from mid-2016 to 2017 [13]. Figure-3 illustrates the trends of deaths and injuries from lightning events from 1990 to 2017. Holle et al., estimated the decadal totals death and injuries by lightning events.

- From 1990 to 1999: 30 deaths and 22 injuries per year,
- From 2000 to 2009: 106 deaths and 72 injuries per year,
- From 2010 to 2017: 260 deaths and 211 injuries per year.

The pre-monsoon season has more fatalities (1,916) than any other season. The second highest fatalities occur in monsoon (998), and the lowest fatalities in winter (45).

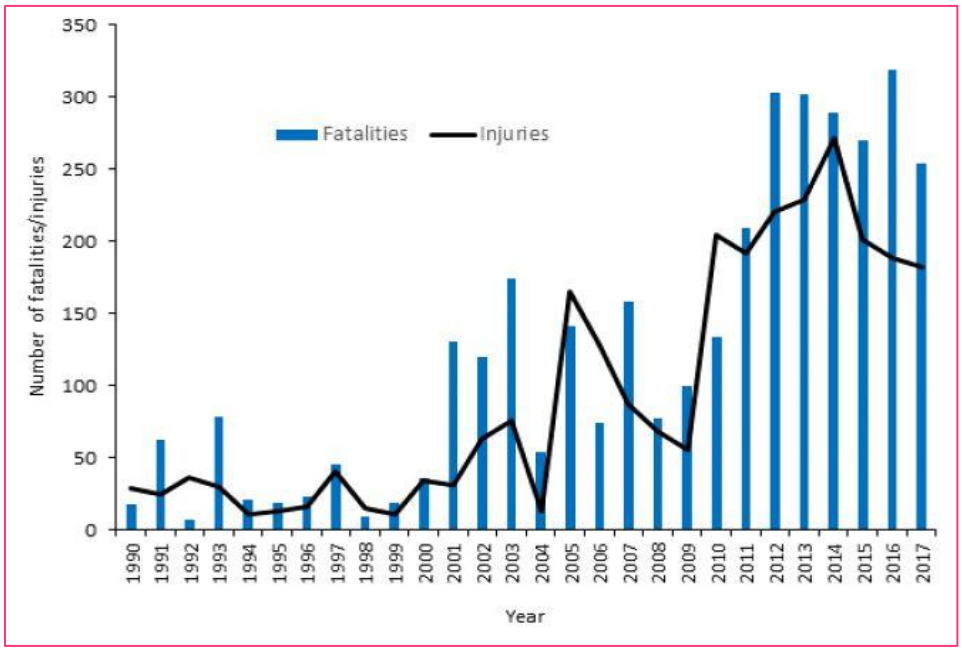

Figure 3: Number of lightning-related fatalities and injuries in Bangladesh from 1990 through 2017. Source: [11,12].

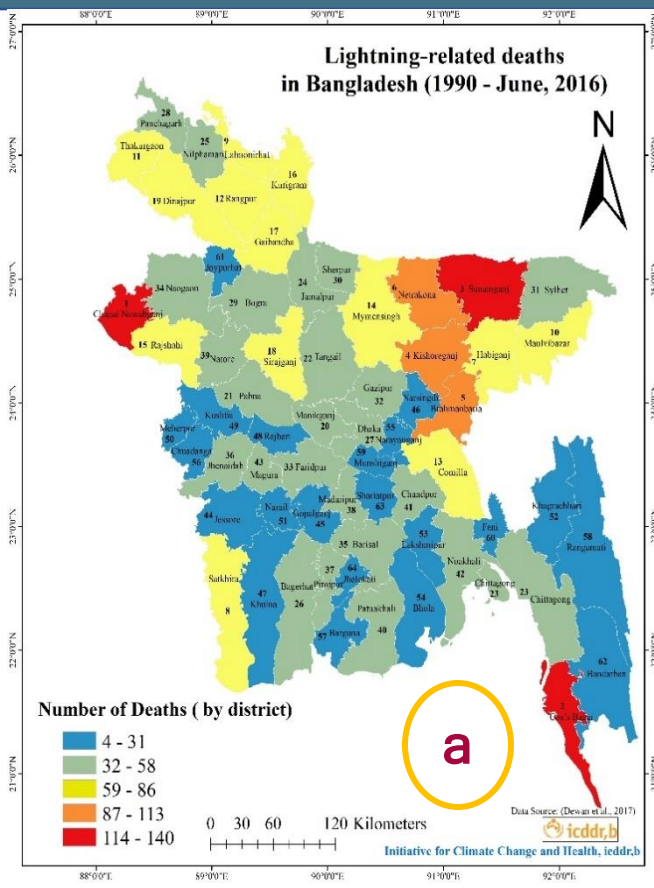

Figure 4(a): District-wise lightning-related deaths from 1990 to June 2016. Color shading in scale ranges from the highest in red to the lowest in blue. Data source: (3)

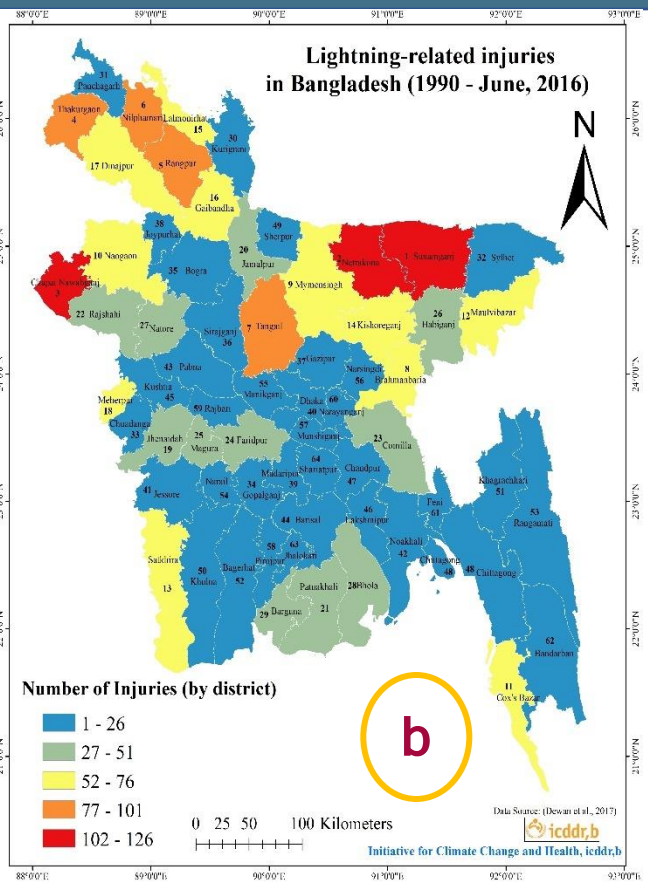

Figure 4(b): District-wise lightning-related injuries from 1990 to June 2016. Color shading in scale ranges from highest injury in red to lowest in blue. Data source: (Dewan et al., 2017 [11])

According to each district, Dewan et al., and Holle et al., estimated the fatality and injury rates per million per year. They also collected the yearly death and injury data of lightning from different sources [11,12]. Figure 4(a) and 4(b) represent the lightning deaths and injuries and rank by district (reproduced from Dewan et al., 2017 [11]). Figure 4(a) shows that the district's number of deaths ranges from 4 to 140. Chapai Nawabganj district has the highest number of deaths (140) followed by Cox's Bazar (137), Sunamganj (132), Kishoregonj (109), and Brahmanbaria (104). On the other hand, the lowest rates have been found in Jhalokati (4), Shariatpur (6), Bandarban (8), Joypurhat (15), and Munshiganj (17). On the other hand, Regarding lightning injuries occurred most in Sunamganj (126) and Netrakona (115) and least in Shariatpur (1) (Figure 4(b)). The lesser number of injuries is mainly due to underreporting. The Foundation for Disaster Forum estimates 3,273 people were killed in lightning strikes between 2010 and 2021, with 363 deaths in 2021 alone [3]. Another research from 2021 found a positive and statistically significant relationship between lightning strikes and climate

variables like temperature, rainfall, humidity and air pressure. It warns that lightning strikes in Bangladesh may become more frequent in future (5).

Lightning Safety Guidelines

Lightning is the most under-reported and less-explored weather hazard [9]. It is one of the most arbitrary and unexpected elements of a thunderstorm. Hence, lightning alert/ alarm is somewhat ineffective or largely absent in many countries, like Bangladesh. Knowing and practicing proven lightning safety guidelines can significantly lower the chance of injury or death.

Where to Go

During a thunderstorm, the safest place is inside a large, enclosed structure with plumbing and electrical wiring such as schools, office buildings and private residences.

If lightning strikes the structure, the plumbing and wiring carry electricity more efficiently than a human body.

Where NOT to Go

During a thunderstorm, not all structures or cars are safe. Buildings with exposed apertures are NOT SAFE (even if they are "grounded").

Even when the top is "up," convertible vehicles provide less protection against lightning.

Where to Go

Stay away from electrical appliances and plumbing equipment once inside a strong structure. If possible, then stay in an interior room for increased security.

If you are inside a car, roll up the windows and prevent contact with any conducting paths connecting to the outside (e.g., radios and ignition, etc.).

Where NOT to Go

Unless there is an emergency, do not use electrical equipment, especially corded telephones (cordless and cell phones are safe to use).

Computers are also risky as they are often connected to both power wires. Take no showers, baths, or use a hot tub.

Measures to Prevent Lightning Fatality

The Bangladesh government took initiative to plant palm trees along the roadside, which should perform as lightning conductors for large open spaces in rural areas. Recently Bangladesh Meteorological Department (BMD) introduced lightning strikes early-warning system in collaboration with the National Aeronautics and Space Administration (NASA) that could provide lightning forecasts up to 54 hours before of a lightning strike [3]. However, its

effectiveness is yet to be proven. The Ministry of Disaster Management and Relief wants to install 723 early warning devices and build 1000 lightning-resistant concrete shelters in 23 lightning-prone districts [14]. A lightning arrester is another preventive measure that the Nepal government successfully adopted a few years ago. The National Plan for Disaster Management (2016-2020) of Bangladesh suggested some actions to minimize the lightning disaster risk [15]:

- Implementing national and regional drills on lightning;
- Installing lightning detectors in all public buildings, hospitals, and schools;
- Establishing a lightning observatory system.

Research Gap

Bangladesh has no spatial or temporal early warning system for lightning strikes. The country does not have any lightning safety plan, strategy, or policy. There are no lightning shelters for particularly vulnerable areas. Apart from Dhaka Medical College, no other health facilities have improved burn units. Majority of the health facilities (especially in the lightning-prone districts) lack the infrastructure to treat lightning stroked patients with internal or neurological injuries and severe burns. Bangladesh has no comprehensive database with lightning records.

Conclusion

Bangladesh is experiencing a growing number of lightning events, injuries, and deaths. The country should concentrate on developing a comprehensive lightning safety plan along with a lightning warning based on user location (Ex. Damini: Lightning Alert app from India). The healthy system, particularly in the lightning-prone districts, needs to be enhanced with treatment provisions for lightning stroked patients. Spatial and temporal lightning vulnerability has to be considered in national-level planning. Lightning safety guidelines should be strictly imposed during the pre-monsoon season. Regular training sessions and mass media campaigns should be arranged to reduce the risk of lightning injury and deaths.

References

1. VAISALA. Total lightning statistics 2022: The Annual lightning report. 2022.
2. Romps DM, Seeley JT, Vollaro D, Molinari J. Projected increase in lightning strikes in the United States due to global warming. Science. 2014;346(6211):851-4.
3. Islam R. For lightning-prone communities in Bangladesh, new warning system may not be enough: Mongabay; 2022 [Available from: https://news.mongabay.com/2022/09/for-lightning-prone-communities-in-bangladesh-new-warning-system-may-not-be-enough/.
4. VAISALA. 2021 global lightning statistics. 2022. Report No.: B212467EN-A.
5. Geographic N. Lightning: National Geographic; undated [Available from: https://www.nationalgeographic.com/environment/article/lightning.
6. Biswas A, Dalal K, Hossain J, Baset KU, Rahman F, Mashreky SR. Lightning Injury is a disaster in Bangladesh?-Exploring its magnitude and public health needs. F1000Research. 2016;5.
7. Jahan N. Lightning: The New Natural Disaster. The Daily Star. 2016.

8. UCAR. Thunder and Lightning: UCAR: Center for Science Education; undated [Available from: https://scied.ucar.edu/learning-zone/storms/thunder-and-lightning.
9. NOAA. How Lightning is Created USA: National Oceanic and Atmospheric Administration; undated [Available from: https://www.weather.gov/jetstream/lightning.
10. RMetS. Types of Lightning United Kingdom: Royal Meteorological Society; 2017 [Available from: https://www.rmets.org/metmatters/types-lightning.
11. Holle RL, Islam A, editors. Lightning fatalities in Bangladesh in May 2016. Proceedings of the 8th Conference on the Meteorological Applications of Lightning Data 2017 American Meteorological Society Annual Meeting, Seattle, Washington; 2017.
12. Dewan A, Hossain MF, Rahman MM, Yamane Y, Holle RL. Recent lightning-related fatalities and injuries in Bangladesh. Weather, climate, and society. 2017;9(3):575-89.
13. Holle RL, Dewan A, Mohammad S, Karim MR, Hossain M, editors. Lightning fatalities and injuries in Bangladesh from 1990 through 2017. 25th International Lightning Detection Conference; 2018: Vaisala Ft Lauderdale^ eFlorida Florida.
14. Express TF. Govt plans to build lightning resistant shelters in 23 districts. The Financial Express. 2021.
15. MoDMR. The National Plan for Disaster Management (2016-2020) Dhaka: Ministry of Disaster Management and Relief; 2017.

Knowledge Brief: Lightning: Death from above
Suggested citation: Dutta, M., Ahmed, S., Rahman, S., Ahmad, T., Nahian, M.A., Ahsan, A., Streatfield, P.K.; (2023), Lightning: Death from above; Knowledge Brief, Dhaka, Bangladesh. Available at: https://cch.icddrb.org/knowledge-briefs

SCAN ME

About the https://cch.icddrb.org website

Monitoring the growing impacts of climate change (CC) on health in Bangladesh requires various data on climate change, health, and population outcome. To bring together relevant data sources and essential links, to provide a more up-to-date climate change and health scenario in the Global and Bangladesh context in a single web-based platform, a resource website “https://cch.icddrb.org” has been developed under the USAID's Research for Decision Makers (RDM) Activity. The website provides essential resources and relevant data sources for health professionals to enhance their understanding of climate change and utilize the knowledge in health research and intervention design, which may minimize the negative impacts of climate change.

The website shows real-time data and interactive graphs on climatic parameters such as hourly, daily, and monthly temperature, humidity, and air pollution (Air Quality Index, PM2.5) through an integrated iQAir device. The website also generates dynamic graphs on the meteorological parameters collected from Bangladesh Meteorological Department (BMD). The website showcases icddr,b works on climate change and health. We believe the resources website should enable researchers, program managers, and policymakers with essential data and discussion to measure and monitor climate change's impact on health and design interventions that may minimize such negative impacts.

This knowledge brief was produced with the support of the United States Agency for International Development (USAID) under the terms of USAID's Research for Decision Makers (RDM) Activity cooperative agreement no. AID-388-A-17-00006. Views expressed herein do not necessarily reflect the views of the US Government or USAID. icddr,b is also grateful to the Governments of Bangladesh, Canada, Sweden and the UK for providing unrestricted/institutional support.

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