KNOWLEDGE BRIEF
HEATWAVES: THE SILENT KILLER

As global temperatures inexorably rise, heat waves are becoming a serious threat to health, not only of humans, but all species. These periods of intense heat are already affecting food security, as well as longer term viability of certain areas of the world. Heat-related morbidity and mortality like heat exhaustion, heat stroke, along with dehydration and electrolyte disorders, diarrhoea and respiratory diseases have become more widespread around the world, particularly in tropical, subtropical, and temperate climate zones like Bangladesh. Heat-related illnesses (HRI) are the most severe health consequences of daily wage workers because of their long exposure to high temperatures. Bangladesh is one of the world's most climate-sensitive health risk countries and future predictions indicate that both the frequency and intensity of risks (heatwaves) will rise (1). For example, recent studies in Australia (2), Bangladesh (3), China (4), India (5), Russia (6), the United Kingdom (7) and the United States (8) reported a significant number of fatalities due to illness caused by extreme heat waves.

Overview

Because heat waves are 'relative' not absolute, meaning a heat wave in the Arctic will be defined differently to heat wave in the tropics, the World Meteorological Organization (WMO) has not adopted a standard definition. Two key characteristics of a heat wave are that the high temperatures must last multiple days, and they must exceed the 'normal', or average temperature for the same period in previous years.

The WMO uses a Heat Wave Duration Index (HWDI) where the maximum temperature is at least 5°C above the climatological average for more than 5 days, however, some argue that this is less useful in regions where temperatures fall into a narrow range, like the tropics. Some countries use shorter durations, like 2+ days (USA), 3+ days (UK, Australia), and some require both daytime maximum and nighttime minimum temperatures to be above normal (India, Australia).

Whatever the definition used, there is broad agreement that the frequency and magnitude of heat waves has been increasing in recent decades, in Africa, Central Europe, India, China and Australia [9]. Heatwaves, or hot weather can have a massive impact on society, including an increase in heat-related mortality. According to World Health Organization (WHO), more than 166000 people died because of heatwaves from 1998 to 2017, including more than 70000 in Europe during the 2003 heatwave (9). Around 125 million people exposed to heatwaves between 2000 and 2016.

Formation Mechanism of Heatwaves

High temperatures are one of the key ingredients to form heat waves and another is a continuous high- pressure area in the upper atmosphere.

When high pressure air moves over a region and the hot air in the nearby atmosphere to sink down toward the surface. As hot air sinks, it forms a bubble that functions as seal and traps heat near the surface.

This seal that forms over the affected area keeps heat that would normally rise into the air, cool and then circulate back to the surface. The inability to ascend not only decreases the possibility of rain clouds, but also allows for the continuous accumulation of heat, earth's surface perceive as a heat wave (11). These heatwaves can last anywhere from a few days to several weeks.

Figure 1: Anatomy of a Heatwave (10)

On the other hand, this heat wave went on for any weeks, with temperatures 4-5°C above seasonal averages and was "primarily due to a natural phenomenon called 'atmospheric blocking' (12). This occurs when an unusually intense area of high pressure in the mid to upper atmosphere acts as a cap, trapping warm air as it rises and pushing it back down to warm the surface even more (13).

Heatwaves and Deaths

Total 4,000 people were killed in 2019 due to the most severe heatwaves, seven of them were recorded in Europe, India and Japan. Around 3,453 individuals were killed by heatwaves across 8 countries in western Europe, the France having the highest number of deaths (1,435) and the UK (892). Heatwaves killed 112 people in India and 173 people in Japan in 2019 (14).

EM-DAT reported 38 heatwaves in the last decade and recorded 70,409 people deaths (55,736 in Russia alone in 2010, mainly to a combination of high heat and wildfires). About 2,500 people died in India during a severe heatwave in 2015, while at least 3,800 people died in Bangladesh during an 8-day heatwave in 2008.

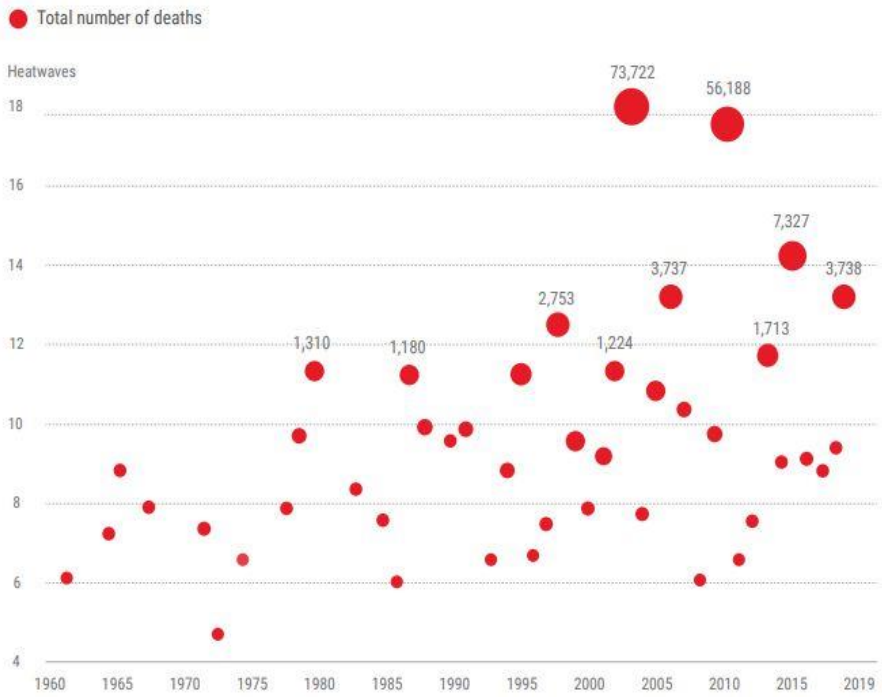

Figure 2: Heatwaves deaths from 1960 to 2019 (Data source: IFRC, World Disasters Report 2020).

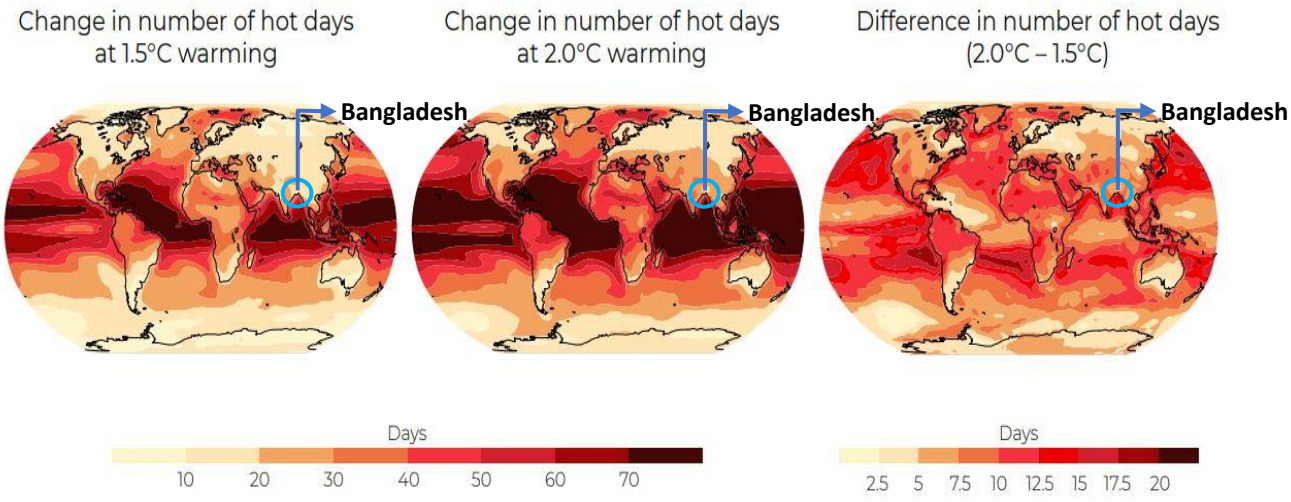

Figure 3: Projection of global heatwave risk (source (14): IFRC, World Disasters Report 2020).

Global Climate Highlights: 2022

According to NOAA Scientists, the global surface temperature for 2022 was the sixth highest since record keeping began in 1880. From the figure it is identified that Asia was the second warmest year on record in 2022. According to NOAA, the global surface temperature in December was the eighth highest in the 143-year record.

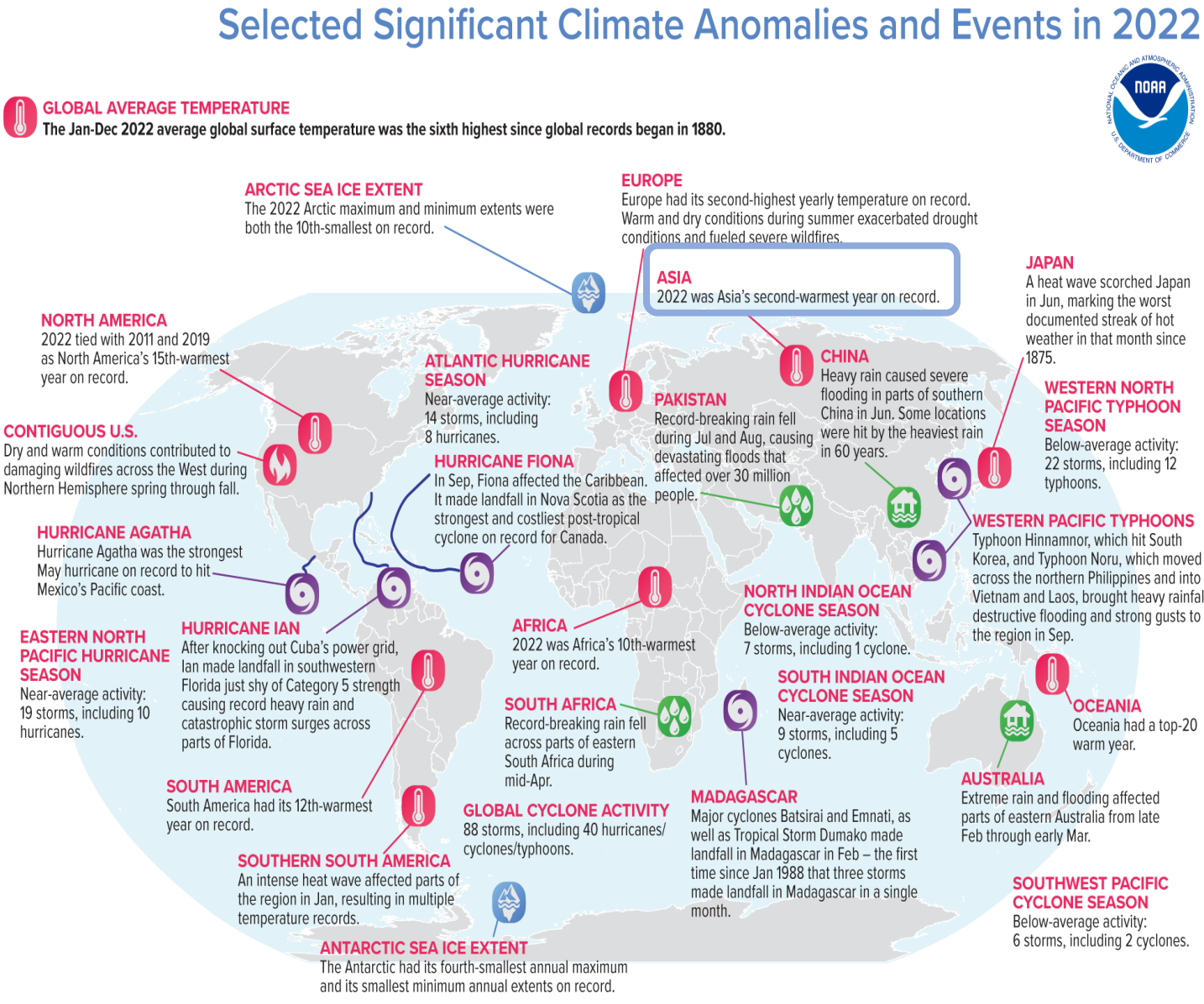

Figure 4: Significant Climate Anomalies and Events in 2022 (15).

Heatwave in Bangladesh

Bangladesh consistently has some experiences of the highest maximum temperatures in Asia, with an average monthly maximum temperature of roughly 30°C and an average April maximum temperature of 33°C (16).

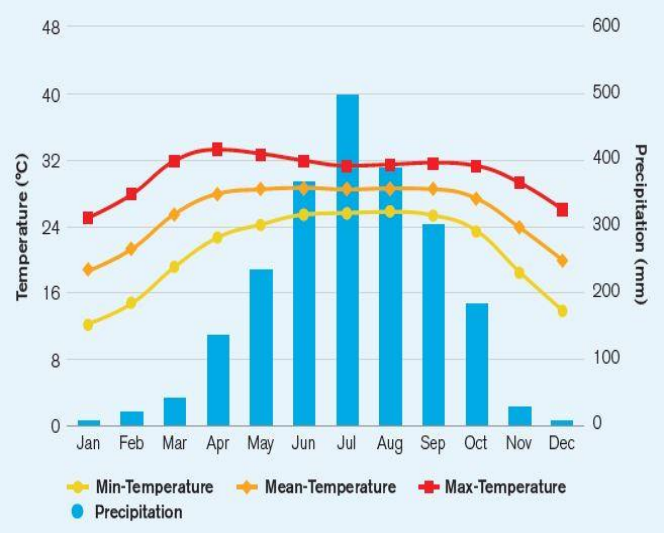

Figure 5: Average Monthly Mean, Maximum and Minimum Temperature and Rainfall in Bangladesh from 1991 to 2020 (17).

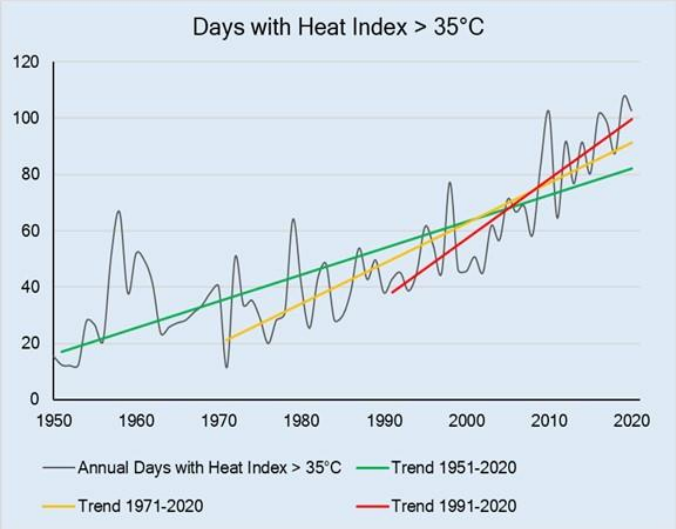

Figure 6: Annual Trends with Significance of Trend per Decade in Bangladesh from 1950 to 2020 (18).

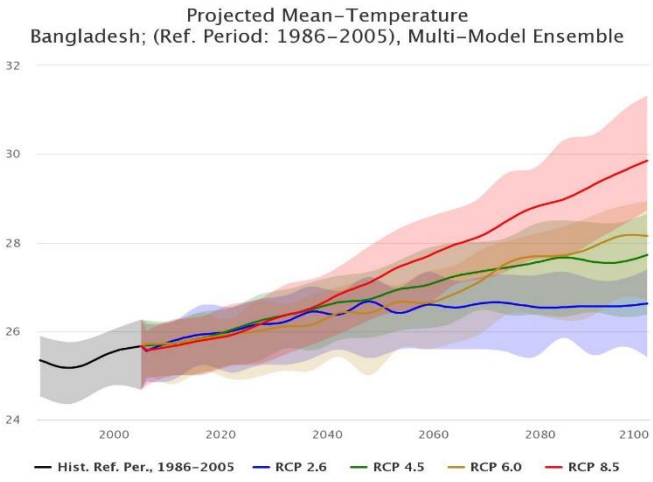

Figure 7: Projected Average Annual Temperature in Bangladesh RCP2.6, RCP 4.5, RCP 6.0 and RCP 8.5 (Ref. Period: 1986-2005), Multi Model Ensemble (19).

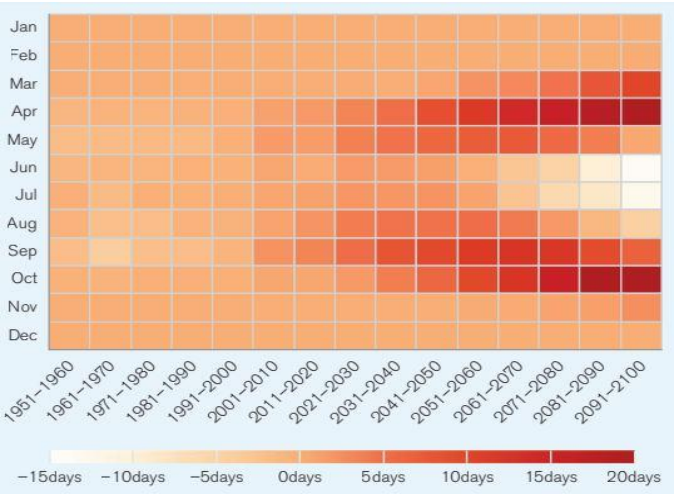

Figure 8: Projected Heat plot Illustrating the Anomaly (Change) of the Number of Days with Heat Index > 35°C (20).

The current chance of a heat wave (defined as a period of three or more days in which the daily temperature exceeds the long-term 95th percentile of daily mean temperature) is about 2% - 3% (1, 16). Climate Change Knowledge Portal model predicts that Bangladesh faces a significant increase in the annual exposure to extreme heat based on the baseline data from

1986 to 2005 (16). Figure 5 has illustrated the average monthly mean, maximum and minimum temperatures, and rainfall in Bangladesh from 1991 to 2020. Figure 6 represents the annual days with heat index >35°C longer-term time series (solid black line) and shows an upward trend consistently. Through the three trend lines, 1951-2020, 1971-2020, and 1991-2020-progressive changes are identified. Projections of future temperature changes are presented in Figure 7. The figure displays the annual and monthly temperature projections and shading represents the 10th and 90th percentile of the multi-model range. These projections can explain more about how daily life might change in a region, affecting key variables such as the viability of ecosystems, health impacts, productivity of daily labor and the total production of crops, that are frequently influenced by temperature extremes. As illustrated by Figure 8, Bangladesh will face emerging hot and humid seasons with heat index exceeding 35°C. The country has already begun to see an increase in the number of days exceeding this threshold value, with significant increases seen in the spring and fall seasons, indicating that the hot and humid summer seasons are likely to expand (16).

Heat Impact on Health

Temperature plays a crucial role in human health (21). Internal organ temperature is referred to as body core temperature (Tc), and the body has multiple thermoregulatory ways to maintain Tc within a degree or two of 37°C, with a range from 36°C to 40°C. When Tc rises above 40.5°C hyperthermia results, with clinical manifestations of “sweating, flushing, tachycardia (rapid pulse), light-headedness, headache, muscle cramps, hypotension, confusion, delirium, seizures, and finally, coma” (Cheshire 2016). Heat waves commonly result in such symptoms of heat exhaustion, with progression to heat stroke, along with dehydration and electrolyte disorders.

Dehydration can result in lower blood volume (and BP) which reduces cardiac filling, and in compensation increasing heart rate. The main cooling mechanism is sweating where salt and water can be lost at up to 2 L/hour. This cutaneous vasodilation dissipates the loss by radiant and convective pathways.

In summary, exposure to high temperatures for an extended period can result in direct damage to respiratory and renal systems, as well as indirect impacts through increased anxiety, violence, and substance [ab]use (22). There are reports of rising levels of kidney diseases, often with kidney stones, among farm workers in hot countries, like India and Egypt (23). Currently there is a lot of attention on migrant workers in the Middle East.

Figure 9: Impacts of heatwaves (Source: WHO (24)).

High temperatures can also manifest in increased risks of stillbirths, preterm labor, and lower birthweight babies (ibid). It is known that pregnant women are susceptible to elevated temperatures and heat waves as their ability to thermoregulate is compromised (25). But the consequences of high heat exposure on pregnancy outcomes is not completely understood as so many factors can impact fetal development (26). But this systematic review found that risk of preterm births seems to certainly be increased with high heat exposure (ibid).

Food security: A study by Battisti and Naylor looked at 23 global climate models and compared projections with historical data (1900-2006) and concluded that "it is highly likely (>90% chance) that growing seasons temperatures by the end of the 21st century will exceed even the most extreme seasonal temperatures recorded from 1900 to 2006 for most of the tropics and subtropics" (27).

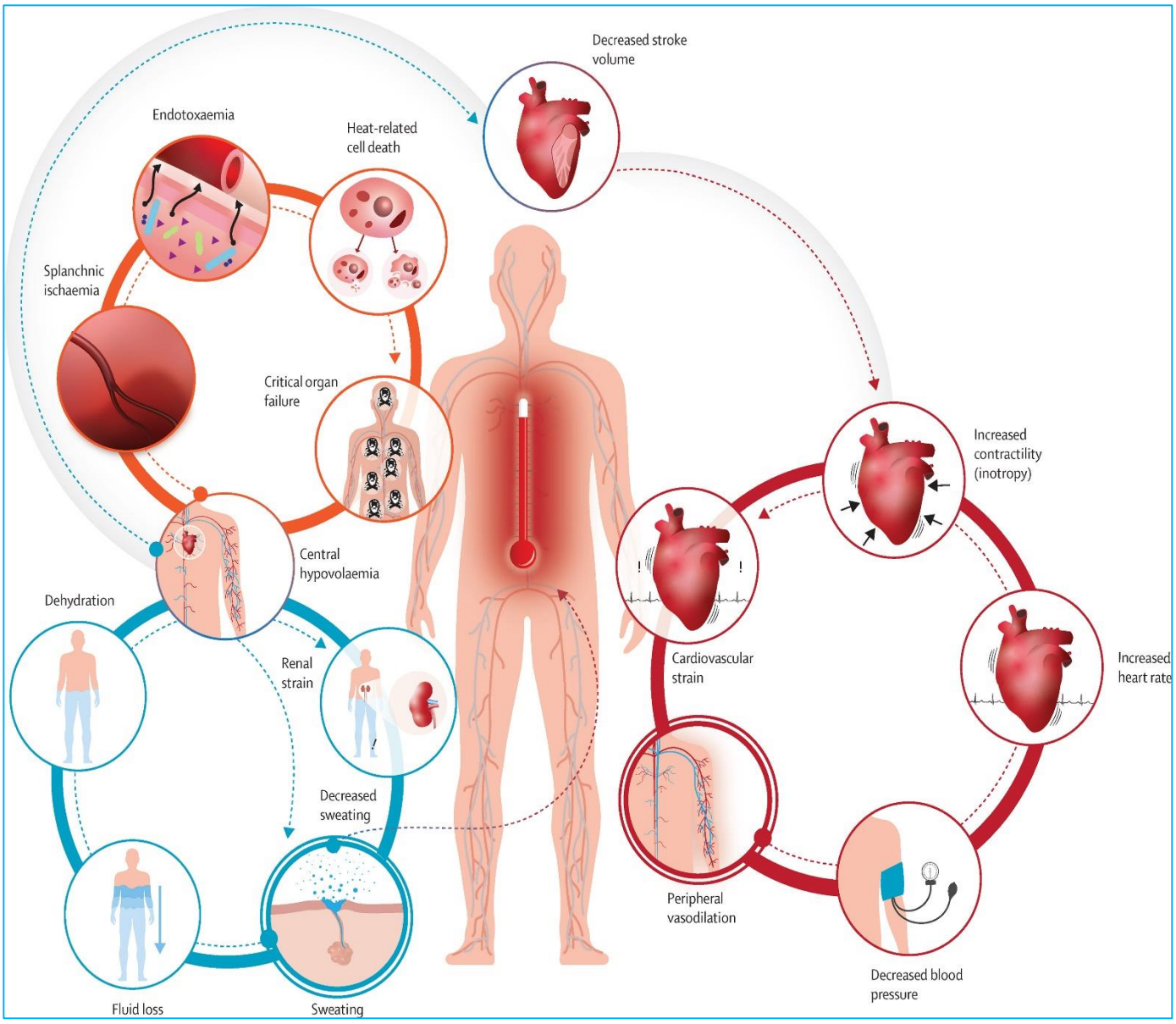

Figure 10: Illustration of the Physiological pathways of human heat strain, illnesses, and death (Source: The Lancet (28)).

Vector-borne diseases: The US has seen more frequent and longer-lasting heatwaves and a rise in vector-borne disease, with cases of diseases transmitted by mosquitoes, ticks and fleas such as Lyme disease and West Nile virus tripling between 2004 and 2016, according to the US CDC.

Labor productivity: In 2016, India experienced its hottest year in over a century, exceeding 45°C in northern parts, and "hundreds died from sunstroke" (29). The impact on agriculture was

significant with a loss of nearly 75,000 million hours of labor in 2017 (compared to 43,000 million hours in 2000), according to Lancet Countdown report.

Vulnerable Groups by Heat Risk

Though high temperatures impact us all, there are several groups that are especially vulnerable during heatwaves and hot weather.

Age and gender: Particularly 75+ year olds people (especially older women) are more vulnerable because of the body's diminished ability to regulate temperature and an increased possibility of having one or more health risks, such as chronic sickness or medication use (31). On the other hand, babies and young children under four years old are more sensitive to and at greater risk of extreme heat. Pregnant women are also more vulnerable and more likely to give birth prematurely in the week following a heatwave (30).

Figure 11: People who are particularly vulnerable to heat (30)

Health: People with chronic and underlying health issues, such as heart, lung or kidney disease and diabetes are particularly vulnerable since these conditions can worsen in hot temperatures (23). People with mental illness are more likely to endure significant discomfort during high temperatures, as well as an increased chance of suicide (32). People with significant physical or learning disabilities, restricted mobility, or Alzheimer's or Parkinson's disease may find it more difficult to alter their behavior to stay cool in hot weather (16).

Housing: People who live alone and live in a top floor flat, in dense urban areas or who live in poor-quality housing may be more vulnerable to extreme hot weather and homeless people are more exposed to the impacts of hot temperatures (16).

Socio-economic: Outdoor workers, those who work in hot places are more likely to suffer from heat-related illness and people on low incomes, those who are economically or socially

marginalized are also struggled with heatwaves because they can't afford transport and utility bills (23).

Heat Action Plans

One of the first heat action plans in the subcontinent was the Ahmedabad Heat Action Plan devised following a spike in deaths maximum temperature over 46°C on May 21, 2010. The HAP involved changing building construction to cooler designs (white painted roofs, etc.), improved hospital preparedness for heat stroke admissions, and establishing city-wide warning systems for coming heat waves (33).

Bangladesh currently has no established heat wave forecasting system, nor any system to convey such warnings to the general public. There is no widely accepted definition of heat wave for Bangladesh, but Nissan suggests "day and nighttime temperatures above the 95th percentile for 3 consecutive days (1). The establishment of these systems need to be a priority. It is well known that heat waves tend to occur in the pre-monsoon months (April-June) and are more likely if there has been a recent winter El Nino. There may be links also with the Indian Ocean Dipole.

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Available at: https://cch.icddrb.org/knowledge-briefs

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.

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