INTERNATIONAL DEVELOPMENT IN FOCUS

An Unsustainable Life

The Impact of Heat on Health and the Economy of Bangladesh

Iffat Mahmud, Wameq Azfar Raza,
and Syed Shabab Wahid

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Main Messages

- Bangladesh is facing an increasing onslaught of extreme heat events, with temperatures rising at an alarming rate. In line with global patterns, the maximum temperature in the country increased by 1.1°C, and the heat index—or "feels like" temperature—rose even more dramatically, by 4.5°C, between 1980 and 2023. The World Meteorological Organization (WMO) noted that the past nine years (2015–23) have been the hottest on record, globally as well as for Bangladesh, highlighting a concerning trajectory for climate-related health risks (WMO 2024).
- While Bangladesh ranks second globally in exposure to elevated temperatures, the case of the capital Dhaka, identified as a global hotspot for urban heat, is particularly concerning. Dhaka warmed notably faster than the rest of the country, as maximum temperature soared by 1.4°C between 1980 and 2023 compared to the national average of 1.1°C. The increase in the heat index for Dhaka is around 65 percent higher than the temperature increases recorded for Bangladesh as a whole. Rapid urbanization, population growth, and unplanned development resulting in loss of green space and vegetation are some of the factors contributing to the "urban heat island" effect in Dhaka.
- Evidence around heat-induced health issues from Bangladesh is largely limited and fragmented. This report—the first of its kind in Bangladesh—utilizes two rounds of nationally representative panel data encompassing over 16,000 individuals in 2024 to quantify the association between heat and physical and mental health and productivity. The findings reveal a troubling picture:
    - Among the surveyed population, persistent or chronic cough was the most frequently reported condition, affecting 6.0 percent of the surveyed individuals in summer compared to 3.3 percent in winter. The elderly population above age 66 years reported the highest

prevalence of persistent cough. In days with temperatures above 30°C, the probability of reporting cough increased by 22.7 percent, compared to days with temperatures below 30°C.

  - Heat exhaustion affected 2.6 percent of respondents during the summer. Heat exhaustion was the highest among the working population between ages 36 and 65 years and the older population above 66 years during the summer. During days with temperatures exceeding 35°C, the likelihood of suffering heat exhaustion increased by 26.5 percent, compared to days when temperatures are below 30°C.
  - The incidence of diarrhea varies significantly by season. During the summer, 4.4 percent of individuals reported having diarrhea, compared to 1.8 percent in winter. The largest burden of the disease is borne by children under age five and women. The probability of having diarrhea increased by 47.7 percent on days with temperatures over 35°C, compared to days with temperatures under 30°C.
  - Mental health is similarly affected by rising temperatures. The survey indicated that the prevalence of depression increased from 16.2 percent in winter to 20.0 percent in summer, while the prevalence of generalized anxiety disorders rose from 8.3 percent to 10.0 percent. During days above 35°C, the probability of reporting depression and anxiety increased by 23.8 percent and 37.1 percent, respectively, over days below 30°C.

- The unprecedented warming has led to a tangible burden on the Bangladesh economy. The report estimates that productivity losses due to heat-induced physical and mental health conditions amounted to 25 million lost workdays in 2024. The resulting economic losses are projected to be between $1.33 billion and $1.78 billion, which represents about 0.3 percent to 0.4 percent of Bangladesh's gross domestic product (GDP) in 2024. Furthermore, when temperatures exceed 37°C, compared with days below 30°C, productivity loss among working-age individuals increases significantly, underscoring the urgency for effective interventions.
- As the world moves toward a potential 3°C increase in global temperatures, the implications for health and well-being will be severe. Projections indicate that by 2030, Bangladesh could lose around 4.9 percent of its GDP due to the adverse effects of extreme heat (Ministry of Environment, Forest, and Climate Change 2022).

- The evidence presented in this report underscores the immediate need for comprehensive strategies to address the escalating health risks posed by climate change in Bangladesh. By leveraging both localized evidence and global insights, Bangladesh can create a more resilient future in the face of climate change. The following options are recommended:

    1. Enhancing national preparedness capacity to better cope with heat waves using a coordinated multisectoral approach.
    2. Strengthening the health sector response to deal with heat-related morbidity and mortality.
    3. Developing adequate preventive measures, using advanced technology, to deal with the adverse impacts of heat on health.
    4. Capturing granular and accurate data to improve the quality of weather information for effective decision-making.
    5. Seeking international support and financing for mitigating the impacts of global warming on Bangladesh.

- The trend toward increasing temperatures in Bangladesh and the consequent harm on the people's health and prosperity are significant and concerning. Bangladesh is not alone in this problem, and it can learn from best practices being used across the globe. Actions to mitigate heat waves and interventions that can help individuals moderate the effects are both urgent and within the capability of Bangladesh with the appropriate attention.

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Executive Summary

INTRODUCTION

Bangladesh is warming at an alarming rate—the maximum temperature increased by 1.1°C between 1980 and 2023. At the same time, the heat index, or "feels like" temperature (which combines humidity and temperature to assess impacts on human health brought on by heat), rose by 4.5°C. Heat waves from global warming have already caused more deaths than all other forms of natural disasters combined in many countries (Jay et al. 2021). Developing countries are particularly susceptible to heat-related adverse impacts because adaptation to climate change is expensive and a large proportion of the workforce is engaged in outdoor occupations (*Lancet* 2018). Countries in South and Southeast Asia, particularly Bangladesh, are vulnerable to a high burden of heat-related diseases (Burkart et al. 2021). Bangladesh ranks second globally in exposure to elevated temperatures, with its capital, Dhaka, identified as a global hotspot for urban heat (Zachariah et al. 2023). Despite the region's high vulnerability, research on the human health impacts of heat waves is limited (*Lancet* 2018; Zachariah et al. 2023).

To better understand the links between heat and health, this report responds to the following question: How does increasing exposure to excess heat affect the physical and mental health outcomes of individuals and their productivity in the short term? In doing so, the report sets the context with a historical analysis of temperature changes in Bangladesh between 1976 and 2023. Next, it uses nationally and subnationally representative two-round panel data comprising more than 16,000 individuals in Bangladesh from 2024 to quantify the impact of exposure to heat on physical and mental health conditions and productivity losses. The report thus serves three specific objectives: (1) grounded in localized evidence that links the effect of heat on health, recommend effective adaptation measures to reduce the vulnerabilities of the Bangladeshi population to heat; (2) quantify economic losses borne by the country due to global warming to assist Bangladeshi policy makers in leveraging international support and financing to mitigate the impacts; and (3) add evidence to the global discourse on heat and human health, especially mental health conditions and loss of productivity.

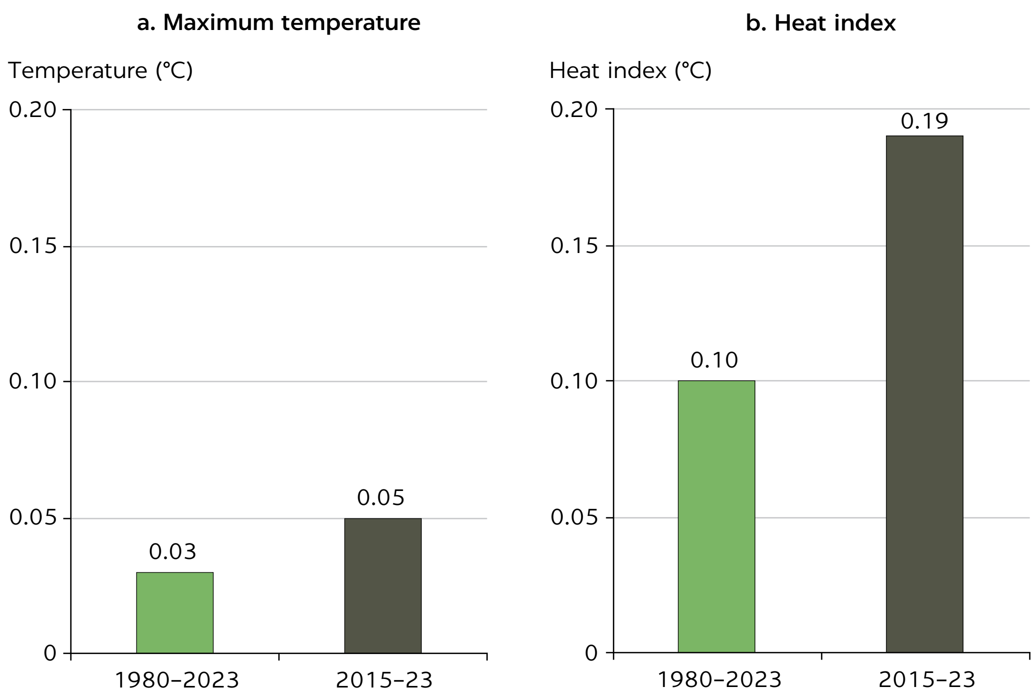
This report is first of its kind in Bangladesh, collecting data on specific physical and mental health conditions to establish the link between heat and health. The evidence-based policy recommendations derived from this study are applicable to other countries as well.

THE HEAT FACTOR IN BANGLADESH AND THE ASSOCIATED ECONOMIC COST

The pattern of rising temperatures for Bangladesh is consistent with global trends. The world witnessed a 1.45°C increase in maximum temperature in 2023 compared to the pre-industrial era (WMO 2024), much of it due to human-induced activities (Romanello et al. 2023). The World Meteorological Organization (WMO) noted the nine years from 2015 to 2023 as the hottest on record globally (WMO 2024). In line with this trend, Bangladesh has experienced a significantly higher rate of warming in the 7 years between 2015 and 2023 than in the 43 years between 1980 and 2023 (national averages). Concurrently, the heat index doubled over the same period (refer to figure ES.1).

FIGURE ES.1

Average annual increments of maximum temperature and the heat index for Bangladesh, 1980–2023

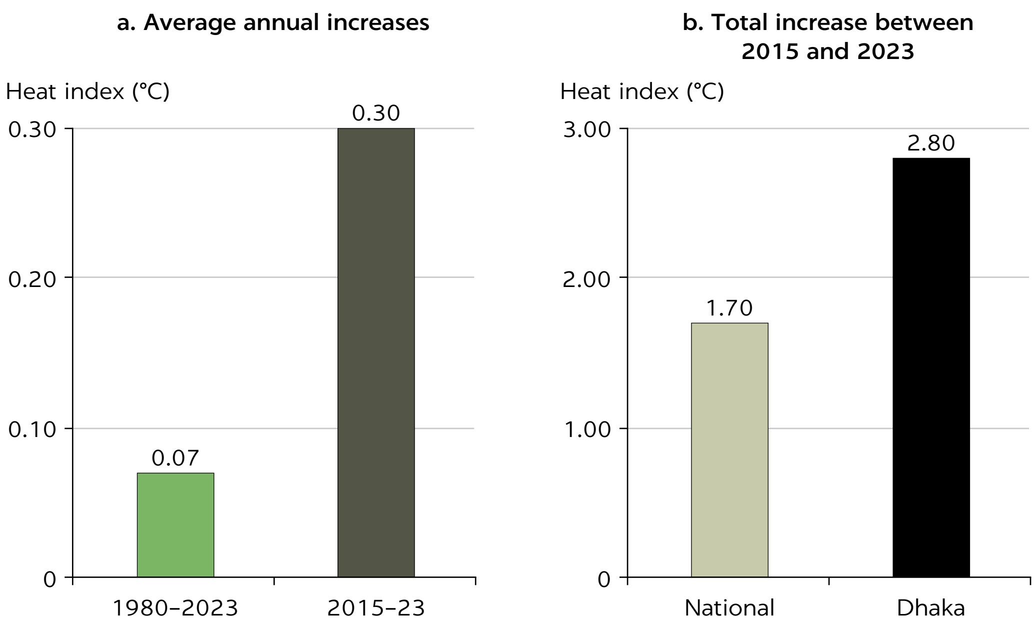


Source: Original figure based on primary data collected for this report.

Dhaka experienced notably higher temperature increases than the national average, as maximum temperature soared by 1.4°C between 1980 and 2023, higher than the national average of 1.1°C recorded over the same period. Dhaka's warming is disconcerting on two fronts (refer to figure ES.2). First, the incremental yearly increase in the heat index during the period 2015–23 was more than three times higher than the yearly increments recorded for the period 1980–2023. Second, the increase in the heat index for Dhaka is around 65 percent higher than the temperature increases recorded for Bangladesh as a whole. Rapid urbanization, population growth, and unplanned development are some of the factors contributing to the "urban heat island" effect in Dhaka. Between 1989 and 2020, Dhaka lost 47 percent of its dense green space and vegetation to make space for urban settlements (Nawar et al. 2022), which is one of the reasons for the rapid rise in temperatures.

FIGURE ES.2

Increases in the heat index in Dhaka, 1980–2023

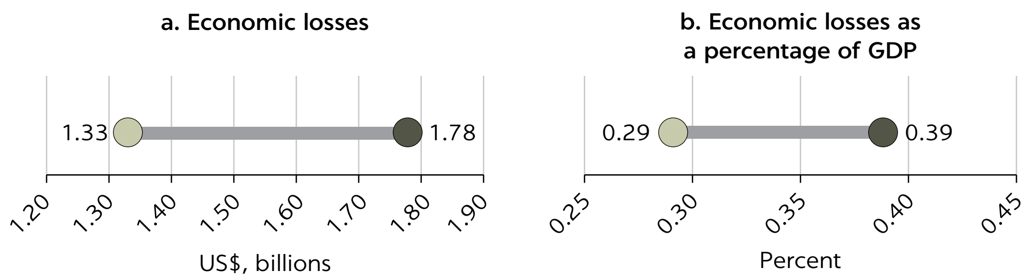


Source: Original figure based on primary data collected for this report.
Note: Figure is based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980; 2015 represents an average of 2013, 2014, and 2015; and 2023 represents an average of 2021, 2022, and 2023.

The unprecedented warming has led to a tangible burden on the Bangladesh economy (refer to figure ES.3). Using the two-round household panel survey data collected for this report, productivity loss was estimated to reach 0.25 billion days in 2024 due to temperature variations between the summer and winter seasons. Economic losses were attributed to heat-induced physical and mental health conditions among the working-age population. The resulting economic losses were estimated to be between $1.33 billion and $1.78 billion, or 0.3–0.4 percent of Bangladesh's gross domestic product (GDP) in 2024 (refer to figure ES.3). Productivity loss for each individual in the working-age population increased by 1.2 percent and 1.9 percent per month when exposed to additional days with maximum temperatures ranging from 35°C to 37°C and above 37°C, respectively, compared to days with temperatures below 30°C (refer to figure ES.4).

FIGURE ES.3

Heat-attributable loss to the economy

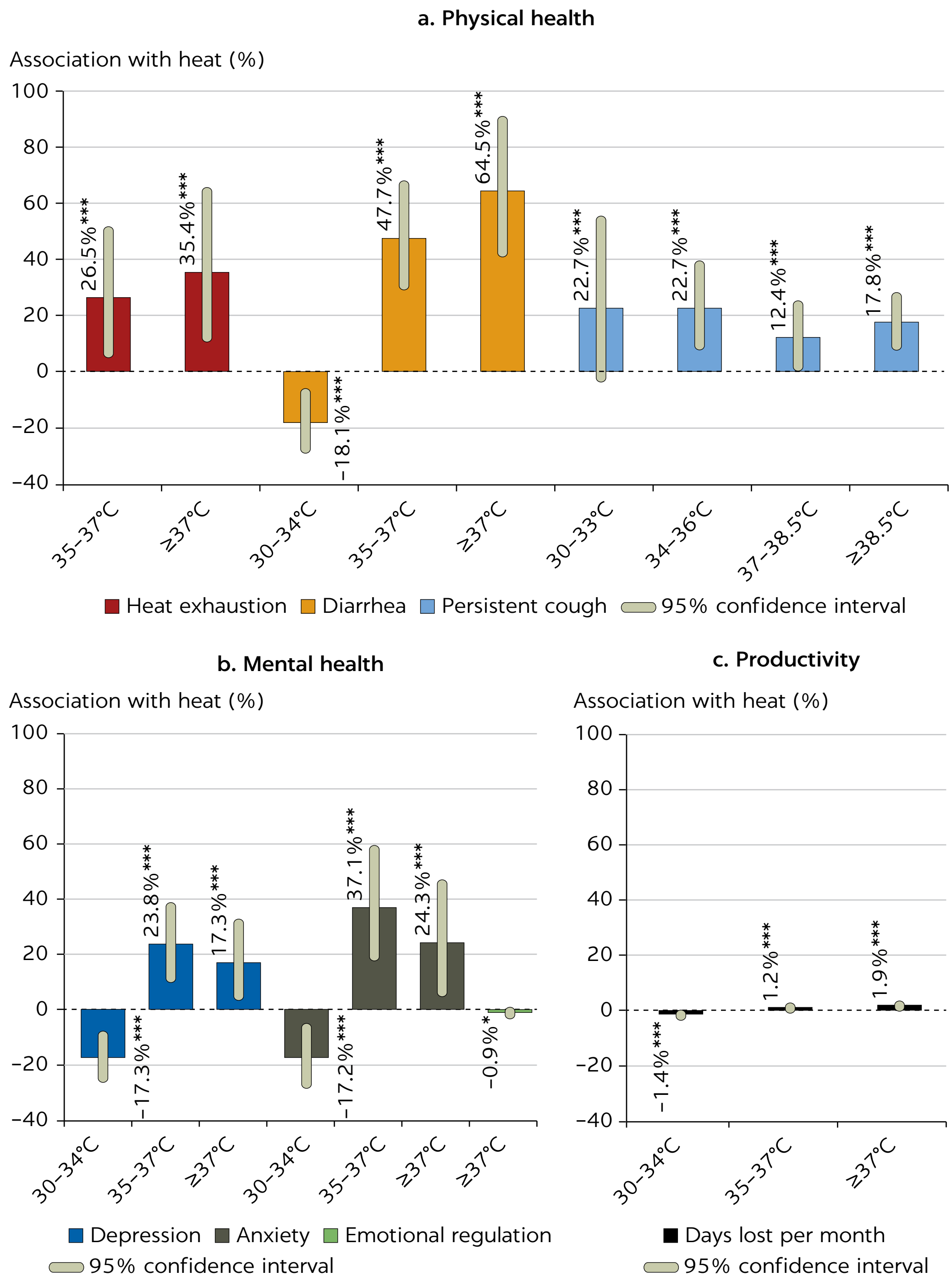


Source: Original figure based on primary data collected for this report.

Note: GDP = gross domestic product.

FIGURE ES.4

Association between additional days exposed to temperature ranges and selected health conditions



Source: Original figure based on primary data collected for this report.
Note: Figure shows the correlation between exposure to temperature ranges (compared to days below 30°C) and physical and mental health outcomes, and productivity—expressed as a percentage change in the probability (with 95 percent confidence intervals) of the outcome occurring. All models control for a vector of individual and household characteristics. Further details are available in the methods section. Emotional regulation is a psychological concept defined as an individual's capacity to manage their own emotional responses (Young, Sandman, and Craske 2019).
Significance level: *10 percent, **5 percent, ***1 percent.

SEASONALITY OF HEALTH CONDITIONS

Guided by global literature, information on specific heat-related physical conditions and mental health issues was collected during the survey. Of the four physical health conditions (heat exhaustion, heat stroke, diarrhea, and persistent cough), the most prevalent illness among the surveyed population was persistent or chronic cough lasting at least two weeks. Around 6.0 percent of the surveyed individuals nationally reported having persistent cough in the summer compared with 3.3 percent in the winter. The elderly population above age 66 years reported the highest prevalence of persistent cough, followed by those between ages 50 and 65 years. On average, 2.6 percent of the surveyed population experienced heat exhaustion during the summer, while the prevalence of heat stroke was considerably lower (approximately 0.5 percent at the national level). Heat exhaustion was the highest among the working population aged between 36 and 65 years (4.5 percent), followed by those above the age of 66 years (3.0 percent) during the summer. Women experienced heat exhaustion more than men, while those in urban locations were more vulnerable than rural ones. Diarrhea was reported by 4.4 percent of individuals nationally in the summer compared with 1.8 percent during the winter—a higher proportion reported by children under age 5 years and women than other age groups or men.

Depression and anxiety were more prevalent during the summer season than in the winter among the population above 15 years old. Depression was reported by 20.0 percent of the sample in summer and 16.2 percent in winter, while anxiety was reported by 10.0 percent of the respondents in summer compared with 8.3 percent in winter. Analyses of the heat-related health conditions by demographic and background characteristics are summarized in the following paragraphs. While both depression and anxiety positively rose with age, higher socioeconomic status played a more protective role.

ASSOCIATION BETWEEN TEMPERATURE AND HEALTH CONDITIONS AND PRODUCTIVITY

Risks to health and productivity are higher at temperatures exceeding 35°C. Figure ES.4 illustrates the relationship between physical and mental health conditions, as well as productivity, when exposed to additional days with maximum temperatures ranging from 35°C to 37°C and above 37°C, compared with days below 30°C. The likelihood of experiencing physical health issues such as heat exhaustion, diarrhea, or persistent cough increased with rising temperatures. Similarly, the probability of developing mental health conditions like depression and anxiety grew alongside higher temperature levels. The increase in the number of days with physical and mental health conditions, which caused working-age adults to be unable to carry out their usual activities, led to a loss in productivity.

Moreover, exposure to excessive heat, compared to the previous two decades, exacerbated these conditions. As a result, individuals lost productive days when exposed to temperatures between 35°C and 37°C, and even more so when temperatures exceeded 37°C.

LOOKING AHEAD

With the world heading toward a 3°C increase in global temperatures (Romanello et al. 2023), the impacts on the health and well-being of the population will be severe. Because of human-induced climate change, heat waves would be 2°C hotter than they would have been otherwise, and such extreme events are likely to occur once in five years over Bangladesh and India (Zachariah et al. 2023). Moreover, because of the synergistic relationship between heat waves and outdoor air pollution (Grigorieva and Lukyanets 2021) and Bangladesh's susceptibility to both of these extreme events, the adverse impacts on health may escalate substantially. By 2030, it is estimated that Bangladesh will have lost around 4.9 percent of its GDP to the adverse impacts of extreme heat (Ministry of Environment, Forest and Climate Change 2022). Urgent actions are therefore needed now. The following recommended policy options are based on the evidence contained in this report (refer to table ES.1):

- ***Enhance national preparedness capacities to deal with heat waves through a coordinated multisectoral approach***. As a first step, heat waves need to be explicitly identified as a natural disaster in government policy and planning documents. This step will ensure adequate protocols and measures are in place to address the situation effectively. A multisectoral task force needs to be established and effective protocols should be developed to plan and implement required interventions. Evidence-based heat action plans need to be developed, drawing from the lessons of other countries.
- ***Strengthen the health sector response for dealing with heat-related morbidity and mortality***. The Ministry of Health and Family Welfare (MoHFW) has developed national guidelines for managing heat-related illnesses that include very detailed actions for enhancing the capacity of the health systems for dealing with heat-related mortality and morbidity. These actions should be implemented and monitored effectively. Measures to deal with mental health conditions need to be mainstreamed. Moreover, health facilities need to be climate resilient.
- ***Ensure adequate preventive measures to deal with the adverse impacts of heat, using advanced technology***. Local governments and communities should use modern technologies to create awareness and disseminate knowledge about prevention of and adaptation to heat-related health conditions. Heat-health early-warning systems can be valuable when combined with surveillance of health issues caused by heat waves. Artificial intelligence, drones, or both could help identify potential zones to guide tree planting.

- ***Improve the quality of weather information for effective decision-making by capturing granular and accurate data***. Increase the number of weather stations to record more localized and better-quality data. Institute the use of the heat index for classifying heat waves and for issuing relevant health advisories.
- ***Advocate for international support and financing for mitigating the impacts of global warming on Bangladesh***. Use real-time data and cutting-edge knowledge to highlight the economic and social burden of heat waves and global warming to make a compelling case for international assistance and investments.

TABLE ES.1 Matrix of policy options

POLICY OPTION	ACTION
Better prepare to deal with heat waves.	Identify heat waves as one of the natural disasters addressed in government policy and planning documents.
	Develop standard operating procedures and protocols for dealing with the impacts of heat waves. This task should involve all relevant sectors, including infrastructure, power, health, education, disaster management, local government, urban areas, and the environment.
	Develop and implement area- and city-specific heat action plans, customized to the needs of the vulnerable population and the locality. Urban planning and building designs should be such that they allow heat to be dissipated and help people rest at night to recover from heat exposures during the daytime.
	Establish a multisector task force to manage heat waves similar to other natural disasters such as floods. Such a task force would activate mobile teams, issue health advisories, prepare health facilities, issue guidance to educational institutions to close down or operate for shorter hours, trigger social protection schemes, and so on.
Strengthen the health sector response.	Ensure health facilities are equipped to deal with heat-related morbidity and mortality.
	Provide targeted training for medical professionals to detect and treat heat-related conditions, including mental health issues.
	Prioritize vulnerable groups when treating patients affected by heat.
	Mainstream response to mental health issues through the provision of community-based solutions for prevention and treatment.
Promote preventive measures using advanced technology.	Develop heat-health early-warning systems using real-time weather data and reliable modeling techniques.
	Use innovative mechanisms to disseminate information and foster behavior change.
	Issue health advisories with heat alerts.
	Create urban green spaces to manage the “urban heat island” effect. Use artificial intelligence to map out potential green zones where trees can be planted.
	Mobilize communities, social influencers, and local leaders to create awareness about the adverse impacts of heat on human health.

continued

TABLE ES.1 *continued*

POLICY OPTION	ACTION
Record more granular and accurate data.	Increase the number of weather stations throughout the country to collect more localized information with accuracy.
	Calculate and use the heat index rather than dry-bulb temperature to classify episodes of heat waves.
Leverage international support and financing.	Prepare convincing evidence-based investment cases to leverage resources from the loss and damage fund.
	Advocate for active actions by the developed countries and the international community for mitigation using cutting-edge research.

Source: Original table for this report.

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Abbreviations

AOR	adjusted odds ratios
BMD	Bangladesh Meteorological Department
BMRC	Bangladesh Medical Research Council
CDC	US Centers for Disease Control and Prevention
CI	confidence interval
COPD	chronic obstructive pulmonary diseases
COVID-19	coronavirus disease
CVD	cardiovascular diseases
ERQ	Emotional Regulation Questionnaire
GAD-7	Generalized Anxiety Disorder-7
GDP	gross domestic product
HDI	human development index
IOD	Indian Ocean Dipole
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHFW	Ministry of Health and Family Welfare
MSE	mean squared error
NAP	National Adaption Plan for Bangladesh 2023–50
NWS	National Weather Service
PHQ-9	Patient Health Questionnaire-9
PM	particulate matter
PPS	probability-proportional-to-size
PSUs	primary sampling units
UHI	urban heat island
WMO	World Meteorological Society

Part 1

Background and Context

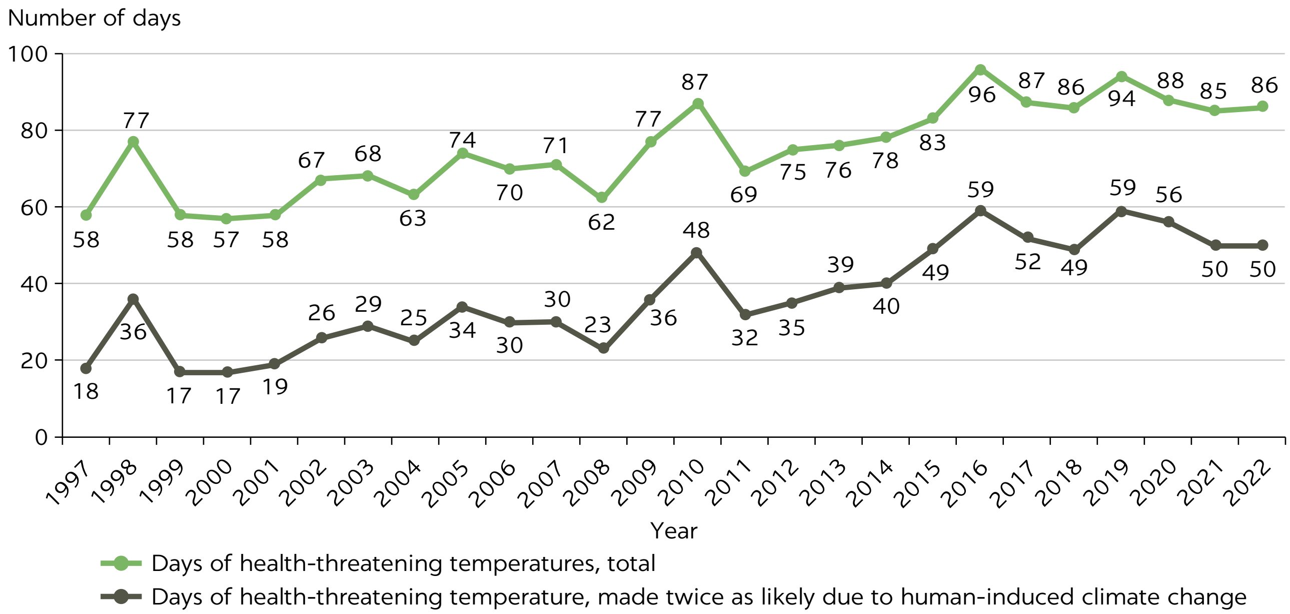
1 Background and Introduction

GLOBAL AND LOCAL CONTEXT: HEAT AND HEALTH

Globally, the year 2023 was the hottest year on record with a mean near-surface temperature of approximately 1.45°C above the average for the preindustrial era (1850–1900) (WMO 2024). This followed the hottest nine consecutive years (2015–23) worldwide (WMO 2024). Human activities are causing much of this global warming. In 2020, 60 percent of the days with health-threatening high temperatures were more than twice as likely to occur because of anthropogenic climate change (refer to figure 1.1) (Romanello et al. 2023). Heat waves are already responsible for more deaths than all other forms of natural disasters combined in many countries (Jay et al. 2021). Developing countries are particularly susceptible to the risks associated with rising temperatures, as adaptation to climate change is expensive and outdoor labor is more common in such countries (*Lancet* 2018). South and Southeast Asia are particularly vulnerable to the impacts of global warming because of the region's topography and climate, with high temperatures and humidity prevalent throughout the year (Zachariah et al. 2023). South Asia experiences the largest annual increases in heat exposure, with Bangladesh ranking second among all countries in the world exposed to elevated temperatures (Zachariah et al. 2023). Sub-Saharan and North Africa, the Middle East, and South and Southeast Asia are prone to a high burden of diseases attributable to heat (Burkart et al. 2021). Bangladesh's capital city, Dhaka, is one of the places worst affected by urban heat globally and is at high risk of extreme heat episodes that will adversely affect human health and living standards (Zachariah et al. 2023). Heat waves, however, are a relatively recent threat, and more work is needed to fully understand their impact (*Lancet* 2018).

FIGURE 1.1

Exposure to health-threatening heat, measured as average number of days per year



Source: Romanello et al. 2023.

Air pollution and high temperatures combined have substantial adverse impacts on health, particularly respiratory illnesses (Grigorieva and Lukyanets 2021). In the Republic of Korea, for example, the highest risk of cardiovascular or nonaccident-related mortality caused by air pollution, as measured by exposure to coarse particulate matter (PM_{10}), was recorded on very hot days (Satbyul, Youn-Hee, and Ho 2015). With increasing concentration of air pollutants like fine particulate matter ($PM_{2.5}$), along with ozone, carbon monoxide, and so on during heat waves, hospital admissions are higher for patients with chronic obstructive pulmonary disease, asthma, and acute and chronic bronchitis (Grigorieva and Lukyanets 2021).

The WMO predicts temperatures will rise further and the average global near-surface temperature for each year between 2023 and 2027 will be between 1.1°C and 1.8°C higher than the average for 1850–1900 (WMO 2023). The likelihood that the April 2023 heat wave, when South and Southeast Asia experienced a prolonged bout of heat, will reoccur has increased by at least a factor of 30 over Bangladesh and India because of anthropogenic climate change (Zachariah et al. 2023). Zachariah et al. (2023) further predict that a heat wave that is 2°C hotter than it would be in a climate not warmed by human activities is likely to occur once in five years in any given year over Bangladesh and India. They also predict a humid heat wave is likely every one to two years over Bangladesh and India, under a 2°C global warming scenario. A synergistic relationship exists between heat waves and outdoor air pollution, and with both air pollution and extreme heat becoming more frequent, the threat to public health will escalate in the future (Grigorieva and Lukyanets 2021).

With the world heading toward a 3°C increase in global temperatures (Romanello et al. 2023), adaptation may not be as effective. According to the Intergovernmental Panel on Climate Change, between half and three-fourths of the world population will be exposed to life-threatening heat by 2100 (Dodman et al. 2022). About 1.2 billion people will be exposed and vulnerable to heat-related morbidity and mortality if the temperature increases by 1.5°C, and the number increases to about 1.7 billion people if the temperature rises by 3°C (Ebi et al. 2021). This increase will have serious consequences, with catastrophic impacts on the lives and livelihoods of people brought on by higher levels of mortality and morbidity. The annual average number of hours per person posing moderate risk of heat stress from light physical activity (like walking) is projected to increase by 426 hours by 2040–60, under a scenario where global warming is limited to 2°C increase (Romanello et al. 2023). Exposure of older adults ages 65 years and up to heat waves is projected to increase, under a scenario compatible with 2°C of global warming, by 1,120 percent circa 2041–60 and 2,510 percent by 2080–2100 (Romanello et al. 2023). Such a high level of exposures is likely to cause an increase of 370 percent by 2041–60 in annual heat-related mortality among this cohort ages 65 years and up, above the average for 1995–2014 (Romanello et al. 2023). Without strong adaptation and mitigation measures, heat-related morbidity, mortality, and productivity losses are expected as climate change is projected to worsen (Ebi et al. 2021).

IMPACT OF HEAT ON HUMAN HEALTH AND PRODUCTIVITY: ECONOMIC IMPLICATIONS

Heat increases the risk of mortality by 0.42 percent mediated through a range of health conditions: cardiac, issues related to blood thickness and coagulability, alteration of fluid and electrolyte balance, and so on (Gasparrini et al. 2015). Two leading causes of death during heat waves are cardiovascular diseases and heat-derived lung damage (Ebi et al. 2021). Ischemic heart disease, stroke, conditions affecting the heart muscles (cardiomyopathy and myocarditis), hypertension, diabetes, chronic kidney diseases, lower respiratory infection, and chronic obstructive pulmonary disease tend to have a J-shaped relationship with temperature—that is, mortality increasing below and above threshold temperatures while risk of mortality increased monotonically with temperature for external causes like homicide, suicide, drowning, unintentional injuries, and so on (Burkart et al. 2021).

The human body responds to heat in two primary ways to cool itself: first, it redirects blood flow toward the skin to improve the rate at which heat is transferred from the muscles to the skin and subsequently dissipates, which requires the heart to beat faster and pump blood harder

(Ebi et al. 2021); second, it produces sweat that then evaporates to remove heat from the body. These physiological responses are regulated by the brain and temperature-sensitive nerve cells and when the body is exposed to extreme heat, these thermoregulatory capacities can be exceeded. The result can be overheating of the body leading to heat stroke that can be fatal if left untreated (Ebi et al. 2021). Excessive sweating can decrease blood volume and eventually worsen existing cardiac issues and also lead to acute renal injury and failure (Ebi et al. 2021). Heat also affects the lungs by increasing pulmonary stress caused by rapid breathing and elevated air pollution (Ebi et al. 2021). Exposure to hot air can cause irritation to the airway and result in cough, particularly among people with preexisting respiratory conditions (Hayes et al. 2012; Mehdi et al. 2014). Because exposure to heat causes multifaceted damage, heat-derived injuries can be dangerous even after the body cools down to normal temperatures (Ebi et al. 2021).

Excess risk to health from heat exposure is more immediate, occurring within a few days, compared with cold spells, the adverse effects of which can extend up to a month (Gasparrini et al. 2015). Older people, younger children, women, people with underlying health conditions, and those who are not wealthy are more vulnerable to heat waves. Between 2013 and 2022, adults over 65 years of age and children 12 months or below were exposed to twice the number of days than in the period 1986–2005 (Romanello et al. 2023). The risk of heat-related mortality increases with social isolation and reduced behavioral capacity to respond and adapt to heat for people who, for example, live alone, are unable to care for themselves, are bedridden, or have preexisting mental health conditions that preclude self-care (Ebi et al. 2021). During the 2003 heat wave in Paris, for example, 90 percent of people who died lived alone (*Lancet* 2018). Heat-related deaths among the population over 65 years increased by 85 percent in the period 2013–22 compared with the period from 1990 to 2000. In contrast, if temperatures had not changed, mortality among this age group would have increased by only 38 percent (Romanello et al. 2023). Women tend to experience more heat-related impacts than men because of existing gender differentials and cultural and societal norms, as well as the greater household responsibilities borne by women (like cooking, childcare, fetching water, and so on) (Zachariah et al. 2023). In coastal Bangladesh, women exposed to temperatures between 28°C and 32°C have a 25 percent higher risk of miscarriage compared with exposure to temperatures 16°C–21°C (Das et al. 2023). Unusually high body temperatures caused by heat directly diminish the capacity for physical work as well as for tasks requiring complex cognitive functions and motor skills (Ebi et al. 2021). Poverty is also a contributing factor—poor-quality housing can overheat at relatively lower temperatures, while the comparably high cost of utilities (like water and electricity) can make it more difficult for bathing or mechanical cooling (*Lancet* 2018). Physiological responses to elevated temperatures are needed to limit heat-related strains and mortality, and such capacities may vary between individuals because of preexisting medical conditions as well as use of alcohol, medications, and illegal narcotics (Ebi et al. 2021).

Temperatures higher than long-term averages are strongly associated with increased emergency room visits and inpatient admissions as well as excess all-cause mortality (Ebi et al. 2021). Ensuring uninterrupted availability of health care services is challenging during heat waves as the demand for these services increases. At the same time, hospitals, particularly in developing contexts, are often not designed to cope with heat, are built with insulation that retains heat, and are vulnerable to spikes in temperatures driven by the equipment in the hospitals (*Lancet* 2018). Even with adaptive measures, higher temperature levels can impede the extent to which heat-related morbidity and mortality can be prevented because physiological limits may be reached when the human body is no longer able to cope with the heat (Ebi et al. 2021).

Heat waves potentially increase the risk of heat-related illnesses for people engaged in outdoor activities. At 20°C temperature and higher, productivity of manual labor starts declining and progressively falling with rising temperature (Ebi et al. 2021). Average annual hours per person when light physical activity (like walking) caused moderate risk of heat stress increased by 241 hours, or almost 20 percent, in 2012–22 compared with 1991–2000, while moderate-intensity activity like jogging or cycling resulted in an increase of 253 hours per person of risk of heat stress (Romanello et al. 2023). For outdoor workers, excess heat generated by heavy physical activity associated with certain occupations, coupled with high ambient temperature, low airflow, and high humidity, severely add to human strains (Ebi et al. 2021). Consequently, heat waves can have significant economic impacts because mortality, morbidity, and people's inability and unwillingness to work increase. For instance, aside from physiological effects, exposure to excess heat also has psychological effects, leading to further loss of productivity. Heat stress can cause common depressive and anxiety disorders, increasing the likelihood of absenteeism and presenteeism (Dasgupta et al. 2021; Kjellstrom, Holmer, and Lemke 2009).

Average financial loss caused by heat-related mortality was US$164 billion, or 0.17 percent of gross world product, between 2018 and 2022,[1] compared with 2000–04. That 2018–22 average was approximately 146 percent higher than the average for 2000–04 (Romanello et al. 2023). In addition, additional losses were incurred because of productivity loss. In 2022, heat waves caused a potential income loss of US$863 billion due to reduction in labor productivity globally, which is equivalent to 0.87 percent of gross world product—of these total losses, sectors requiring outdoor labor were the most affected, such as the agricultural sector accounting for 40 percent and construction, 31 percent (Romanello et al. 2023). Countries with low and medium human development index

(HDI)[2] experienced the highest average income losses, which were estimated at 6.1 percent and 3.8 percent of their gross domestic product (GDP), respectively (Romanello et al. 2023).

OBJECTIVES AND PURPOSES OF THE REPORT

This report, using national and subnational representative household-level data from Bangladesh and evidence from existing literature, responds to the question, How does increasing exposure to excess heat affect the physical and mental health of individuals and their productivity in the short term? In doing so, the report serves three purposes: (1) provides evidence that directly links the effect of heat on health and recommends that policy makers and key stakeholders in Bangladesh implement effective heat protection and adaptation measures to deal with future bouts of heat waves; (2) quantifies the economic burden of heat waves on Bangladesh to make a better case for mobilizing resources from the loss and damage fund; and (3) contributes to the global discourse by filling an important knowledge gap in linking heat to mental health conditions.

APPROVAL AND QUALITY ASSURANCE PROCESSES

The ethical approval for this study was obtained from the Bangladesh Medical Research Council (BMRC) and its terms and conditions adhered to during field work. The following procedures were followed:

- Written informed consent of the interviewee was obtained.
- Names of respondents were not recorded; instead, a unique identity number was attached to the household. The privacy of information collected was ensured by keeping it anonymous (not attaching names of the respondents to the data).
- Data on nationality and religion were not collected.
- Respondents' personal information was not included in data files.
- Results were presented in aggregate form, without identifying any individual.

The draft report was shared with the Ministry of Health and Family Welfare and the Ministry of Environment, Forest, and Climate Change of the government of Bangladesh before finalization. For quality assurance, the report was reviewed at an internal World Bank meeting, chaired by Abdoulaye Seck, Country Director for Bangladesh and Bhutan. The review was organized to discuss the methodology and findings and the potential implications of the conclusions and recommendations for Bangladesh.

Detailed discussions during the internal review and extensive comments provided by the reviewers were used in finalizing the report. Reviewers included Eun Joo Allison Yi (Senior Environmental Specialist), Martin Heger (Senior Environmental Specialist), and Stephen Geoffrey Dorey (Senior Environment and Health Specialist) from the World Bank.

NOTES

1. Gross world product is the combined gross domestic product of all countries in the world. See "Gross World Product," Wikipedia.org, https://en.wikipedia.org/wiki/Gross_world_product.
2. Human development index (HDI) is a composite measure of three indicators: life expectancy at birth, education (average years of school completed for adults ages 25 years and more, and expected years of schooling for children of school-entering age), and gross national income per capita. Bangladesh is a medium HDI country. See United Nations Development Programme, "Human Development Index," https://hdr.undp.org/data-center/human-development-index#/indicies/HDI.

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2 Frequency of Extreme Heat in Bangladesh: 1976–2023

INTRODUCTION

This section analyzes patterns in the maximum dry-bulb temperature and heat index from 1976 to 2023 on the basis of data available from the Bangladesh Meteorological Department (BMD). The chapter first explains the concept of the heat index. Particular attention is paid to the period between 2015 and 2023 because those years were globally the warmest nine years on record (WMO 2024). The analyses in this chapter reveal that the patterns observed in Bangladesh are in line with the changes in global temperatures. Data for the Dhaka district are presented separately to ascertain the "urban heat island" (UHI) effect on the capital city.[1] UHI is a phenomenon used to describe urban areas experiencing higher temperatures by absorbing more solar radiation than surrounding rural areas (Kim, Henry, and Jain 2023). At night, UHI is amplified when heat stored during the daytime is emitted and intensified inside a building, especially in highly dense cities and those with a larger population size (Ebi et al. 2021).

THE HEAT INDEX: DEFINITION AND RELEVANCE

In the absence of a globally accepted definition, the standard meteorological approach defines a heat wave as a temperature increase of 5°C or more above the average maximum temperature recorded for the period 1961–90, lasting for at least five days (*Lancet* 2018). The heat index, a composite function of the dry-bulb temperature and relative humidity, is a more pertinent indicator of human health impacts related to heat stress. During humid heat waves, the human body is unable to evaporate sweat, causing body temperature to rise and triggering a vicious cycle—rising body temperature leads to further loss of moisture through sweat as the body attempts to cool, resulting in dehydration, fatigue, and fatalities caused

TABLE 2.1 Heat index classification

TEMPERATURE	CLASSIFICATION
Over 54°C	**Extreme danger**—Heat stroke is imminent.
41–54°C	**Danger**—Heat cramps and heat exhaustion are likely; heat stroke is probable with continued activity.
33–40°C	**Extreme caution**—Heat cramps and heat exhaustion are possible. Continuing activity could result in heat stroke.
27–32°C	**Caution**—Fatigue is possible with prolonged exposure and activity. Continuing activity could result in heat cramps.

Source: United States, NWS 2020.

by heat strokes (Zachariah et al. 2023). Many countries now regularly report heat indexes alongside surface temperature, because the heat index provides a more comprehensive understanding of thermal discomfort and potential health risks (Zachariah et al. 2023). Risks to human health and comfort associated with the heat index are categorized as shown in table 2.1.

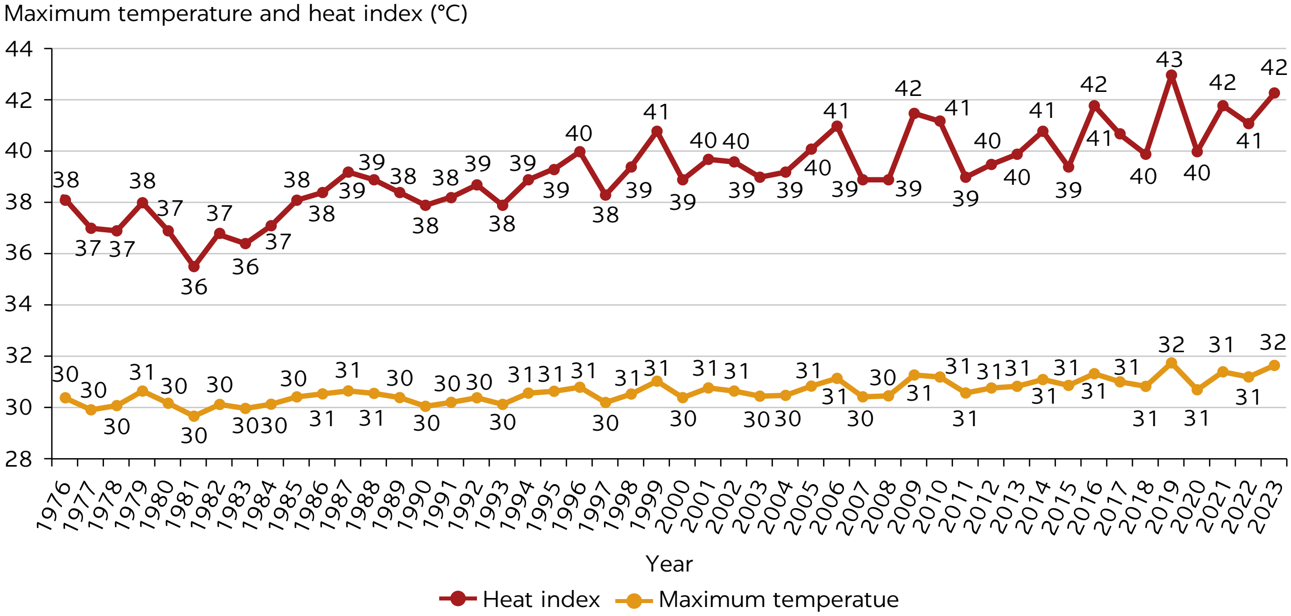
HEAT AND TEMPERATURE PATTERNS FOR BANGLADESH (NATIONAL AVERAGES)

Between 1980 and 2023 (using three-year moving averages), the annual maximum temperature increased by 1.1°C (or 4 percent), at a rate of 0.03°C per year. Over the same period, the heat index increased by 4.5°C, which is three times more than the average maximum temperature, at a rate of 0.10°C per year. The average maximum temperature and heat index from 1976 to 2023 are depicted in figure 2.1, using BMD's data. Consistent with global patterns, the increases in both maximum temperature and heat index were significantly higher for the period 2015–23; maximum temperature increased by 0.5°C while the heat index increased by 1.7°C over this period. As shown in figure 2.2, maximum temperature increased at a rate of 0.05°C per year between 2015 and 2023 compared with 0.03°C per year between 1980 and 2023 while the heat index doubled in the past nine years at a rate of about 0.2°C between 2015 and 2023 compared with 0.1°C between 1980 and 2023 (using three-year moving averages).

Measured by the heat index, the hottest part was southern Bangladesh with an average heat index of 43.7°C in 2023 compared with 1980, when it was the third warmest zone with an average heat index of 38.1°C (using three-year moving averages). The northern and central parts of Bangladesh also experienced considerable increases in the heat index, higher than the national average. Figure 2.3 and map 2.1 depict the zones with the highest heat index in 2023 compared with 1980 as well as the incremental change over the period.

FIGURE 2.1

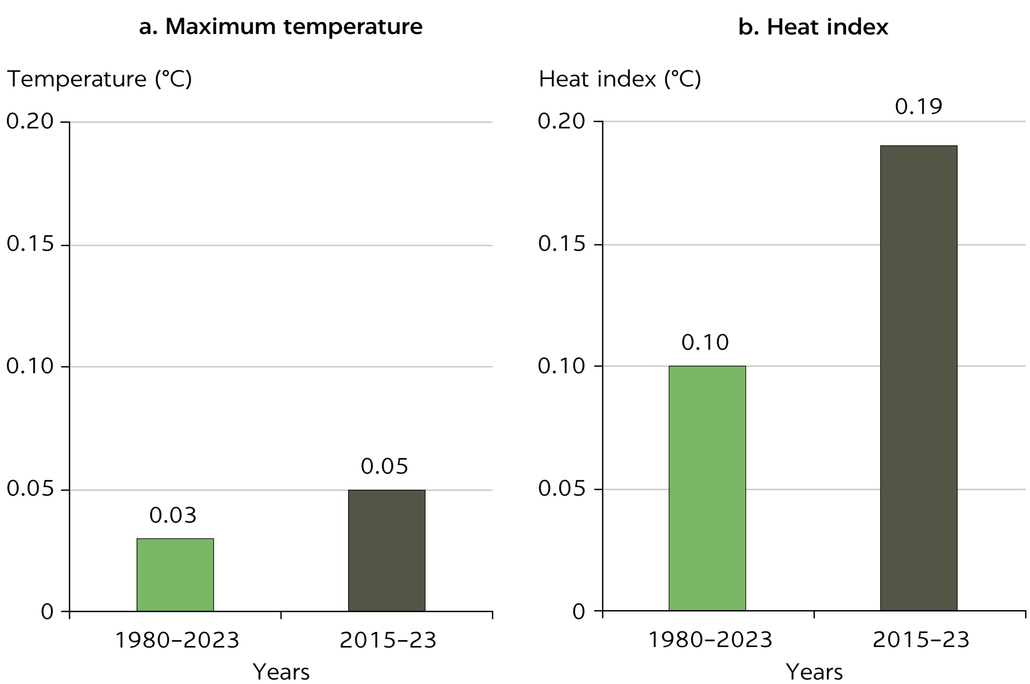
Annual maximum temperature and heat index for Bangladesh (national average), 1976–2023



Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.

FIGURE 2.2

Average annual increments of maximum temperature and heat index for Bangladesh, 2015–23 compared with 1980–2023

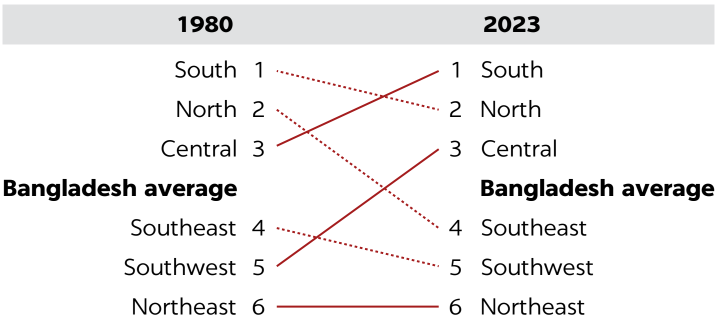


Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.
Note: The figure is based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980; 2015 represents an average of 2013, 2014, and 2015; and 2023 represents an average of 2021, 2022, and 2023.

FIGURE 2.3

Warmest zones of Bangladesh, measured by heat index, 1980 and 2023

a. Ranking of various zones by heat index (°C)



b. Increase in the heat index as a percentage of 1980 (°C)

Rank	Zone	Percent
1	South	14.7
2	North	13.2
3	Central	12.1
	Bangladesh average	**12.0**
4	Southeast	11.7
5	Southwest	8.5
6	Northeast	6.1

Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.
Note: Figures are based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980, and 2023 represents an average of 2021, 2022, and 2023. The zones cover the following administrative divisions of Bangladesh: central, Dhaka and Mymensingh; northeast, Sylhet; southeast, Chattogram; south, Barisal; southwest, Khulna; and north, Rajshahi and Rangpur.

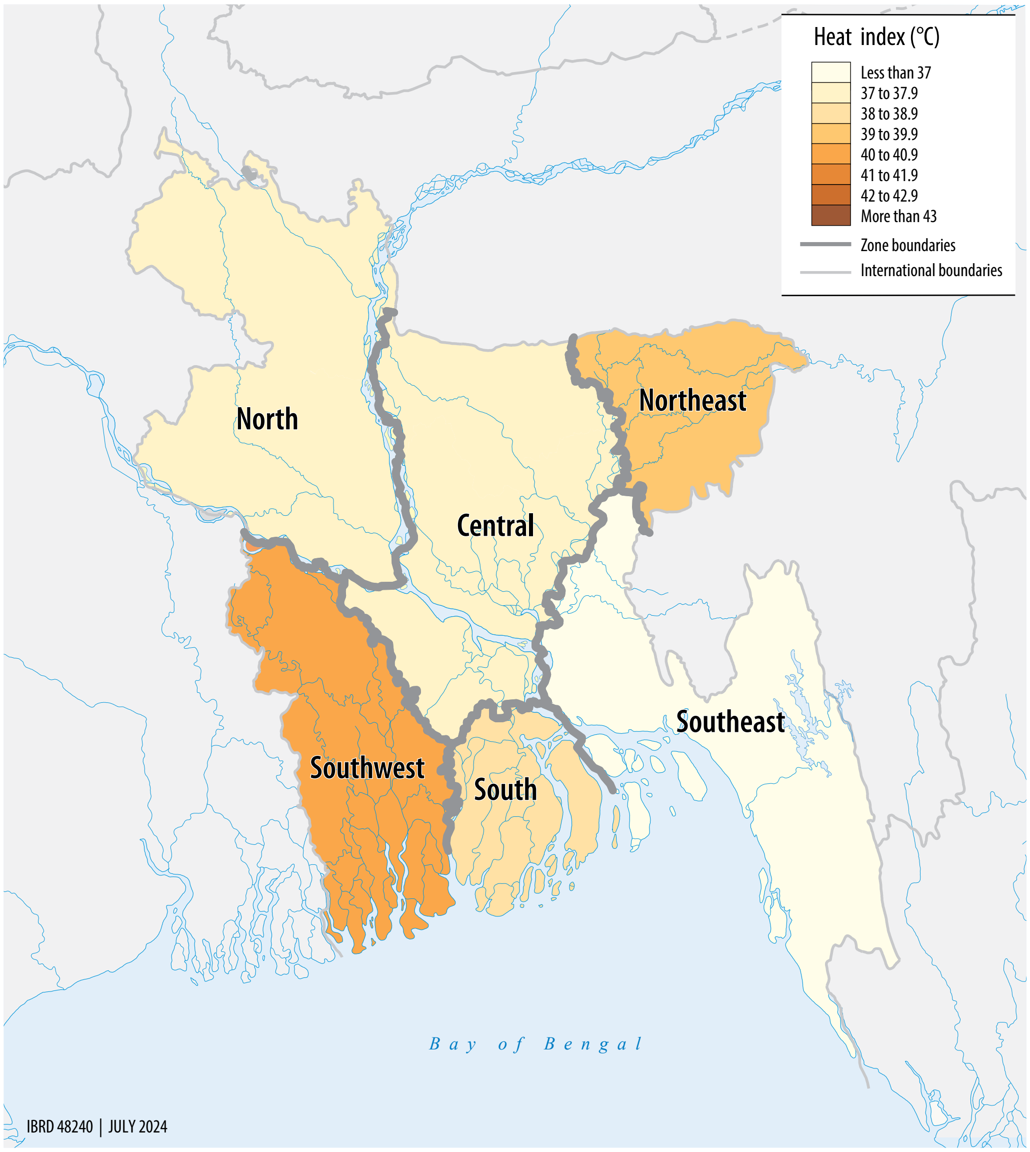
The increases in the heat index between 1980 and 2023 (using three-year moving averages) varied significantly across Bangladesh, with the highest increases observed in the south (5.6°C or a 14.7 percent increase) and north (4.9°C or a 13.2 percent increase), followed by the central zone (4.5°C or a 12. 1 percent increase). The lowest increase in the heat index was recorded for the northeast of Bangladesh of 2.4°C or a 6.1 percent increase. The southwest part experienced an increase in the heat index of 8.5 percent or a 3.4°C, which is significantly lower than the south, southeast, north, and central parts of the country. This change could be partly explained by the Indian Ocean Dipole (IOD) phenomenon.[2] The central part, in terms of the average heat index, ranked the fifth highest (41.6°C) in 2023 compared with the fourth highest (37.1°C) in 1980; however, with regard to incremental change as a proportion of the 1980 baseline, the increase in central Bangladesh was the third highest (12.1 percent). The central zone includes Dhaka, where the “urban heat island” effect is a factor, as further described in this chapter.

Globally, July is typically the warmest month and July 2023 was the hottest on record (WMO 2024). Consistent with this pattern, the heat index for July in Bangladesh noted the largest increase between 1980 and 2023 (using three-year moving averages). The monthly variation in the heat index is presented in figure 2.4. The heat index in July 2023 was 15 percent higher than that recorded in 1980.

MAP 2.1

Variation in the heat index across Bangladesh: 1980 and 2023

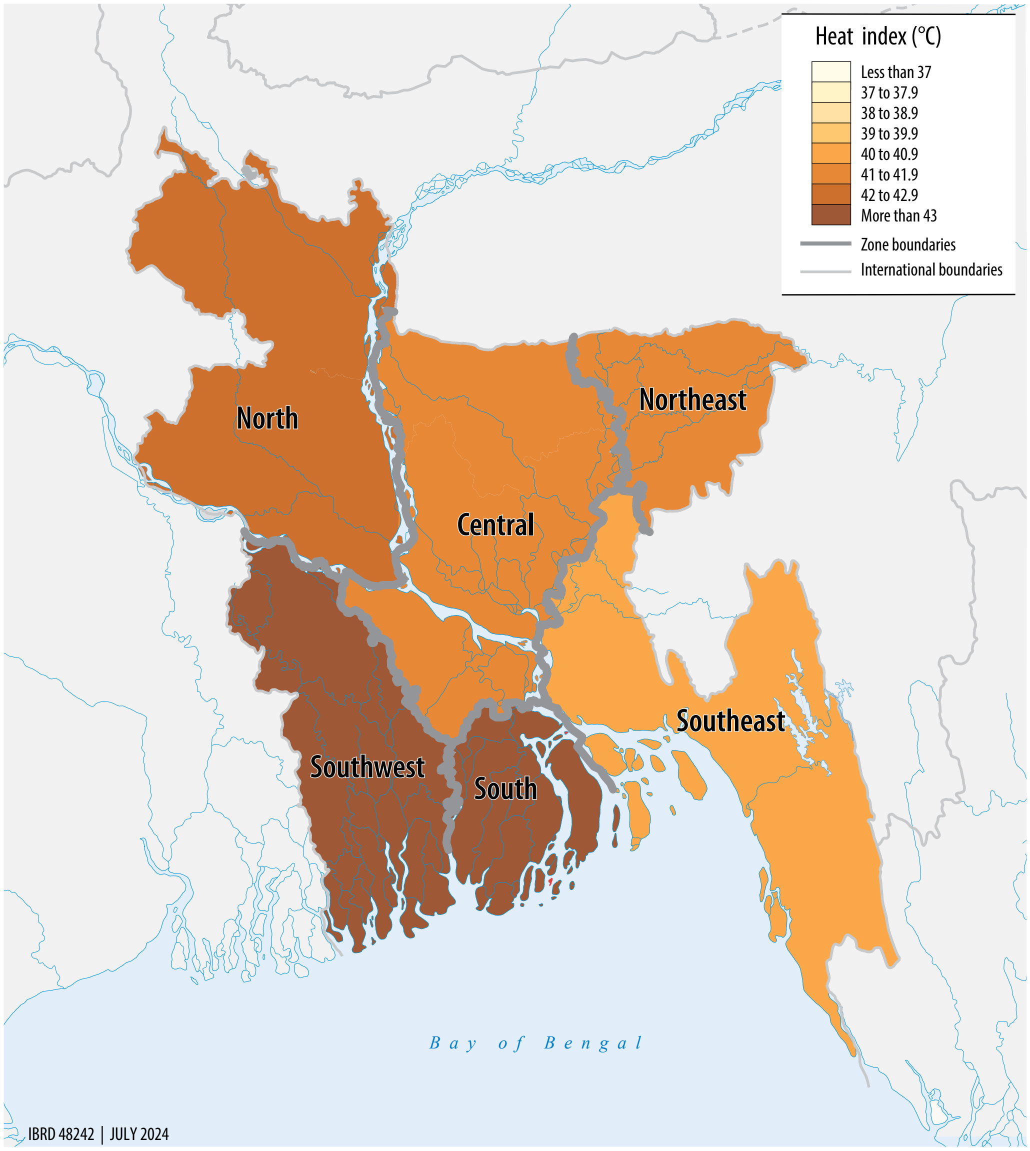
a. 1980



continued

MAP 2.1 *continued*

b. 2023

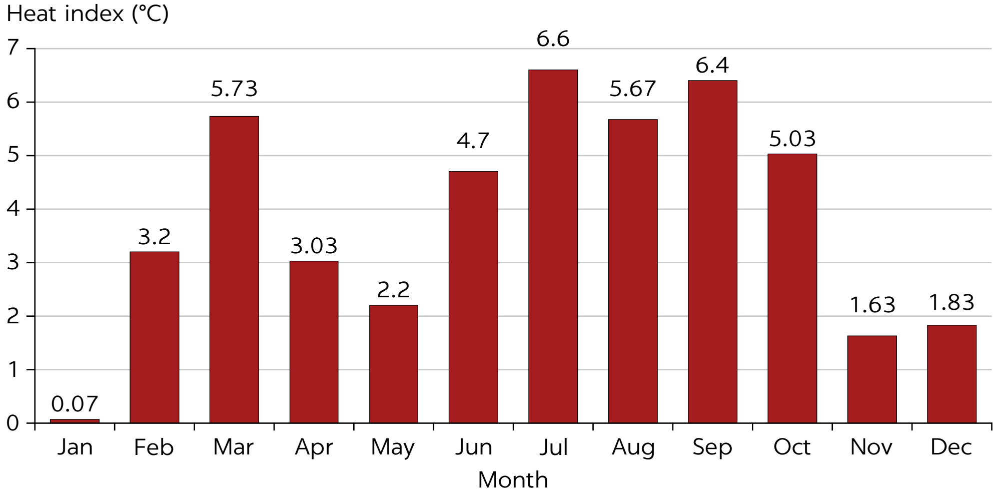


Source: Original map for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.

Note: Maps are based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980, and 2023 represents an average of 2021, 2022, and 2023. The zones cover the following administrative divisions of Bangladesh: central, Dhaka and Mymensingh; northeast, Sylhet; southeast, Chattogram; south, Barisal; southwest, Khulna; and north, Rajshahi and Rangpur.

FIGURE 2.4

Monthly variation of the heat index for Bangladesh, 2023 compared with 1980



Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.

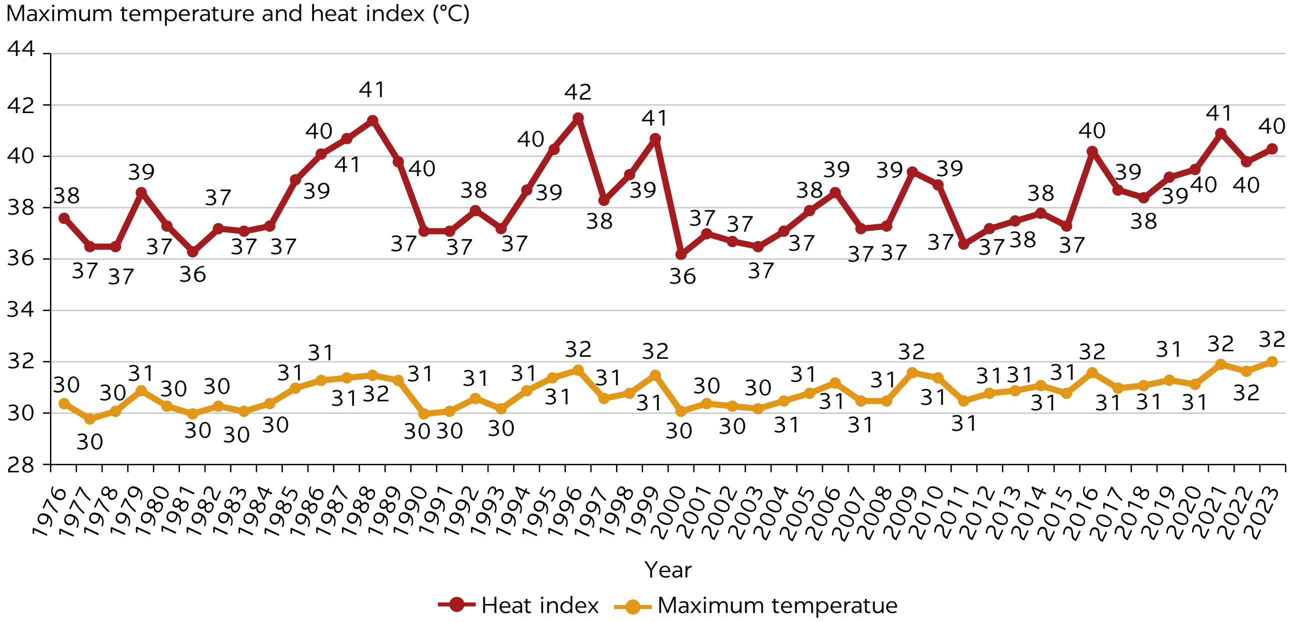
Note: Figure is based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980, and 2023 represents an average of 2021, 2022, and 2023.

HEAT AND TEMPERATURE PATTERNS FOR DHAKA

Dhaka recorded an increase of 1.4°C in maximum temperature between 1980 and 2023 (using three-year moving averages), which is considerably higher than the national average of 1.1°C recorded over the same period. This 1.4°C increase in maximum temperature translated to an increase in the heat index by 2.9°C or 7.7 percent, at a rate of 0.07°C per year, between 1980 and 2023 (using three-year moving averages). Figure 2.5 presents the increases in maximum temperature and the heat index for Dhaka for every year between 1976 and 2023. Compared with the increase in the heat index for Bangladesh (national average) of 4.5°C, the increase for Dhaka was lower (2.9°C) between 1980 and 2023 (using three-year moving averages). The incremental change in heat recorded for Dhaka was lower than the national average because the relative humidity decreased by 3.9 percentage points for Dhaka between 1980 and 2023 (using three-year moving averages).

FIGURE 2.5

Increases in average maximum temperature and the heat index for Dhaka, 1976–2023



Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.

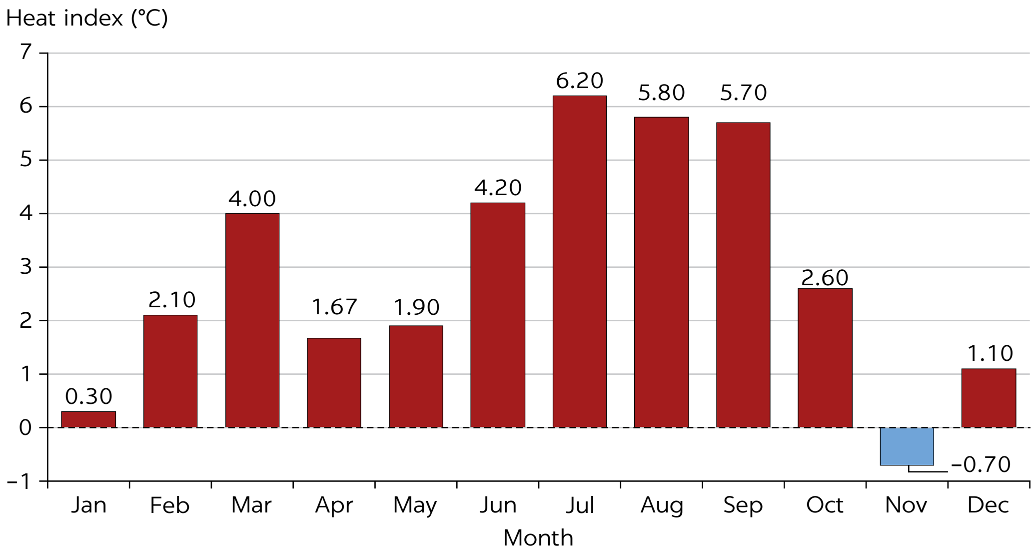
Consistent with the global trends and the national averages, July was the hottest month for Dhaka. Figure 2.6 depicts the monthly variation in the heat index. November is an exception when the heat index decreased by 0.7°C in 2023 compared with 1980, although the maximum temperature increased by 0.82°C over the same period. This decrease in heat for November can be attributed to relative humidity decreasing by about 9 percentage points over this period.

For the period 2015–23, the heat index in Dhaka increased at a higher rate than the national average for Bangladesh: 2.8°C in nine years at a rate of 0.3°C per year, compared with the national average of 1.7°C over the same period at a rate of 0.2°C per year. Dhaka's rate of increase in the heat index by 0.3°C per year between 2015 and 2023 was considerably higher than the increase recorded for the period 1980–2023 of 0.07°C. Figure 2.7 presents these comparisons. These changes can be explained by the UHI effect,[1] as Dhaka has seen rapid developments in infrastructure in recent years.

Factors contributing to the UHI effect may include reduced coverage of naturally cooling vegetation and water bodies, higher use of heat-absorbing and heat-retaining building materials, reduced air circulation from densely built infrastructure, and higher output of anthropogenic heat sources, such as waste heat from vehicles and cooling devices (Kim, Henry, and Jain 2023). Dhaka lost 47 percent of its dense green space and other vegetation between 1989 and 2020 because spaces were converted into built-up areas

FIGURE 2.6

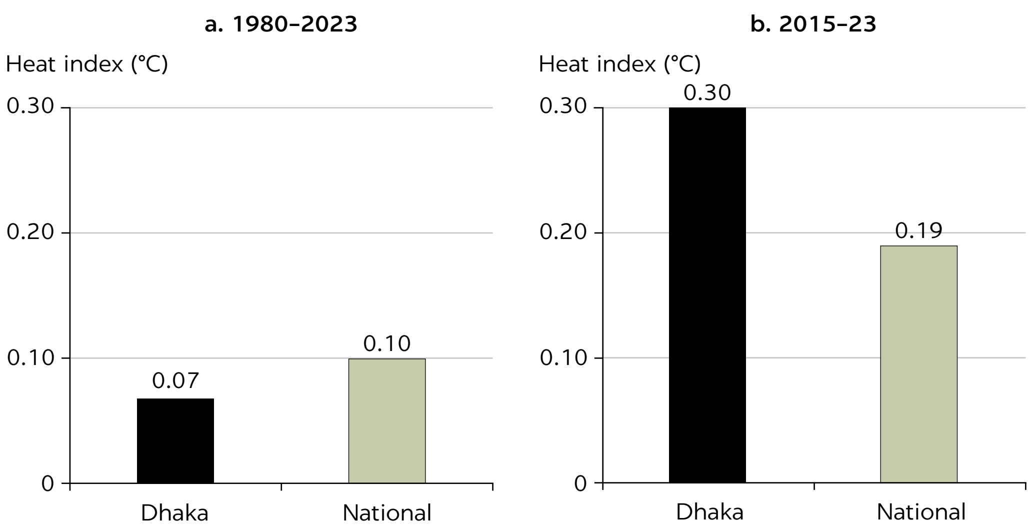
Monthly variation of the heat index for Dhaka, 2023 compared with 1980



Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.
Note: Figure is based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980, and 2023 represents an average of 2021, 2022, and 2023.

FIGURE 2.7

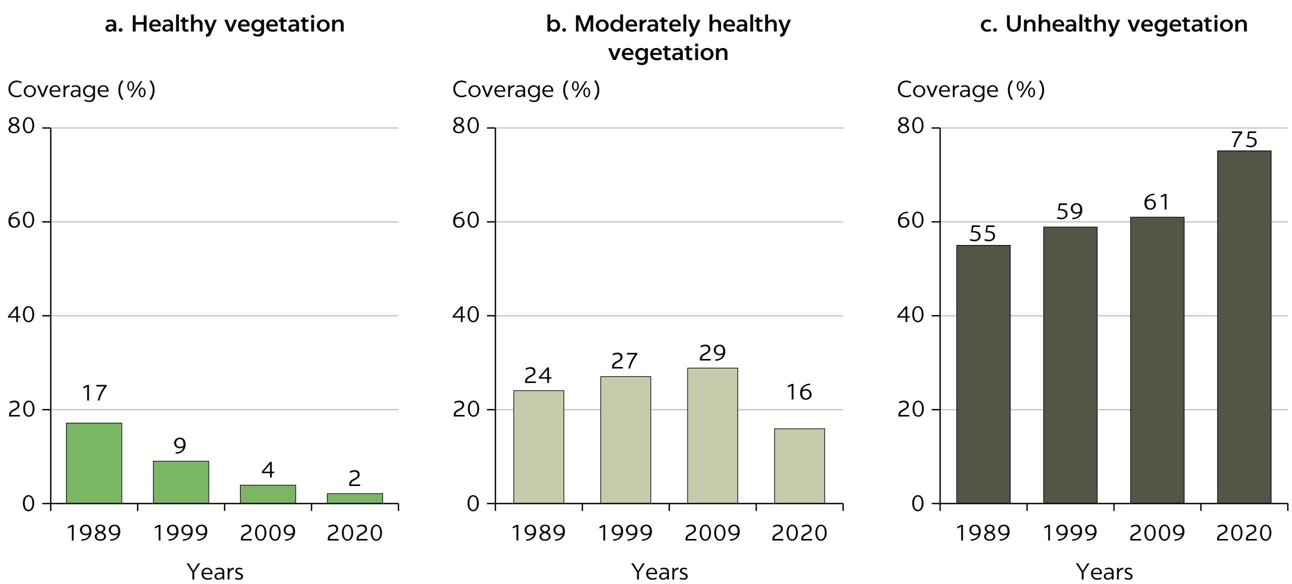
Increases in the heat index per year, Dhaka compared with the national average



Source: Original figure for this report, based on Bangladesh Meteorological Department data from 1976 to 2023.
Note: Figure is based on three-year moving averages: that is, 1980 represents average figures for the years 1978, 1979, and 1980; 2015 represents an average of 2013, 2014 and 2015; and 2023 represents an average of 2021, 2022, and 2023.

to meet the growing demands of urbanization (Nawar et al. 2022). Figure 2.8 depicts the change in vegetation type in Dhaka, showing a reduction in the proportion of healthy vegetation from 5,202 hectares or 17 percent in 1989 to 612 hectares or 2 percent in 2020 while moderately healthy vegetation declined by 8 percentage points over the same period. Urban settlements started expanding in the city after 1999 and by 2020 green spaces were fragmented, covering around 5,600 hectares of area compared with 12,745 hectares in 1989 (Nawar et al. 2022). The total city area increased by 19 percent between 2001 and 2017, but the total population residing in Dhaka city increased by almost 77 percent at the same time (Uddin et al. 2021). Use of heat-trapping building materials is increasing indoor air temperature in South Asian cities and at night indoor air temperature of tin-roofed structures can exceed outdoor temperature by up to 4°C (Kim, Henry, and Jain 2023). The nighttime heat is detrimental for human health as the body needs to cool down at night to be able to function properly after being exposed to extreme heat during the daytime; otherwise, it gets overheated. People from low-income groups often live in buildings with tin roofs. Building designers need to consider factors like roof and wall materials, window design and ventilation, internal and external shading, and so on to ensure that indoor spaces do not trap heat. Green spaces can help reduce the intensity of heat in urban areas, improve air quality in the locality, reduce the risk of flooding, and thus positively affect human health (Romanello et al. 2023).

FIGURE 2.8
Change in vegetation in Dhaka, 1989–2020



Source: Adapted from Nawar et al. 2022.
Note: Healthy vegetation includes dense vegetation and forests; moderately healthy vegetation includes shrubs, herbs, grassland, and moderately dense plants; and unhealthy vegetation includes unhealthy plants, bare lands, and urban areas (Nawar et al. 2022).

NOTES

1. Urban heat islands are urban areas that experience higher temperatures than other areas. Infrastructure such as buildings, roads, and bridges absorb and reemit the sun's heat more than natural sites like parks and water bodies. Urban areas where such infrastructure is more abundant and green areas are limited become "islands" of higher temperatures relative to outlying areas. "Heat Island Effect," US Environmental Protection Agency, https://www.epa.gov/heatislands#:~:text=Heat%20islands%20are%20urbanized%20areas,as%20forests%20and%20water%20bodies.
2. IOD, or the Indian Niño, is a climate pattern affecting the Indian Ocean. During a negative IOD, warm waters are washed to the eastern parts of the Indian Ocean, while colder water is pushed to the western side of the Indian Ocean. The patterns are reversed during a positive phase of the IOD. "Sea Level Key Indicators: What Is the Indian Ocean Dipole," Jet Propulsion Laboratory, https://sealevel.jpl.nasa.gov/data/vital-signs/indian-ocean-dipole/

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Part 2

Data and Findings from the Household Survey

3 Data and Methods

INTRODUCTION

The findings of this report use several sources of data, including data from a panel of households collected over January and May 2024, localized daily weather data from the Bangladesh Meteorological Department (BMD), and metadata from existing evidence.

HOUSEHOLD PANEL DATA

This section provides information on the collection of data on the demographics and health of households in Bangladesh.

Survey design and sampling

Researchers conducted a two-round survey of households representing urban and rural areas across Bangladesh for this report. The first round of the survey canvassed 3,746 households (16,054 individuals) from January 18, 2024, to February 7, 2024, capturing the typically coldest time of the year. The second round of the survey, administered between May 20, 2024, and June 7, 2024, to capture the beginning of summer, typically one of the hottest periods of the year, followed up with the same set of households. The rate of household-level attrition between the two rounds was approximately 5.6 percent, resulting in a balanced panel of 3,521 households (15,163 individuals) per each round of data collection. Within existing households, 320 individuals left their households because of death, marriage, or migration. The 225 attrited households were replaced in each location with ones having matching characteristics.

In constructing the survey, the team employed a two-stage stratified random sampling approach. The first stage entailed the selection of primary sampling units (PSUs) and leveraged probability-proportional-to-size (PPS) methods based on data from the 2022 Population and Housing Census, stratified by the type of location—that is, urban or rural (Bangladesh Bureau of Statistics 2022). The urban areas comprised the eight city corporations, divisional capital districts, and union parishads. The remaining were classified as rural. Given the particular emphasis of this report on extreme heat in urban areas, the stratification was purposively done to capture the urban heat island effects on health. Of the 180 PSUs identified, 79 were designated as urban and the remaining 101 as rural. The distribution of the PSUs is presented in map 3.1.

MAP 3.1

Distribution of the urban and rural primary sampling units

Source: Original map for this report.

TABLE 3.1 Sample distribution of the study

	RURAL				URBAN			
		HOUSEHOLDS				HOUSEHOLDS		
	PSUs	*n*	%	INDIVIDUALS	PSUs	*n*	%	INDIVIDUALS
Households with women and children <10 years	101	429	20.6	2,100	79	343	20.6	1,577
Households with elderly population (>65 years)	n.a.	117	5.6	528	n.a.	106	6.4	515
Mixed demographics households	n.a.	1,538	73.8	6,458	n.a.	1,213	73.0	4,876
Subtotal	101	2,084	n.a.	9,086	79	1,662	n.a.	6,968

Source: Original table based on primary data collected for this report.
Note: PSUs = primary sampling units; n.a. = not applicable.

In the second stage of the household sampling process, the survey team carried out a listing exercise in each of the PSUs to identify clusters of approximately 150–200 households. A second level of stratification was introduced to mimic the demographic distribution in the 2022 Population and Housing Census: (1) households with women and children under 10 years of age; (2) households with an elderly population (65+ years); and (3) households with mixed demographics, following a 20:5:75 ratio, respectively. With these categories as a basis, the team randomly selected the listed households until the criteria were fulfilled in each PSU (refer to table 3.1).

Data

A structured questionnaire was used to collect individual and household-level information. The questions were typically directed toward the primary female member of the household, or one of the other adult household members if she was unavailable. In addition to sociodemographic profiles such as age, gender, disability status,[1] and usual activity status, the survey collected detailed information on whether the individual had experienced any shocks, such as economic or environmental (natural disasters such as floods, droughts, extreme heat, or landslides), at the household level during the 12 months preceding the survey. Additional household-level information was collected on the household's water, sanitation, and hygiene status and detailed information on household assets to construct a relative wealth index,[2] following guidance from the Bangladesh Demographic and Health Survey (NIPORT and ICF 2020) and migration history for the 10 years preceding the survey.

Using a 14-day recall, researchers collected data on physical health conditions from each household member. Responses for children under 10 years of age were collected from the children's primary caregiver. Because heat makes individuals more likely to experience heat exhaustion or heat strokes, the survey collected a range of symptoms to assess whether the individual had these symptoms during the 2024 survey (CDC 2024). For this report, a scoring mechanism was developed to assess whether the individual experienced heat exhaustion or stroke in the 2024 survey period (refer to appendix A, table A.1, for further details on the scoring mechanism). Information was also collected on whether the respondents experienced diarrhea, dengue/chikungunya, persistent cough that lasted for at least one week, jaundice, typhoid, tuberculosis, or the novel coronavirus disease (COVID-19). Except for heat strokes, reporting is limited to health conditions prevalent above 0.5 percent during each round. Moreover, information on noncommunicable diseases such as diabetes, hypertension, cardiovascular diseases, and renal conditions, among others, was also collected as a part of the survey for individuals above 15 years old on the basis of a 12-month recall.

Data associated with mental health conditions were also collected, including for emotional regulation, depression, and anxiety. Emotional regulation is a psychological construct defined as the capacity of individuals to manage their own emotional responses (Young, Sandman, and Craske 2019). Emotional regulation strategies can entail the increase, maintenance, or decrease of the intensity, duration, and trajectory of both positive and negative emotions. Disruptions to emotion regulation capacities, also termed *emotional dysregulation*, have been identified in a growing body of scientific literature as being central to how anxiety and depressive disorders may manifest and persist or worsen (Cisler and Olatunji 2012; Visted et al. 2018). Therefore, examining associations between emotional regulation and mental health outcomes, such as depression and anxiety, can indicate psychological factors that increase vulnerability to adverse mental health outcomes, in addition to sociodemographic factors, and present a more nuanced picture of mental illness manifestation.

In this study, emotional regulation was measured using the Emotional Regulation Questionnaire (ERQ). The ERQ is a 10-item self-report questionnaire created by Gross and John (2003), which consists of two subscales corresponding to two different emotion regulation strategies: cognitive reappraisal (six items) and expressive suppression (four items). The 10 items are rated on a seven-point Likert-type scale (from 1 = strongly disagree to 7 = strongly agree). The possible scale score ranges from a low of 6 to a high of 42 for the cognitive reappraisal subscale. For the expressive suppression subscale, the scale score ranges from a low of 4 to a high of 28. Higher scores on each subscale indicate greater use of the particular emotion regulation strategy. The ERQ has previously been culturally adapted for Bangla-speaking populations and reported excellent internal consistency for both subscales, with a Cronbach's alpha of 0.92 and 0.84, respectively, for cognitive reappraisal and expressive suppression (Uddin and Rahman 2022). Accordingly, this adapted Bangla version of the ERQ was administered to the sample population covered for this report (Uddin and Rahman 2022). Depression was assessed using the Patient Health Questionnaire-9 (PHQ-9), a widely employed tool for depression screening (Spitzer, Kroenke, and Williams 1999). This questionnaire comprises nine items rated on a four-point Likert scale using a two-week recall period. Culturally adapted for Bangla-speaking populations with a Cronbach's alpha of 0.837, the PHQ-9 has been extensively used in Bangladesh in research and clinical settings (Chowdhury, Ghosh, and Sanyal 2004; Hossain et al. 2012; Wahid et al. 2023).

Anxiety was measured using the Generalized Anxiety Disorder-7 (GAD-7), a seven-item instrument also rated on a four-point Likert scale that uses a similar two-week recall period for symptoms (Spitzer et al. 2006). Adapted for use in Bangla-speaking populations with a Cronbach's alpha of 0.869, the GAD-7 has been used in various clinical and nonclinical settings in Bangladesh as well (Faisal et al. 2022; Hossain et al. 2012).

Consistent with standards established in the literature, validations from other South Asian countries, and prior research in Bangladesh, a clinical threshold score of 10 was applied to determine the presence of depression and anxiety using the PHQ-9 and GAD-7, respectively. Recent meta-analyses have corroborated the efficacy of this threshold score (Carroll et al. 2020; Spitzer, Kroenke, and Williams 1999; Spitzer et al. 2006). For the PHQ-9, a meta-analysis encompassing 6,725 participants from 29 studies indicated a sensitivity of 0.88 and a specificity of 0.85 at the cutoff score of 10, which is deemed pertinent for research purposes (Levis, Benedetti, and Thombs 2019). Notably, this approach to defining depression on the basis of the PHQ-9 has garnered recognition for its practical utility by a *Lancet*–World Psychiatric Association Commission on depression (Herrman et al. 2022). Similarly, with regard to the GAD-7, a meta-analysis that involved 5,223 participants across 11 studies reported a sensitivity of 0.83 and a specificity of 0.84 at the cutoff score of 10 (Plummer et al. 2016). These findings underscore the validity and reliability of using the PHQ-9 and GAD-7 with a cutoff score of 10 for assessing depression and anxiety in research settings.

Self-reported productivity loss data were gathered separately for physical and mental health issues, using a 30-day recall period for the working-age population between 15 and 64 years old (ILO 2019). Productivity loss was measured by the inability to perform usual activities, attributable to either absenteeism or presenteeism, for each illness in increments of 0.5 days. The overall impact of conditions like heat exhaustion or heat stroke on lost days of usual activity was determined by calculating a weighted average of the individual symptom impacts. Assessing productivity loss attributable to individual mental health outcomes, such as depression or anxiety, is challenging. Therefore, the respondents were asked about their inability to carry out usual activities because of factors like excessive stress, fatigue, or lack of interest in their usual activities. Extreme values, defined as observations above the 99th percentile, are replaced by the mean of the distribution for each survey year. It is important to note that while the report focuses on the working-age population, the full sample of the population within the age group of 15–64 years is included to account for the loss associated with the unpaid care burden that women predominantly provide (Kotikula, Raza, and Hill 2019).

Meteorological data used for this report were derived from 47 weather stations operated by the BMD. The data collected from these stations were subsequently localized across the 180 PSUs (refer to figure B.1 in appendix B for further methodological details). Temperature bins were constructed over two durations: (1) two weeks and (2) four weeks preceding each round of the survey. The total number of days the maximum dry-bulb temperature was within a specific bin was calculated for each PSU over the two survey rounds.[3] Moreover, the report also accounts for exposure to excess heat, defined as the number of days within each of the two-week spans and four-week spans where the temperature exceeded the 80th and 90th percentile over the 20 years preceding the survey round (2004–23).

ANALYTICAL TECHNIQUES

This section describes the analytical approaches adopted for this report.

Correlates of binary outcomes

The relationship between the binary outcomes of interest, such as the presence of physical and mental health conditions, and heat are assessed leveraging the following weighted logistic specifications with population-average effects using a pooled sample across the two survey waves:

$$Y_{itj} = \frac{e^{T'_{tj}\Theta + X'_{ijt}\Gamma + \varepsilon_{itj}}}{1 + e^{T'_{tj}\Theta + X'_{ijt}\Gamma + \varepsilon_{itj}}} [\omega'_{ij}] \tag{1}$$

$$t = 1 \ldots 2$$
$$i = 1 \ldots n$$
$$j = 0 \ldots 180$$

where Y_{itj} reflects the presence (or absence) of health outcomes for i^{th} individual living in the j^{th} PSU during the survey round t. Θ are the coefficients of interest, denoting the association between the temperature bins and excess heat, with the outcomes of interest. For physical and mental outcomes that are more likely affected by a short exposure to high temperatures, such as heat exhaustion, diarrhea, depression, and anxiety, the temperature range across two weeks preceding the survey is considered. For health outcomes that are more likely associated with longer exposure to heat, such as persistent cough, a four-week temperature range is considered. It is important to note that the temperature ranges between the summer and winter rounds of the survey perfectly capture the time trends (refer to figure C.1 in appendix C). Accordingly, the base category in the models reflects the temperature range during the winter round. Given the perfect collinearity, time-trends (survey rounds) are not explicitly controlled in the model.

The population-weighted (ω) models control for individual and household-level characteristics, such as age, reported gender, usual activity, socioeconomic status, time spent in indoor conditions, employment, and location (urban/rural), denoted by X'. The Huber-White (1967) robust idiosyncratic error term is denoted by ε_{ijt}. The results are presented as adjusted odds ratios (AOR)[4] and can be interpreted as percentage changes.

Correlates of count outcomes

The relationship between heat and count outcomes, such as the left-censored emotional regulation score and days of usual activity lost, is measured using the following population-weighted Tobit specification (Cameron and Trivedi 2010; Honoré 1992; Long 1997):

$$E\,[Y^*_{itj} \mid 0 \geq Y_{itj}] = T'_{tj}\Theta + X'_{ijt}\Gamma + \varepsilon_{itj}\,[\omega'_{ij}] \tag{2}$$

$$t = 1 \ldots 2$$
$$i = 1 \ldots n$$
$$j = 0 \ldots 180$$

where Y^*_{itj} is the expected value of the latent count data of interest for the i^{th} individual during survey round t, living in the J^{th} PSU. T'_{tj} represents the temperature bins and excess heat indicators reflecting two weeks before each round of the survey in each PSU. X'_{ijt} represents the vector of individual and household-level characteristics. The models report the Huber-White (1967) robust idiosyncratic error term, denoted by ε_{ijt}.

National annualized aggregation of productivity loss

The loss of productivity, as measured through the number of days respondents were unable to carry out their usual activities and attributable to physical and mental health conditions exacerbated by heat, is calculated using the following approach:

$$Y_{ij} = \sum (\Psi_{ij} * \omega_{hj}) - (\Upsilon_{ij} * \omega_{hj}) \tag{3}$$

where the net loss of days at the national level (Y) for individual i in the j^{th} PSU is the difference between the weighted aggregation of days during the summer minus the weighted sum of days lost during the winter.

To calculate the annualized figures, the study team followed the method suggested by Dasgupta et al. (2021), which indicates that labor productivity starts to decline at wet-bulb temperatures above 24.9°C and approaches zero at 39.5°C and above.[5] By considering the midpoint of this range, based on historical weather data from the previous 20 years (2003–23), it was found that temperatures exceeded this threshold at least five months each year. Due to data constraints, the study team could not differentiate between absenteeism and presenteeism. Therefore, for monetization purposes, two thresholds were estimated for calculating the aggregated cost to gross domestic product (GDP): (1) a combination of absenteeism and presenteeism results in a 75 percent real productivity loss for the days respondents report lost and (2) a 100 percent real productivity loss of daily GDP results each day that respondents report lost productivity. The monetized figures for the two thresholds were calculated using per capita GDP per day of US$7.36 (World Bank 2023).

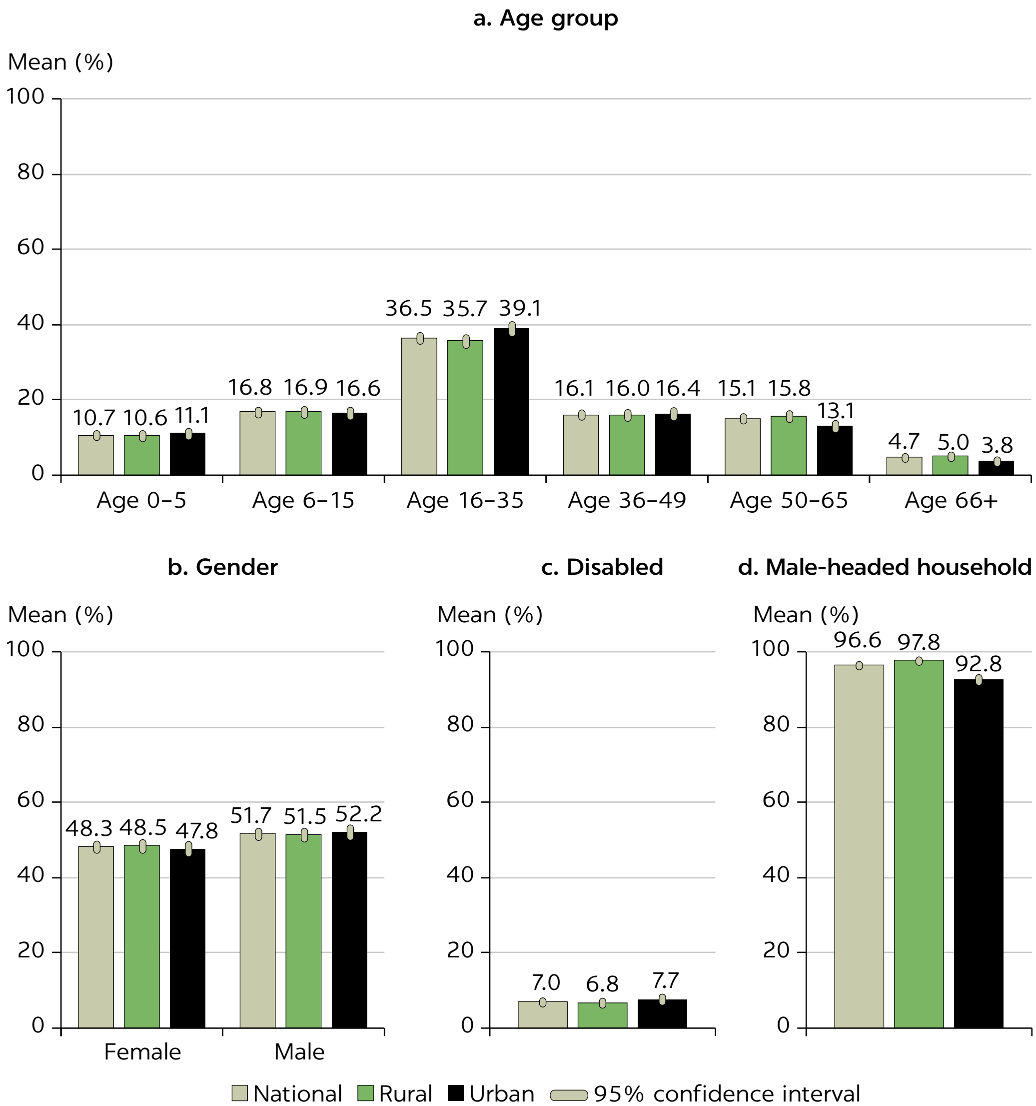
All analysis was conducted using STATA v17.1 and Tableau 2021.8.4.

RESPONDENT AND CLIMATE PROFILE

This section outlines the respondent profile at the baseline in January 2024 along with the climate exposure a month preceding each round of the survey. Figure 3.1 shows the distribution of demographic characteristics of the sample. Of the 16,054 individuals, approximately 48.3 percent were female while 51.7 percent were male. Approximately 10.7 percent of the respondents were between 0 and 5 years old, with little variation across the urban and rural space. Approximately 16.8 percent were between 6 and 15 years old. The largest proportion, individuals between ages 16 and 35 years, represented 36.5 percent of the sample. The proportions of ages 36–49 years and 50–65 years were comparable, ranging from 16.1 percent to 15.1 percent, respectively. Nearly 7 of every 100 people were disabled, a higher proportion living in urban areas than in rural ones (7.7 percent versus 6.8 percent). Households with male heads were nearly universal (96.6 percent), with a higher proportion represented in rural areas than in urban ones.

FIGURE 3.1

Demographic profile at baseline, January 2024

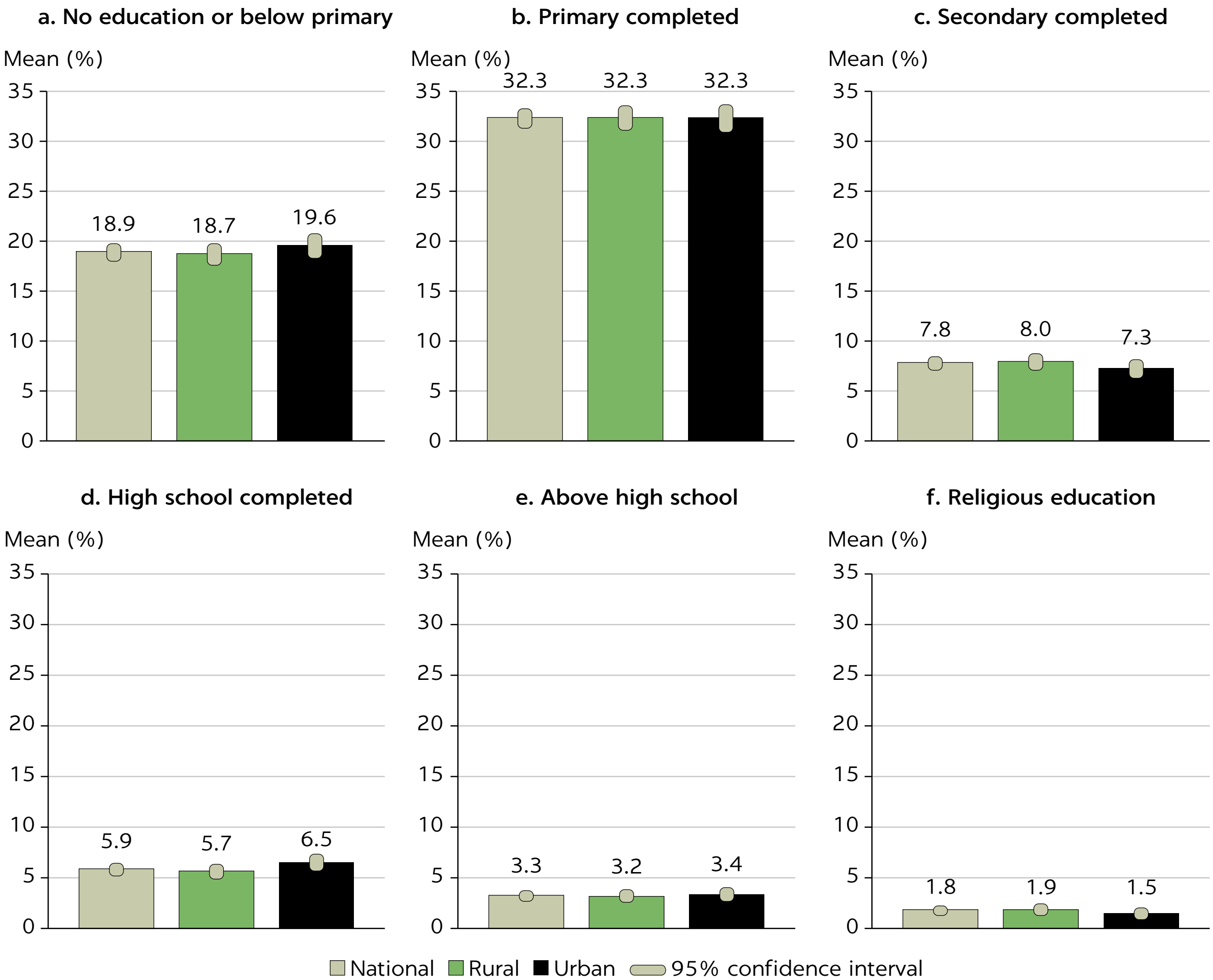


Source: Original figure based on primary data collected for this report.
Note: Figure shows means (%) and confidence intervals (95%) from January 2024.

About 18.9 percent of the respondents had no formal education or were in the below-primary-education level (refer to figure 3.2). About a third of the respondents (32.3 percent) had completed primary education, with the proportion comparable across the urban and rural spaces. Approximately 7.8 percent had completed secondary education, 5.9 percent high school, while about 3.3 percent had completed or were in the process of acquiring higher degrees, with differences negligible across rural and urban areas. Approximately 1.8 percent were enrolled in religious education.

FIGURE 3.2

Education status baseline, January 2024



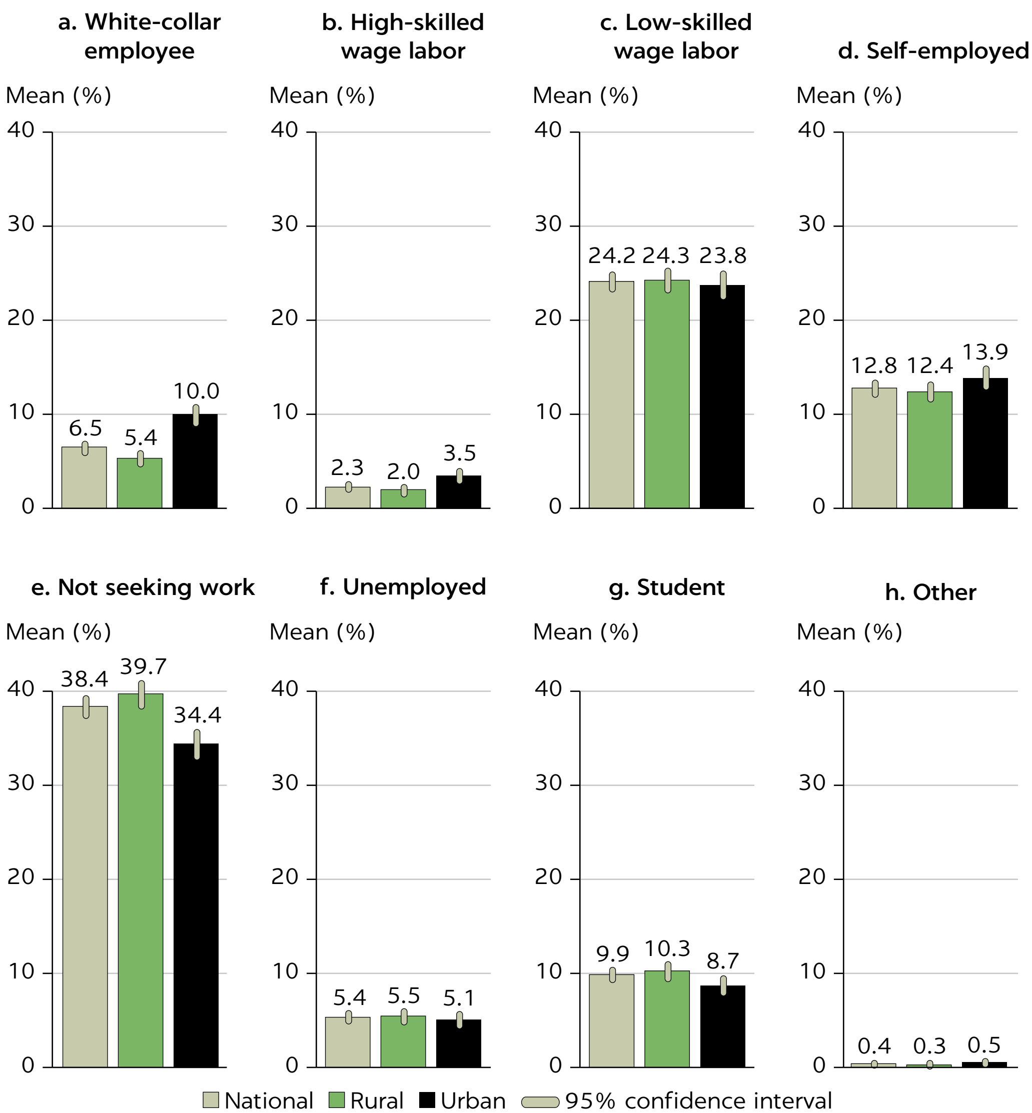
Source: Original figure based on primary data collected for this report.
Note: Figure shows means (%) and confidence intervals (95%). Sample restricted to individuals above five years of age.

Figure 3.3 shows the usual activity status of the respondents above 15 years of age. Approximately 6.5 percent of the respondents were white-collar employees and 2.3 percent were engaged in high-skilled wage work, a proportion notably higher in urban areas than in rural ones. About 24.2 percent were engaged as low-skilled wage labor while a further 12.8 percent were self-employed—with no significant difference between urban and rural areas. Approximately 38.4 percent were not seeking income-generating activities. The proportions, mostly representative of homemakers, were notably higher in rural areas (39.7 percent) than in urban (34.4 percent) ones. Approximately 9.9 percent were students, while another 5.4 percent were unemployed.

Figure 3.4 shows the median number of days each PSU spent across the temperature bins/ranges over the four weeks preceding each survey round. During the month preceding the winter survey in January 2024, temperatures below 20°C were experienced for approximately five days, between 20°C and 22°C for six days, between 23°C and 24°C for four days, between 25°C and 27°C for 11 days, and for two days between 28°C and 29°C. In contrast, during the month preceding the summer survey in May 2024, temperatures between 30°C and 38.5°C were experienced for approximately seven days on average, while eight additional days were above 38.5°C.

FIGURE 3.3

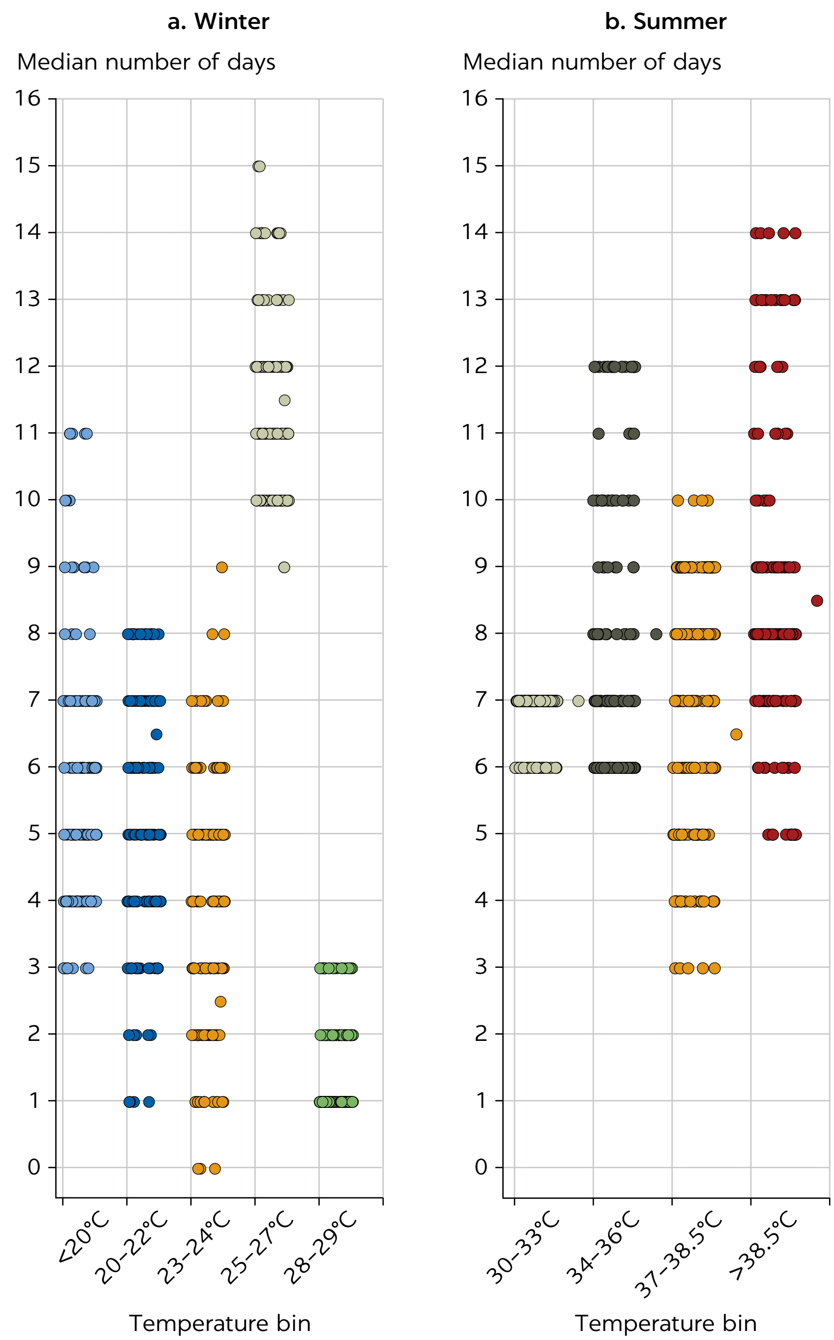
Usual activity status at baseline, January 2024



Source: Original figure based on primary data collected for this report.
Note: Figure shows means (%) and confidence intervals (95%). The sample is restricted to individuals above 15 years of age.

FIGURE 3.4

Days per temperature bin/range over the month preceding each survey round in January and May 2024



Source: Original figure based on primary data collected for this report.
Note: Figure shows the median number of days spent in each maximum temperature bin, aggregated at the PSU level. PSU = primary sampling units.

LIMITATIONS

The report's findings are subject to several limitations. The reliance on a relatively small number of weather stations reduces the granularity of climate data, leading to potential inaccuracies in localized heat exposure estimates. However, the margins of error of models leveraged to generate the PSU-level measures were found to be well within acceptable limits. Furthermore, the presence of outliers and missing data, particularly for the period preceding 2000, within the dataset further reduced data reliability. Regarding health data, the reliance on self-reported symptoms without corroborating medical records, such as hospitalization or specific diagnoses, limited the depth of analysis on the extent and severity of the heat-related illnesses. Consequently, the study could only infer heat exhaustion cases from a constellation of reported symptoms rather than from confirmed medical diagnoses. Moreover, the aggregated productivity losses presented in this study likely underestimate the true economic burden of heat stress. This underestimation is primarily due to the exclusion of noncommunicable diseases from the calculations, which are known to be exacerbated by heat exposure and can significantly contribute to overall productivity losses. It is important to note, however, that the report only presents correlations between heat and health and economic outcomes and does not claim to draw causal inferences.

NOTES

1. Disability status was defined using the Washington Group Short Questionnaire that asked whether the respondent faced difficulty in seeing (with glasses), hearing (with hearing aid), walking or climbing steps, remembering or concentrating, or performing self-care such as changing or washing.
2. The relative wealth index for replacement households was computed using multiple imputation techniques.
3. In the interest of keeping comparably sized bins, the number of days in the two-week temperature range were organized accordingly: (1) <20°C; (2) 20°C–22°C; (3) 23°C–24°C; (4) 25°C–27°C; (5) 28°C–29°C; (6) 30°C–34°C; (7) 35°C–37°C; (8) >37°C. Similarly, the number of days in the four-week temperature range were organized in the following bins: (1) <20°C; (2) 20°C–22°C; (3) 23°C–24°C; (4) 25°C–27°C; (5) 28°C–29°C; (6) 30°C–33°C; (7) 34°C–36°C; (8) 37°C–38.5°C; and (9) >38.5°C.
4. (AOR – 1) * 100 = Percentage change. For example, an AOR of 1.66 is interpretable as a 66 percent increase over the base category.
5. Kjellstrom, Holmer, and Lemke (2009) suggest that productivity rapidly begins to decline when the wet-bulb temperature exceeds about 26°C–30°C.

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4 Heat and Physical Health

INTRODUCTION

This chapter explores the effects of heat and seasonality on select physical health conditions—namely, heat exhaustion, heat strokes, diarrhea, and persistent cough. The chapter begins by exploring the prevalence of these physical health outcomes across the coldest and hottest times of the year by location, demographic, and socioeconomic characteristics. Those observations are followed by an assessment of associations between exposure to heat and physical health outcomes.

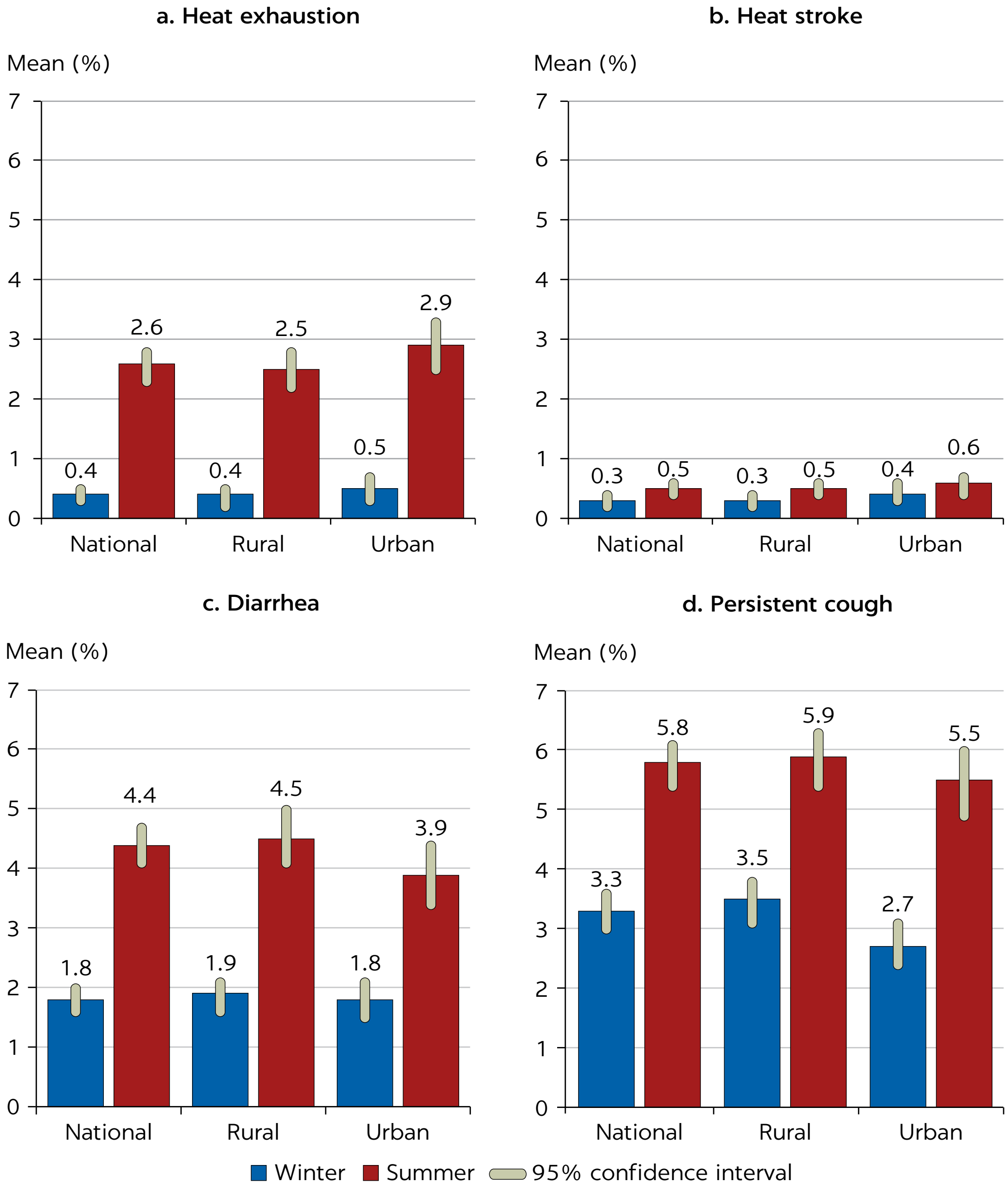
PREVALENCE OF SELECT SHORT-TERM PHYSICAL HEALTH CONDITIONS AND SEASONALITY

Figure 4.1 shows the weighted prevalence of the health conditions across national, rural, and urban areas. On average, 2.6 percent of the population reported the likelihood of experiencing heat exhaustion during the summer, with a marginally higher prevalence in urban areas compared with rural ones (2.9 percent versus 2.5 percent). Heat stroke prevalence was considerably lower, approximately 0.5 percent at the national level, and about the same across urban and rural areas. Heat stroke and heat exhaustion are weighted constructs based on a range of symptoms delineated in figure 4.2, table A.1 in appendix A, and figure C.1 in appendix C.

Nationally, 4.4 percent of individuals reported experiencing diarrhea over the summer compared with 1.8 percent during the winter, with higher prevalence in rural areas (4.5 percent) compared with urban areas (3.9 percent) in the summer (refer to figure 4.1). Of the four health conditions explored in this report, the most reported illness was persistent or chronic cough lasting at least two weeks. Approximately 5.8 percent of the population reported experiencing this condition during the summer, compared with 3.3 percent in the winter, with higher prevalence in rural areas across both seasons than in urban ones.

FIGURE 4.1

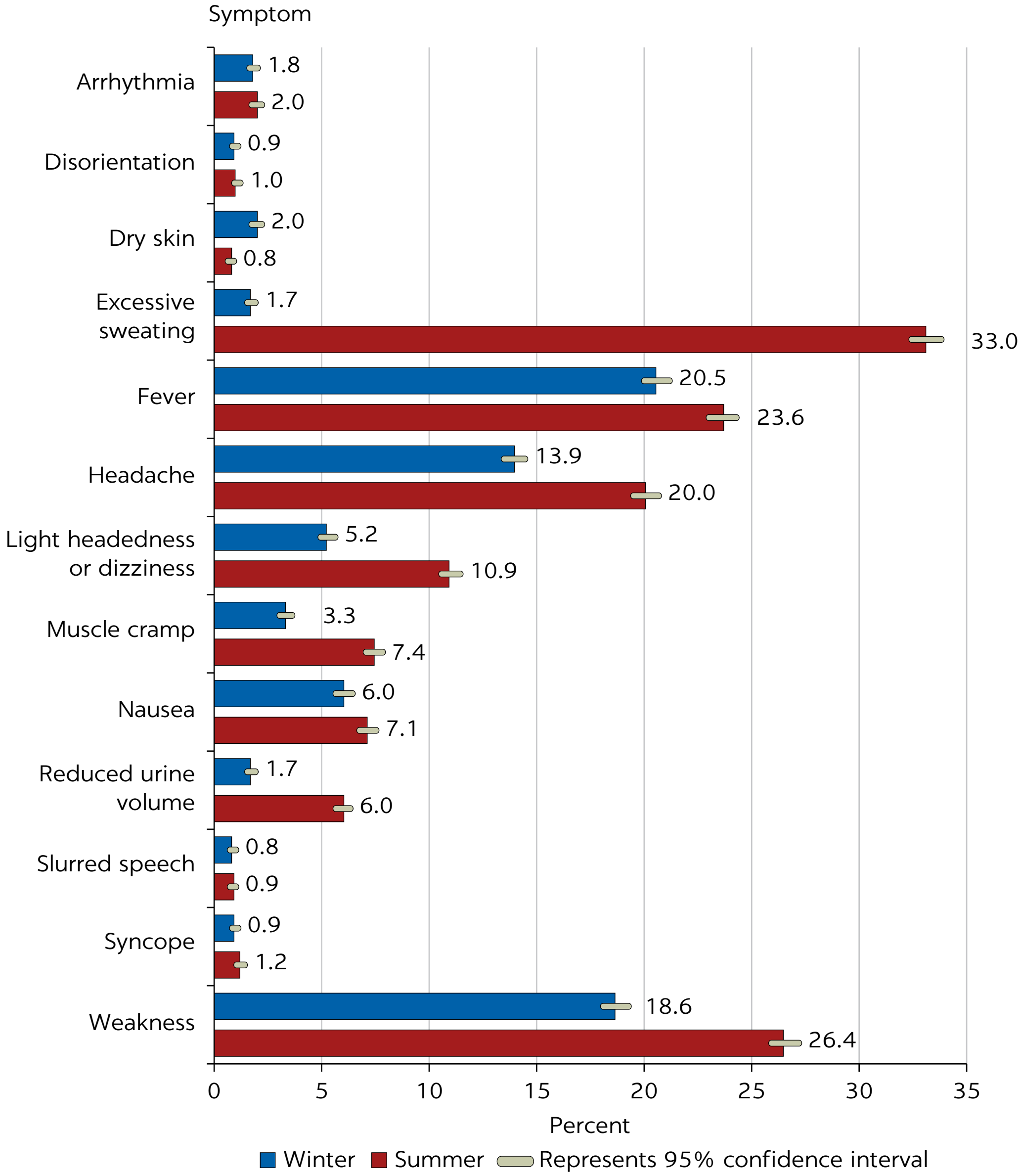
Prevalence of heat-related illnesses, by location



Source: Original figure for this report, based on primary data collected for this report.
Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of health conditions based on a 14-day recall period from 16,054 individuals surveyed across two rounds.

FIGURE 4.2

Distribution of symptoms used to construct heat exhaustion and heat stroke



Source: Original figure for this report, based on primary data collected for this report.

Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of symptoms used to calculate the probability of a respondent experiencing heat exhaustion or a stroke using a 14-day recall period from 16,054 individuals surveyed across two rounds. The composition weights are provided in appendix A.

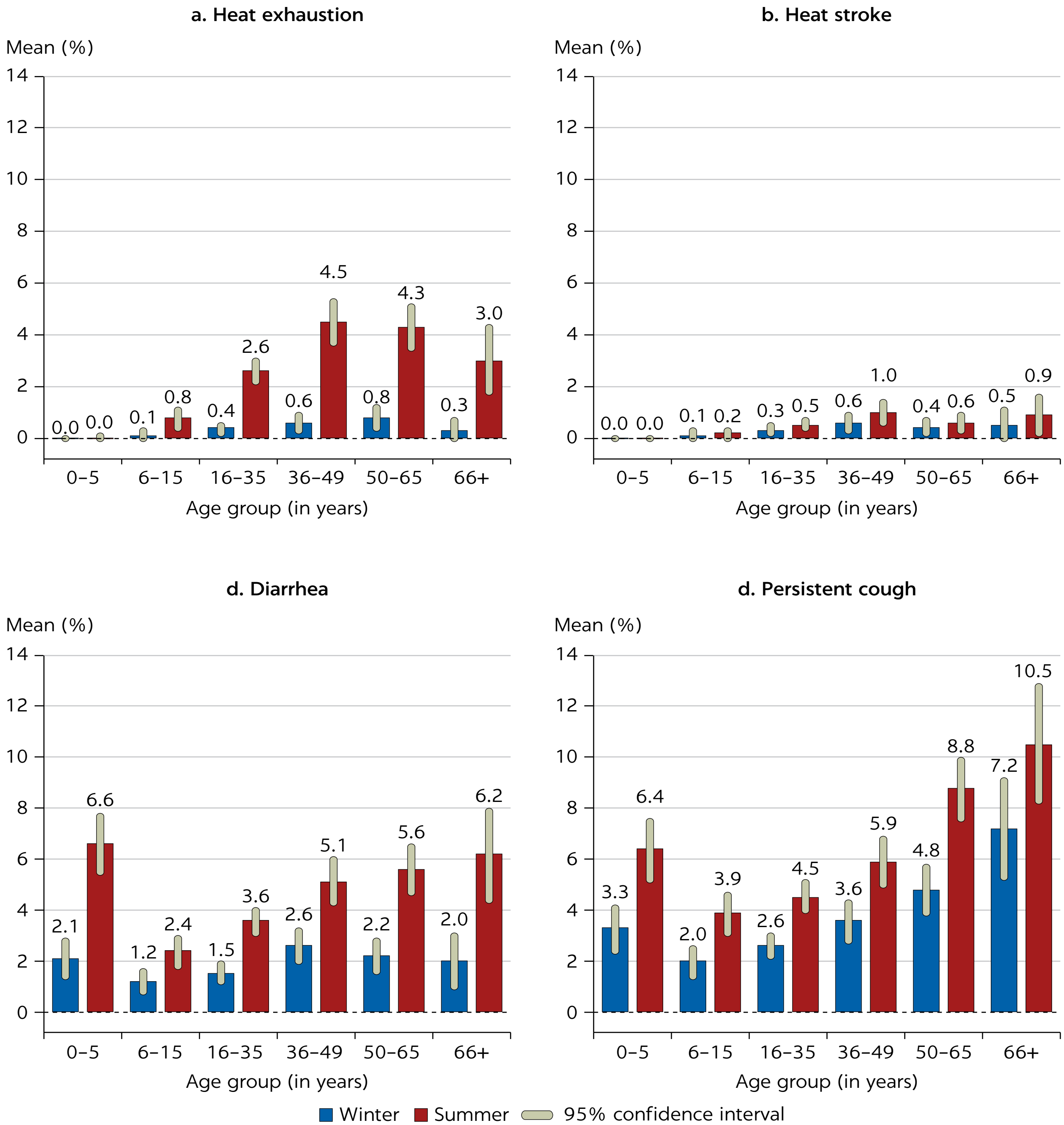
The highest prevalence of heat exhaustion was reported by those between ages 36 and 65 years (4.5 percent), followed by those above the age of 66 years (3.0 percent) during summer, compared with negligible proportions during winter (refer to figure 4.3). Heat stroke cases were infrequent across all age groups, with the highest rates reported among individuals ages 36–49 years (1.0 percent) and those over 66 years (0.9 percent). Diarrhea was a common occurrence in both summer and winter seasons, though more prevalent in the former than the latter. The highest prevalence of diarrhea was reported among children 5 years old and below during the summer (6.6 percent), triple the rates over the winter (2.1 percent). The results for children were followed closely by the elderly 66 years old and above, 6.2 percent of whom reported experiencing diarrhea during the summer in contrast with 2.0 percent over the winter. The prevalence of the condition across the seasons continued to decline for each age group thereafter. The largest reported condition in the sample was persistent or chronic cough lasting for more than two weeks. More than one in 10 of the population 66 years and older reported having a persistent cough, with the prevalence nearly a third higher in summer (10.5 percent) over winter (7.2 percent). The prevalence decreased by age except for children ages 5 years and below, who reported a prevalence of 6.4 percent persistent cough during the summer and 3.3 percent during the winter.

On average, females were more likely to report experiencing heat exhaustion than males (3.3 percent versus 1.9 percent), as presented in figure 4.4. Similarly, females were nearly twice as likely to report heat strokes than males (0.7 percent versus 0.4 percent). Males reported a higher prevalence of diarrhea during both the summer and winter periods (4.8 percent and 2.2 percent, respectively) than females (4.0 percent and 1.5 percent, respectively). On average, a significantly higher proportion of males reported having persistent cough than females across both summer (6.8 percent versus 4.7 percent) and winter (3.8 percent versus 2.7 percent) seasons.

The prevalence of heat exhaustion, heat strokes, or diarrhea did not vary significantly by socioeconomic status during either of the survey rounds (refer to figure 4.5). The trend, however, is different for persistent cough. The highest proportion of the respondents from the lowest-income wealth tertile reported experiencing the condition over the recall period during both the winter and summer seasons (4.0 percent and 6.2 percent, respectively) than those in the middle or the highest-income group.

FIGURE 4.3

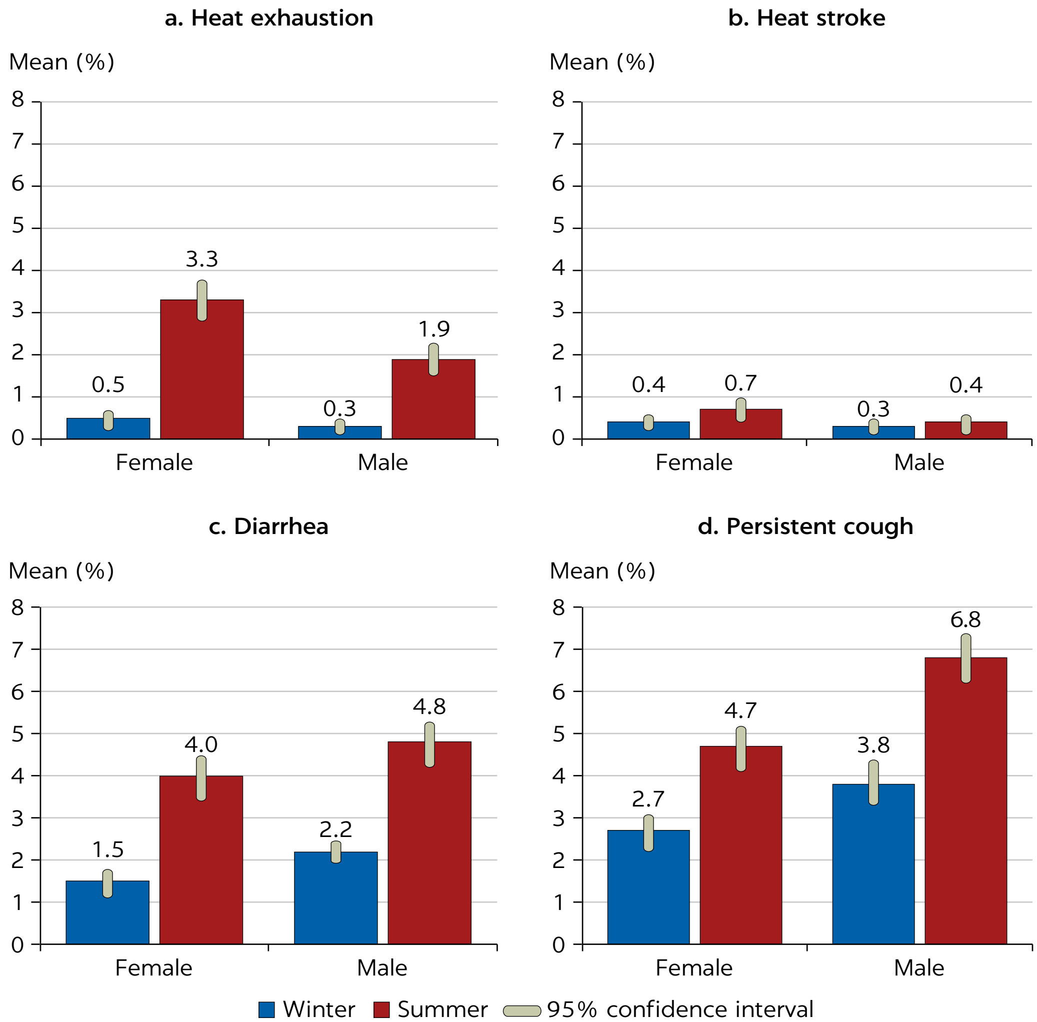
Prevalence of heat-related illnesses, by age group



Source: Original figure for this report, based on primary data collected for this report.
Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of health conditions based on a 14-day recall period from 16,054 individuals surveyed across two rounds.

FIGURE 4.4

Prevalence of heat-related illnesses, by gender

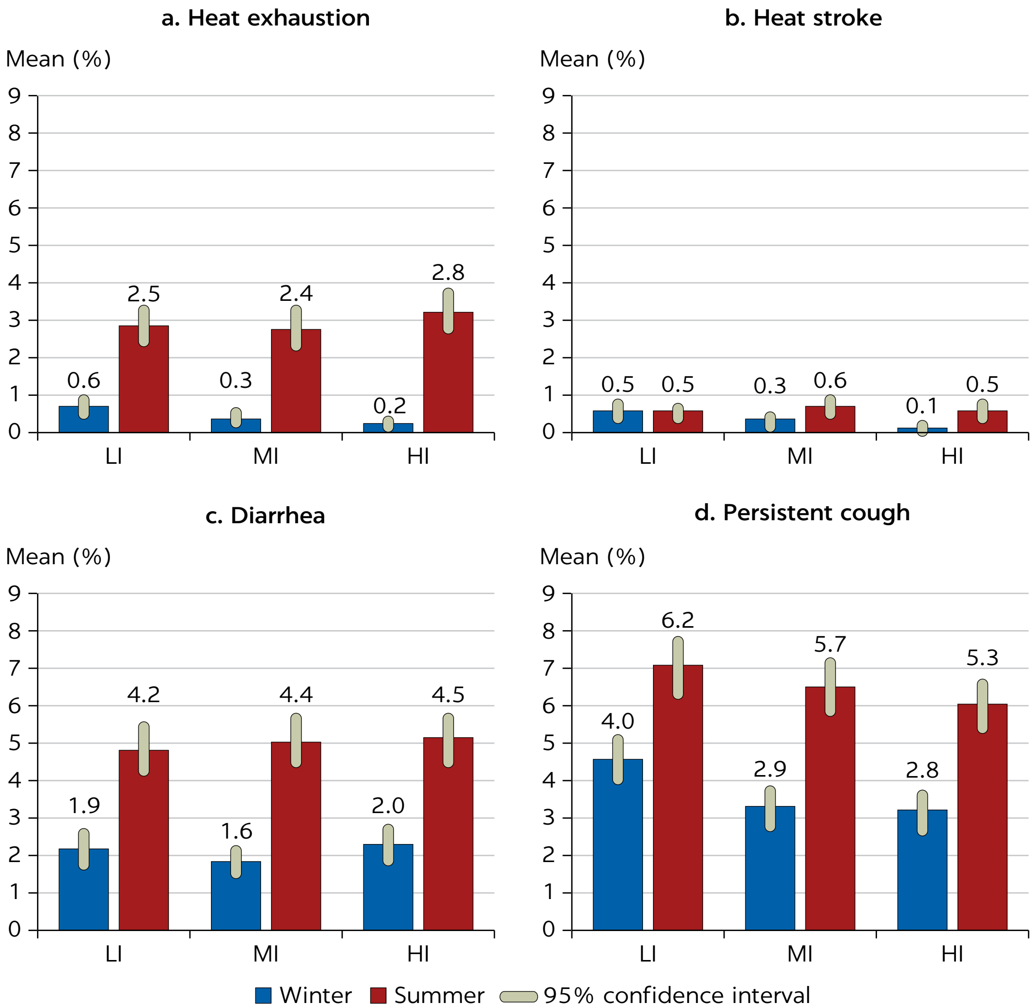


Source: Original figure based on primary data collected for this report.

Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of health conditions based on a 14-day recall period from 16,054 individuals surveyed across two rounds.

FIGURE 4.5

Prevalence of heat-related illnesses, by socioeconomic status



Source: Original figure based on primary data collected for this report.
Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of health conditions based on a 14-day recall period from 16,054 individuals surveyed across two rounds. LI = lower income; MI = middle income; HI = higher income.

CORRELATES OF HEAT EXHAUSTION, DIARRHEA, AND PERSISTENT COUGH

The research team used adjusted odds ratios (AOR) from the pooled binary models adjusting for population averages to assess the association between the select health outcomes and heat exposure and sociodemographic and household characteristics, as seen in figure 4.6.

FIGURE 4.6

Correlates of physical health conditions

Category	Variable	Heat exhaustion	Diarrhea	Persistent cough
Excess heat	Days T >80th percentile	0.926	0.967	0.740***
	Days T >90th percentile	1.069	0.909	1.091***
Number of days (base: <30°C) –2 week recall	30–34°C	1.03	0.819***	
	35–37°C	1.265***	1.477***	
	≥37°C	1.354***	1.645***	
Number of days (base: <30°C) –1 month recall	30–33°C			1.227*
	34–36°C			1.227***
	37–38.5°C			1.124**
	≥38.5°C			1.178***
Age group (base: 36–49 years)	0–5 years	0.008***	1.845***	0.984
	6–15 years	0.197***	0.628***	0.655***
	16–35 years	0.614***	0.701***	0.803**
	50–65 years	1.04	1.045	1.394***
	>66 years	0.663	1.097	1.738***
Gender	Female	1.774***	934	0.745***
Disabled	Yes	2.671***	2.087***	1.605***
Education (base: less than primary/none)	Children <6 years	0.667**	0.762*	1.154
	Primary completed	0.845	1.107	1.005
	Secondary completed	0.877	1.227	0.952
	High school completed	1.086	1.108	1.07
	Above high school	0.719	1.357	0.781
	Religious education	1.322	0.696	1.226
Location (base: rural)	Urban	1.169	0.921	0.897
Relative wealth tertile (base: lowest income)	Middle income	0.808*	0.982	0.820**
	Highest income	0.796	1.039	0.773***
Time spent indoors	Hours	1.027**	1.006	1.008
Usual activity status (base: low-skilled wage worker)	White-collar worker	1.193	0.751	1.17
	High-skilled wage work	1.053	1.389	1.099
	Self-employed	1.007	0.794	0.889
	Unemployed	0.895	0.638***	0.875
	Student	0.585**	0.526***	0.922
	Not seeking work	0.858	0.663***	0.842
	Other	1.003	0.692	1.345
		0 1 2 3 4 Adjusted odds ratio	0 1 2 3 4 Adjusted odds ratio	0 1 2 3 4 Adjusted odds ratio

Source: Original figure based on primary data collected for this report.
Note: Figure shows adjusted odds ratios (AOR) from a weighted population-average logistic model using a pooled sample of 16,054 individuals surveyed across two rounds. The binary dependent outcomes are whether the individual experienced (1) a heat stroke; (2) diarrhea; or (3) a persistent cough during the recall period preceding each of the two survey rounds. Base categories are reported in parentheses in the "Category" column. Results are also interpretable as percentage changes ([AOR – 1] * 100 = percentage change).
Significance level: *10 percent, **5 percent, ***1 percent.

Associations between heat exhaustion, diarrhea, and persistent cough and the exposure to heat

On average, an additional day with temperatures between 35°C and 37°C was associated with a 26.5 percent increased AOR of experiencing heat exhaustion compared with additional days with temperatures below 30°C during the recall period (refer to figure 4.6, column a). Moreover, an additional day with temperatures exceeding 37°C was associated with a 35.4 percent higher likelihood of heat exhaustion compared with additional days with temperatures below 30°C. Factors such as excess heat or temperatures below 34°C were not associated with the probability of heat exhaustion.

An additional day with temperatures between 30°C and 34°C was negatively associated with the likelihood of reporting diarrhea than with days below 30°C (refer to figure 4.6, column b). However, strong positive trends were noted for higher temperatures. Additional days with temperatures ranging between 35°C and 37°C increased the AOR of having diarrhea by 47.7 percent, and additional days above 37°C were associated with a 64.5 percent higher likelihood than additional days below 30°C during the two weeks preceding each round of survey.

Prolonged exposure to excess heat was found to be more strongly predictive of the presence of persistent or chronic cough that lasted for at least one week before each round of the survey than conditions such as heat exhaustion or diarrhea (refer to figure 4.6, column c). Additional days above the 90th percentile raised the AOR, by 9.1 percent, of reporting the condition. Moreover, each additional day with temperature ranges between 30°C and 33°C, 34°C and 36°C, 37°C and 38.5°C, and above 38.5°C in the month before the survey was positively associated with the probability of a respondent reporting persistent cough compared with additional days below 30°C (by 22.7 percent, 22.7 percent, 12.4 percent, and 17.8 percent, respectively).

Associations between background characteristics and heat exhaustion, diarrhea, and persistent cough

Age was regressively associated with the likelihood of experiencing heat exhaustion. Compared with individuals ages 36–49 years, respondents ages 5 and under were 99.2 percent less likely to report experiencing heat exhaustion, 6–15 years 80.3 percent, and 16–35 years 38.6 percent. Females had a 77.4 percent higher probability of experiencing heat exhaustion than males. Interestingly, that statistic coincides with the positive association between time spent indoors and heat exhaustion (by 2.7 percent), likely driven by the fact that females are more likely to be engaged with cooking in poorly ventilated areas. Disabled individuals were particularly vulnerable, with a 167.1 percent higher probability of reporting heat exhaustion compared with nondisabled individuals.

Individuals from a higher socioeconomic status were less likely to report experiencing heat exhaustion than the lowest-income group (by 19.2 percent). Notably, factors such as excess heat, education, and occupation were largely not statistically associated with the likelihood of experiencing heat exhaustion.

Children 5 years of age and under were 184.5 percent more likely to report diarrhea than adults ages 36–49 years. Conversely, those ages 6–15 years and 16–35 years were 46.3 percent and 37.6 percent less likely, respectively, to report having diarrhea. Disabled individuals were particularly affected, with a 208.7 percent higher AOR of reporting diarrhea compared with abled individuals. As for the influence of employment status, students, the unemployed, and nonworking individuals (such as housewives) were significantly less likely to report diarrhea by 47.4 percent, 36.2 percent, and 33.7 percent, respectively, compared with low-skilled wage workers. In contrast, high-skilled wage workers were 44.6 percent more likely to report the condition than the low-skilled workers. Neither gender, socioeconomic status, nor location was a significant predictor of diarrhea.

With the exception of children under 5 years, age was progressively associated with the likelihood of having a persistent cough during the two weeks preceding the survey. Individuals in the 6–15 age range and 16–35 age range were 34.5 and 19.7 percent (respectively) less likely to experience persistent coughs than those 36–49 years old. In contrast, older individuals than the reference population, such as those 55–65 years and older, had greater AOR of reporting the condition (39.4 percent and 73.8 percent, respectively). Females had a lower probability of reporting the condition than males (by 25.5 percent). Disabled individuals had a 60.5 percent higher likelihood of having persistent cough than abled ones. Unlike heat exhaustion or diarrhea, increasing socioeconomic status was negatively associated with persistent cough—compared with the lowest-income wealth tertile, those in the middle tertile were 18.0 percent less likely while the highest-income wealth tertile were 22.7 percent less likely to have the condition. Neither education, usual activity status, nor location was a significant predictor of the condition.

5 Heat and Mental Health Conditions

INTRODUCTION

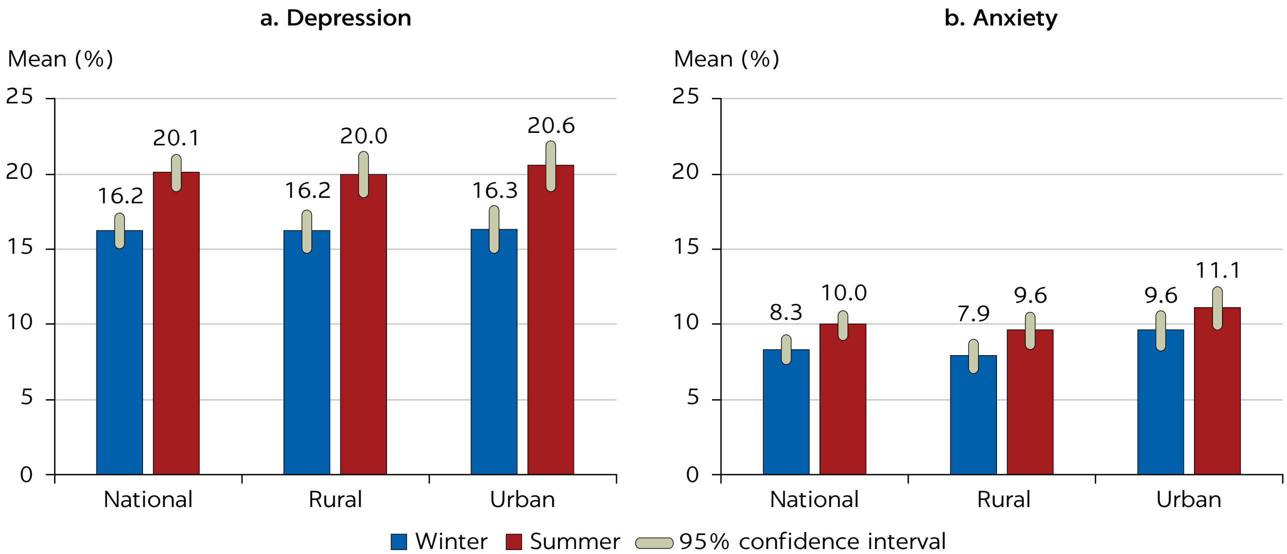
This chapter explains the association of heat and seasonality on select mental health outcomes such as depression, anxiety, and emotional regulation. The chapter first explores the seasonality of outcomes by location, demographic, and socioeconomic characteristics. Next, an assessment shows associations between exposure to heat and the mental health outcomes.

PREVALENCE OF MENTAL HEALTH CONDITIONS AND SEASONALITY

The overall prevalence of depression, as measured by the Patient Health Questionnaire 9 (PHQ-9), was higher in the summer than in the winter at 20.1 percent nationally, and 20.0 percent for rural and 20.5 percent for urban areas (refer to figure 5.1). During the winter, overall national prevalence fell to 16.2 percent, with little variation between rural and urban areas. Similarly, higher prevalence of anxiety, as measured by the General Anxiety Disorder 7 (GAD-7), was detected in the summer with an overall national prevalence of 10.0 percent, and 9.6 percent in rural and 11.1 percent in urban areas. In the winter, national prevalence of anxiety fell to 8.3 percent, with 7.9 percent and 9.6 percent for rural and urban areas, respectively.

FIGURE 5.1

Prevalence of mental health condition illnesses, by location



Source: Original figure based on primary data collected for this report.

Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of mental health conditions based on a 14-day recall period from 7,434 individuals surveyed across two rounds.

For depression, the prevalence increased with age (refer to figure 5.2) and saw higher percentages in summer than in winter. In summer, prevalence of depression was 16.5 percent for ages 16–35 years, 21.2 percent for 36–49 years, 24.4 percent for 50–65 years, and 26.3 percent for those ages 66 years or older. During winter, depression fell in comparison to summertime estimates across all age groups, with 13.3 percent for 16–35 years, 16.5 percent for 36–49 years, 20.4 percent for 50–65 years, and 21.8 percent for those ages 66 years or older. For anxiety, the youngest and oldest age groups had lower prevalence compared with those in the middle-aged groups, and summertime prevalence was higher compared with winter for all age groups. During the summer, prevalence of anxiety was 8.7 percent for ages 16–35 years, 10.3 percent for 36–49 years, 12.3 percent for 50–65 years, and 9.2 percent for those ages 66 years or older. Like depression, the prevalence of anxiety was lower in the winter compared with summer for all age groups.

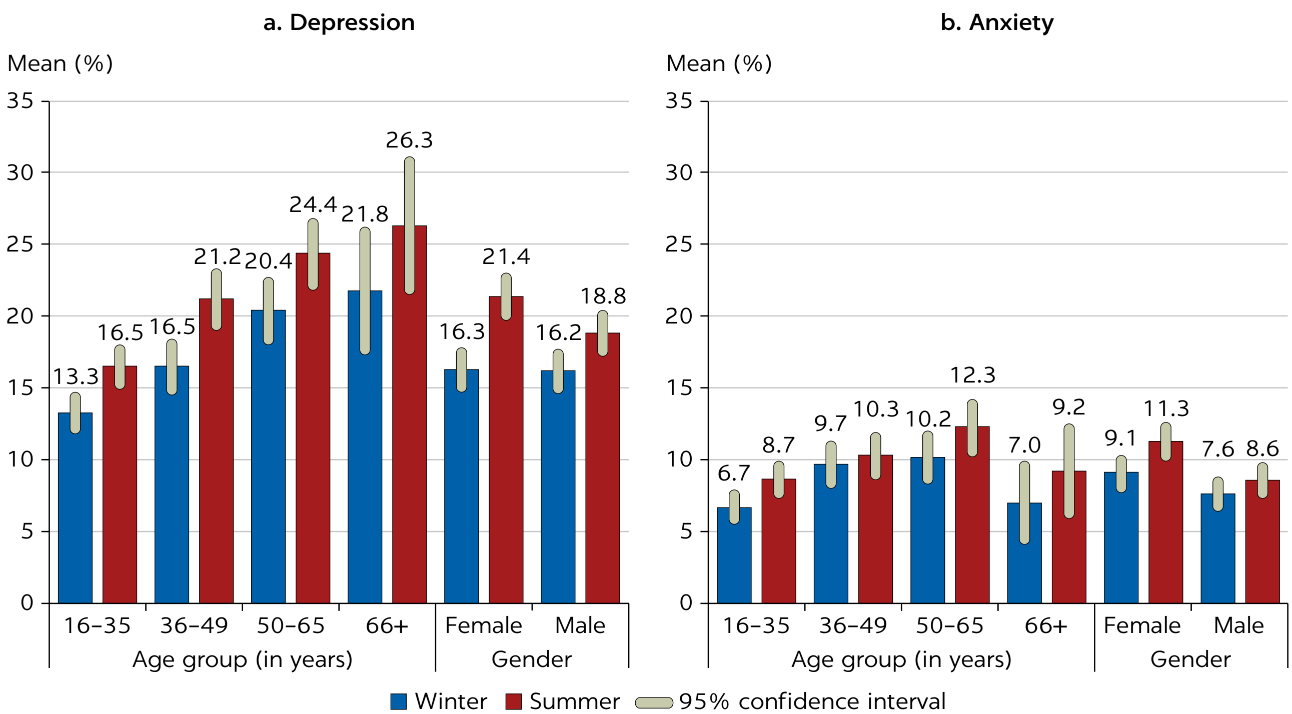
For gender, females had a higher prevalence of depression and anxiety, and estimations were higher for both conditions for both females and males during the summer compared with the winter. In the summer, females had 21.4 percent and 11.3 percent and males had 18.8 percent and 8.6 percent prevalence of depression and anxiety, respectively. In winter, females had

16.3 percent and males had 16.2 percent prevalence for depression. For anxiety prevalence, females had 9.1 percent and males had 7.6 percent in winter.

Across wealth index tertiles (refer to figure 5.3), richer populations had lower prevalence of both depression and anxiety, and were both lower in winter compared with summer. The lowest-income wealth tertile populations had 21.5 percent of depression in the summer, which fell to 18.4 percent in winter, and 10.5 percent prevalence of anxiety in summer compared with 9.7 percent in winter. For those in the middle-income wealth tertile, depression was 19.6 percent prevalent in summer and 15.8 percent in winter. For anxiety, the prevalence was 10.3 percent in summer and 7.7 percent in winter for the middle-income wealth tertile population. For the highest-income wealth tertile, prevalence of depression was 18.7 percent in summer and 13.8 percent in winter, and 8.7 percent and 7.2 percent for anxiety for summer and winter, respectively.

FIGURE 5.2

Prevalence of depression and anxiety across demographic characteristics

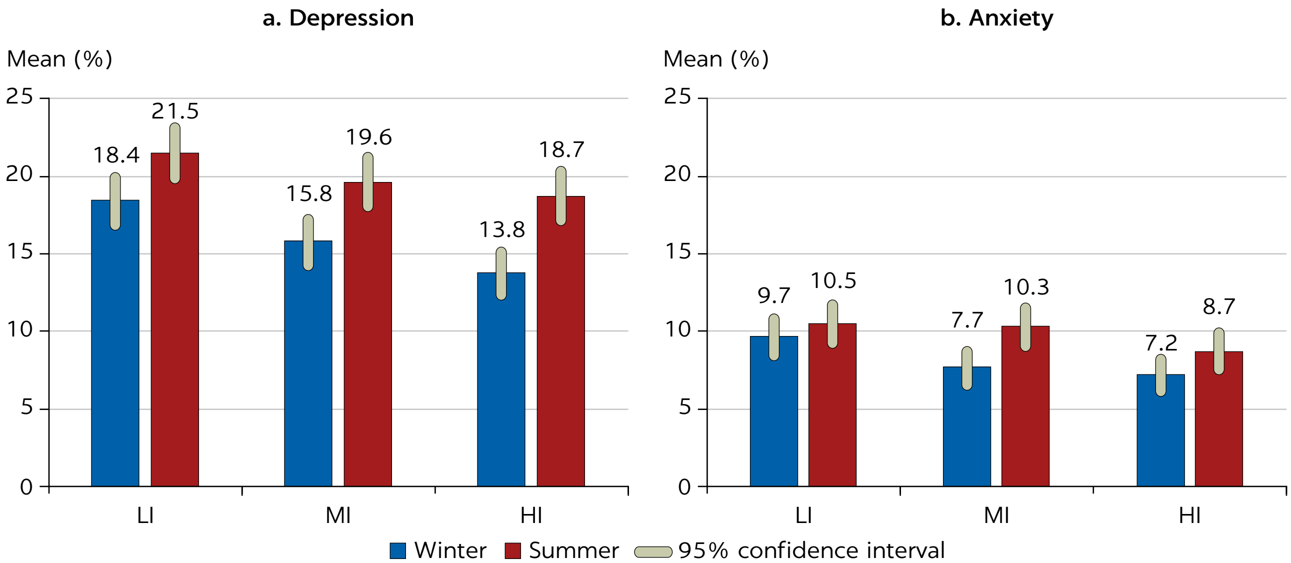


Source: Original figure based on primary data collected for this report.

Note: Figure shows the weighted prevalence of (means with 95 percent confidence interval) mental health conditions based on a 14-day recall period from 7,434 individuals surveyed across two rounds.

FIGURE 5.3

Prevalence of depression and anxiety across socioeconomic status



Source: Original figure based on primary data collected for this report.
Note: Figure shows the weighted prevalence (means with 95 percent confidence interval) of mental health conditions based on a 14-day recall period from 7,434 individuals surveyed across two rounds. HI = higher income; LI = lower income; MI = middle income.

ASSOCIATIONS OF HEAT WITH DEPRESSION, ANXIETY, AND EMOTIONAL REGULATION

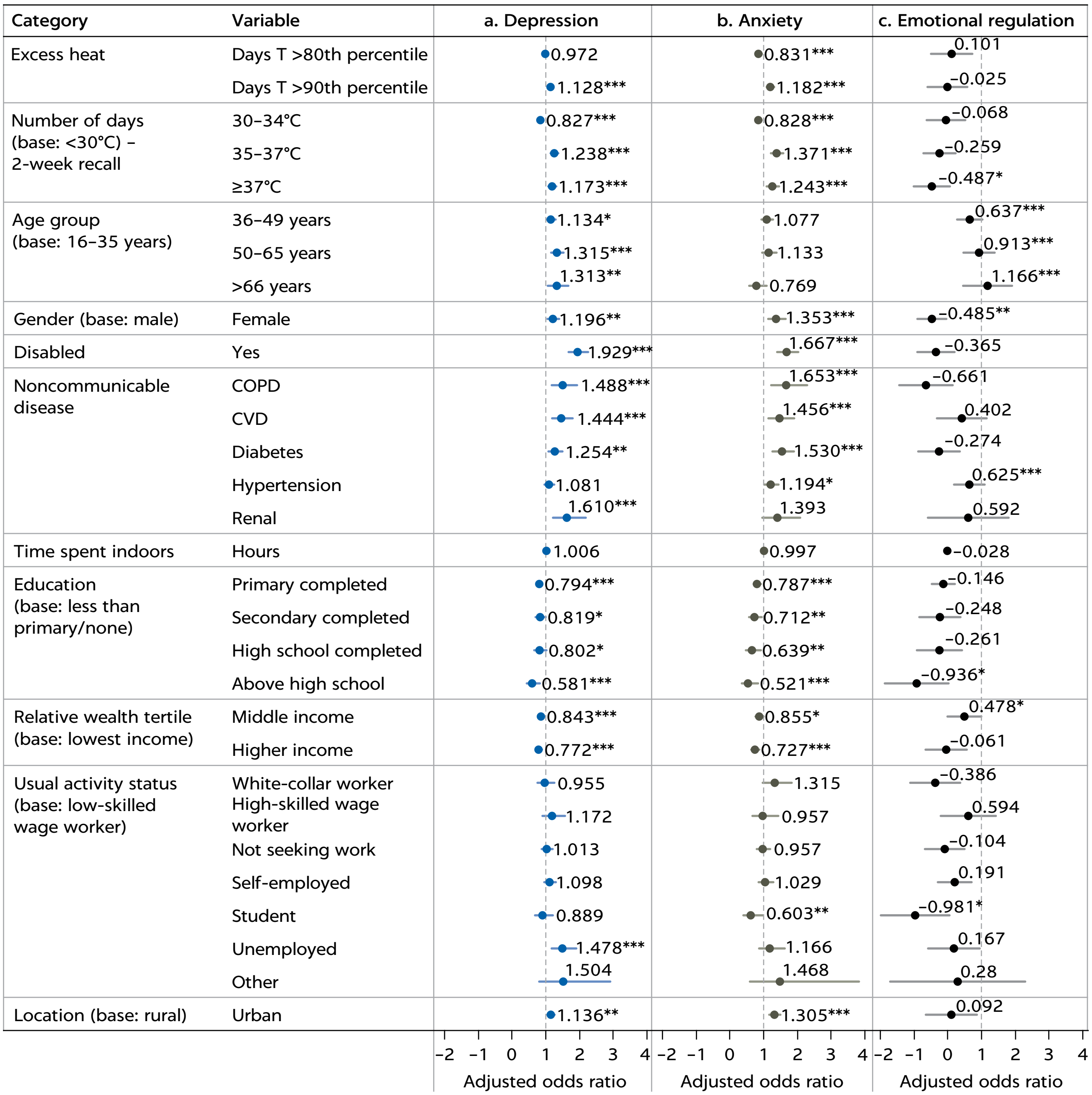
Mental health outcomes are affected both by environmental conditions such as heat and by sociodemographic conditions.

Associations between mental health outcomes and heat exposure

Additional days with excess heat, defined as 90th percentile above comparable months over the past 20 years, increased the adjusted odds ratio (AOR) of depression by 12.8 percent more than days below the threshold (refer to figure 5.4, column a). Although each additional day with temperatures between 30°C and 34°C was negatively associated with the likelihood of depression (17.3 percent), additional days with temperatures between 35°C and 37°C and above 37°C increased the AOR of depression by 23.8 percent and 17.3 percent, respectively, over further days with temperatures below 30°C.

FIGURE 5.4

Correlates of mental health outcomes



Source: Original figure based on primary data collected for this report.
Note: Figure shows adjusted odds ratios (columns a and b) from a weighted population-average logistic model and coefficients from a left-censored count model (column c) using a pooled sample of 7,434 individuals surveyed across two rounds. The two binary dependent outcomes are whether the individual experienced (1) depression and (2) anxiety during the two weeks preceding each of the two survey rounds. The correlates of the aggregated emotional regulation score (column c) are from a weighted Tobit model based on a pooled sample. Base categories are reported in parentheses in the "Category" column. Results are also interpretable as percentage changes ([AOR – 1] * 100 = percentage change). COPD = chronic obstructive pulmonary disorders; CVD = cardiovascular diseases. Significance level: *10 percent, **5 percent, ***1 percent.

Elevated temperatures were associated with higher likelihood of anxiety as well (refer to figure 5.4, column b). Each additional day of excess heat above the 90th percentile was associated with 18.2 percent higher odds of anxiety. For each additional day exposed to temperatures between 35°C and 37°C, there was a significant association with 37.1 percent higher AOR of anxiety, and each additional day of exposure to temperatures greater than or equal to 37°C was significantly associated with 24.3 percent higher odds of anxiety than further days below 30°C.

For emotional regulation, significant negative associations were identified with exposure to hot days and reduction in the ability to regulate emotions (refer to figure 5.4, column c). Each additional day of exposure above 37°C was associated with a decrease of 0.48 points in the emotional regulation score, reflecting a lower ability to manage emotions, compared with further days below 30°C. Exposure to days between 30°C and 36°C was not associated with emotional regulation.

Associations between background characteristics and mental health outcomes

A range of sociodemographic variables was associated with depression, anxiety, and emotional regulation. Compared with those ages 16–35 years, the 36–49 age group had a higher probability of depression (13.4 percent). Furthermore, the 50–65 group and the 66 years and up group were significantly associated with 31.5 percent and 31.3 percent higher AOR of depression, respectively. For anxiety, there was no association identified with age. Compared with the age group 16–35 years, all older age groups had statistically significant higher emotional regulation scores. Female respondents had 19.6 percent and 35.3 percent significantly higher AOR of depression and anxiety, respectively. For emotional regulation, females had statistically significant 0.49 points lower score than males.

Depression was found to be significantly lower among the highest-income wealth tertile compared with the lowest-income wealth tertile. People belonging to the middle-income and highest-income wealth tertiles were associated with 15.7 percent and 22.8 percent lower AOR of depression, respectively. Similarly, for anxiety, those in the middle-income and highest-income wealth tertiles had significantly reduced AOR (14.5 percent and 27.3 percent, respectively). Belonging to the middle-income wealth tertiles, as compared with the lowest-income wealth tertile, was associated with 0.48 points higher score for emotional regulation, and no association was detected with the highest-income wealth tertile.

All forms of formal education, except religious education, were inversely related to depression and anxiety. Compared with the group with below-primary or no formal education, the following groups showed these percentages: completion of primary (depression 20.6 percent lower AOR, and anxiety 21.3 percent lower AOR); secondary (depression 21.3 percent lower AOR, and anxiety 28.8 percent lower AOR); high school (depression 19.8 percent lower AOR, and anxiety 36.1 percent lower AOR); and education extending beyond high school (depression 41.9 percent lower AOR, and anxiety 47.9 percent lower AOR). The groups were all significantly associated with a lower likelihood of both depression and anxiety. The only significant association between education and emotional regulation was between those who had education beyond high school compared with those with less than primary or no formal education, with a lower score of 0.94 points of emotional regulation challenges for those in the higher level of education group.

Considering respondents' professions, no protective relationships with depression or anxiety were noted. However, for those who were unemployed, a 47.8 percent significant higher AOR of depression was detected compared with those engaged in low-skilled wage work. Only student status was associated with anxiety (39.7 percent lower AOR) and emotional regulation, with students having significant 0.98 lower scores compared with low-skilled wage work. Urbanites had significant 13.3 percent higher AOR of depression and 30.5 percent higher likelihood of anxiety compared with rural counterparts, and no association was detected for emotional regulation for location.

The presence of most forms of noncommunicable diseases was significantly associated with higher AOR of depression and anxiety. Having diabetes (depression 25.4 percent higher AOR, anxiety 53.0 percent higher AOR); chronic obstructive pulmonary disorders (COPD) (depression 48.8 percent AOR, anxiety 65.3 percent higher AOR); cardiovascular diseases (CVD) (depression 44.4 percent higher AOR, anxiety 45.6 percent higher AOR); and renal disease (depression 61.0 percent higher AOR, anxiety 39.3 percent higher AOR) were all associated with higher likelihood of both depression and anxiety. Hypertension was only significantly associated with higher AOR of anxiety (19.4 percent) and no significant association with depression. For emotional regulation, having hypertension (0.62) was associated with a higher emotional regulation score. Having a disability was associated with 92.9 percent higher AOR of depression and 66.7 percent higher AOR of anxiety, but no statistically significant relationship with emotional regulation was identified.

6 Heat and Productivity Losses

INTRODUCTION

This chapter assesses the impact of seasonality and heat on the loss of productivity across the working-age population in Bangladesh. The chapter first explores the seasonal difference in the outcomes across locations, demographic types, and socioeconomic characteristics. Those findings are followed by an assessment of associations between exposure to heat and days of productivity lost. The chapter concludes with an annualized extrapolation of the economic burden of lost productivity at the country level.

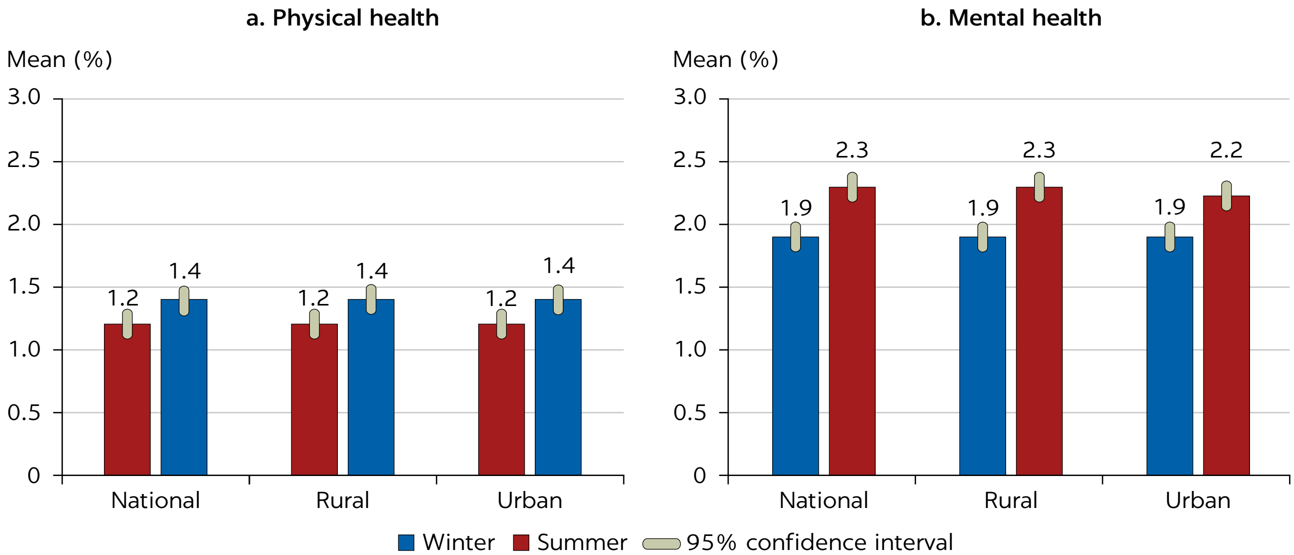
LOSS OF PRODUCTIVITY AND SEASONALITY

The average number of days that respondents reported being unable to carry out their usual activities because of physical health conditions ranged from 1.4 days during the summer to 1.2 days during the winter (refer to figure 6.1). Days attributable to mental health conditions were notably higher, ranging from 1.9 days during the winter to 2.3 days during the summer. The means across rural and urban areas did not vary significantly.

On average, males reported higher incidences of days lost than females across both summer and winter seasons for both physical and mental health conditions (refer to figure 6.2). Among age groups, individuals ages 36–49 years reported the highest number of days they were unable to carry out usual activities over the summer and winter seasons because of physical health conditions (1.7 and 1.4 days, respectively) and mental health conditions (2.5 and 2.0 days, respectively). Days lost reported by individuals

FIGURE 6.1

Prevalence of average days of productivity lost due to physical and mental health conditions, by location



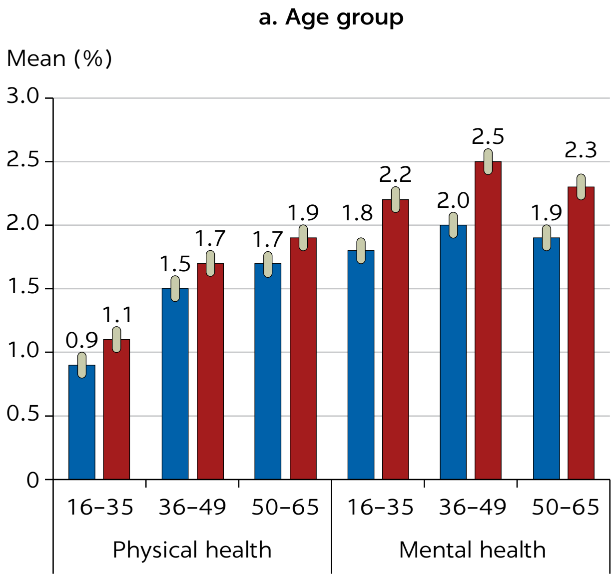
Source: Original figure based on primary data collected for this report.
Note: Figure shows the weighted mean (95 percent confidence interval) days of productivity lost among individuals 15–64 years old based on a 30-day recall from 10,331 individuals surveyed across two rounds.

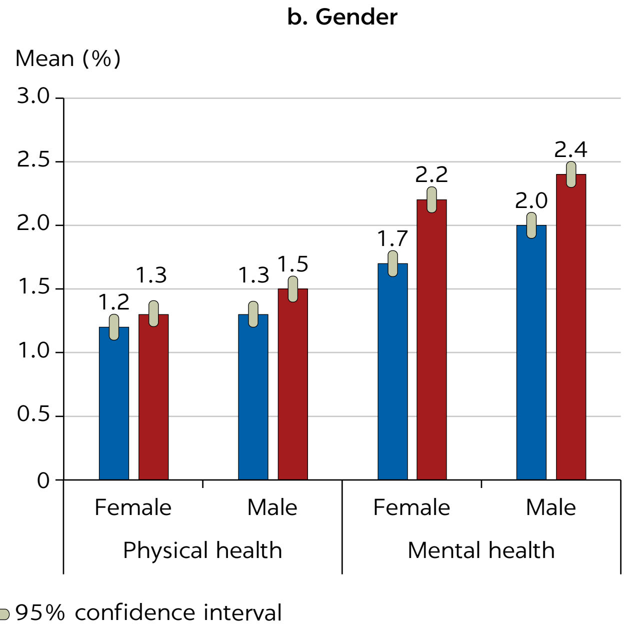
ages 50 years and above did not vary significantly by season or condition. The lowest proportions were reported by those ages 16–35 years, who lost 1.1 days because of physical health conditions and an additional 2.2 days because of mental health conditions during the summer, figures notably higher than what they had reported during the winter.

In the categories of socioeconomic status and type of work activity, the research team reported the lowest-income group had higher incidences of days of productivity lost because of physical health conditions across the seasons, with 1.7 days during the summer and 1.5 days in winter, compared with the richest, who reported 1.1 and 0.8 days lost, respectively (refer to figure 6.3). Interestingly, the average days lost because of mental health conditions did not vary by socioeconomic status during summer but was lower among higher-income people compared with the lowest-income group during winter (2.0 versus 1.7 days). Low-skilled wage workers reported the highest average days lost due to physical health conditions during both the summer (1.8 days) and winter seasons (1.7 days), while white-collar workers reported the lowest (1.1 and 0.8 days, respectively). For mental health conditions, however, high-skilled wage workers reported the highest loss during the summer (2.9 days), while white-collar workers reported the lowest (2.2 days).

FIGURE 6.2

Average days of productivity lost due to physical and mental health conditions, by demographic characteristic

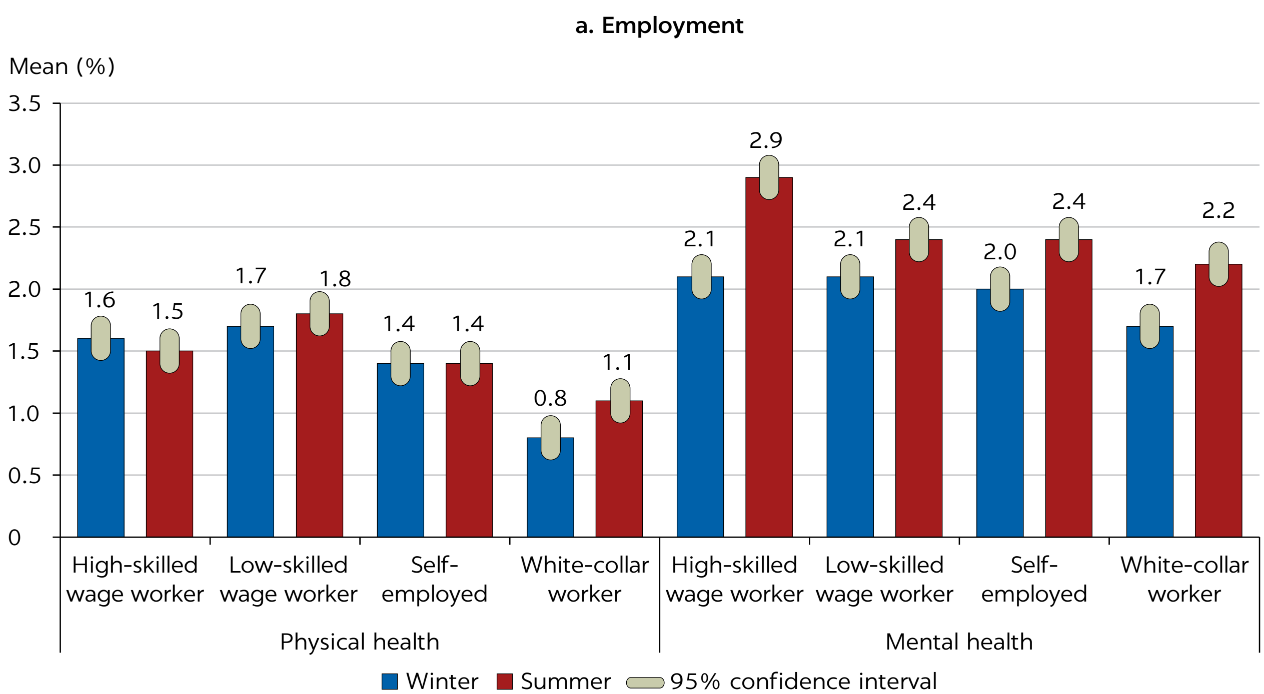




Source: Original figure based on primary data collected for this report.
Note: Figure shows the weighted mean (95 percent confidence interval) days of productivity lost among individuals 15–64 years old based on a 30-day recall from 10,331 individuals surveyed across two rounds.

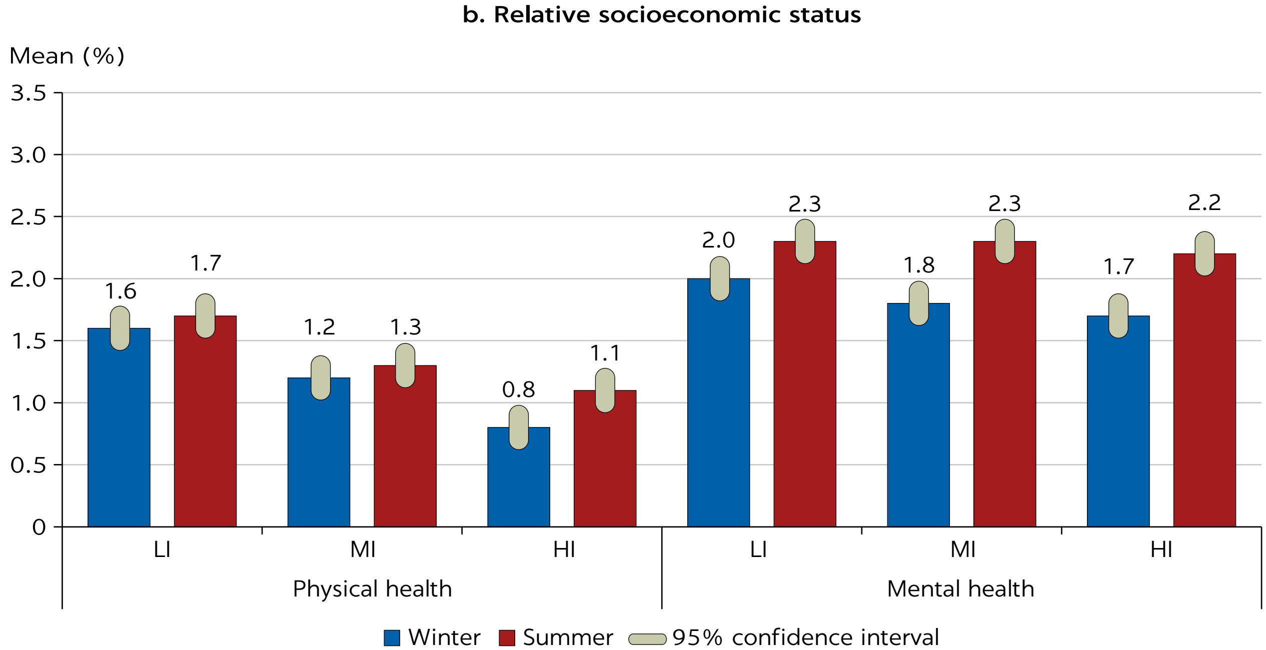
FIGURE 6.3

Average days of productivity lost due to physical and mental health conditions across socioeconomic status and usual activity



continued

FIGURE 6.3 *continued*



Source: Original figure based on primary data collected for this report.
Note: Figure shows the weighted mean (95 percent confidence interval) days of productivity lost among individuals 15–64 years old based on a 30-day recall from 10,331 individuals surveyed across two rounds. HI = higher income; LI = lower income; MI = middle income.

ASSOCIATIONS OF HEAT WITH PRODUCTIVITY LOSS

This section explores the association between heat and the probability of productivity loss due to physical and mental health conditions.

Associations of heat and the loss of productivity

The coefficients from a count model, which presents the association between heat exposure and productivity loss, are presented in figure 6.4. On average, additional days with temperatures between 35°C and 37°C were associated with 0.8 additional days of lost productivity attributable to physical and mental health conditions over the 30 days preceding the survey, while more days above 37°C increased the potential losses by another 1.4 days compared with additional days below 30°C.

FIGURE 6.4

Factors associated with days of productivity lost

Category	Variable	Productivity loss (days)
Excess heat	Days T >80th percentile	0.262
	Days T >90th percentile	−0.219
Number of days (base: <30°C) – 2-week recall	30–34°C	−0.749
	35–37°C	−0.821*
	≥37°C	−1.359**
Age group (base: 16–35 years)	36–49 years	−2.478***
	50–65 years	−2.070**
Gender (base: male)	Female	−0.616
Disabled	Yes	6.335***
Noncommunicable disease	COPD	3.968***
	CVD	4.710**
	Diabetes	1.914**
	Hypertension	2.544***
	Renal	1.907
Time spent indoors	Hours	−0.121**
Education (base: less than primary or none)	Primary completed	−0.376
	Secondary completed	−1.176
	High school completed	−1.14
	Above high school	−3.800*
	Religious education	−0.809
Relative wealth tertile (base: lowest income)	Middle income	−1.611***
	Higher income	−2.906***
Usual activity status (base: low-skilled wage worker)	White-collar worker	−3.062***
	High-skilled wage worker	1.8
	Self-employed	0.15
	Unemployed	−0.698
	Not seeking work	−1.708*
	Student	−5.233***
	Other	2.769
Location (base: rural)	Urban	1.362*

−5 0 5

Coefficients (count model)

Source: Original figure based on primary data collected for this report.
Note: Figure shows coefficients from a weighted Tobit model using a pooled sample of 10,331 working-age individuals (15–64 years) surveyed across two rounds. The outcome of interest is the number of days of productivity lost at the individual level during the 30 days preceding each of the two survey rounds. Base categories are reported in parentheses in the "Category" column. Results are also interpretable as the change in number of days lost. COPD = chronic obstructive pulmonary disorders; CVD = cardiovascular diseases.
Significance level: *10 percent, **5 percent, ***1 percent.

Associations between lost productivity and background characteristics

Individuals ages 36–49 years and those ages 50–64 years were more likely to report higher days of lost productivity (2.5 and 2.1 days, respectively) than respondents ages 16–25 years over the recall period (refer to figure 6.4). Although no gender differentials were noted, those with disabilities lost an additional 6.3 days of productivity compared with those without. The presence of noncommunicable diseases was a significant predictor of days lost. Individuals with cardiovascular diseases (CVD), followed by those with chronic obstructive pulmonary disorders (COPD), were likely to lose the highest number of days of productivity compared with those without these conditions (an additional 4.7 and 3.9 days, respectively). Similarly, individuals with diabetes, hypertension, and renal conditions were likely to lose additional days of productivity compared with those without these conditions (1.9, 2.5, and 1.9 additional days, respectively). Individuals who spent an additional hour indoors were less likely to report lost time (0.12 days) compared with those who spent additional hours outdoors.

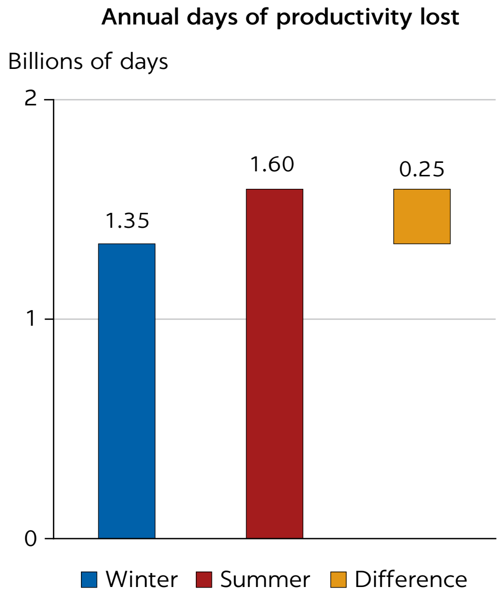
Individuals with education levels greater than high school were less likely (3.8 days) to lose days of productivity than ones with no formal education (refer to figure 6.4). Comparably, higher socioeconomic status was found to be negatively associated with lost days caused by physical or mental health conditions. Compared with the lowest-income group, those in the middle lost 1.6 fewer days and the highest-income group lost 2.9 fewer days during the month preceding the survey. On average, respondents engaged in white-collar work lost 3.1 fewer days of productivity attributed to physical and mental health conditions than those engaged in low-skilled wage labor. Similar trends were noted for those not seeking work or students (5.2 and 1.4 fewer days, respectively). Finally, respondents living in urban areas reported a higher number of days lost because of physical or mental health conditions (1.4 days) than those living in rural areas over the recall duration.

ANNUALIZED IMPACT AT THE NATIONAL LEVEL

With the previous section as a basis, an extrapolation of national estimates indicates that the country loses approximately 1.35 billion days of productivity because of select physical and mental health conditions during the winter season (refer to figure 6.5). This figure rises to 1.60 billion days in the summer, resulting in a net loss of about 25 million days because of excess heat.

FIGURE 6.5

Annualized cost to productivity loss to the gross domestic product due to physical and mental health conditions

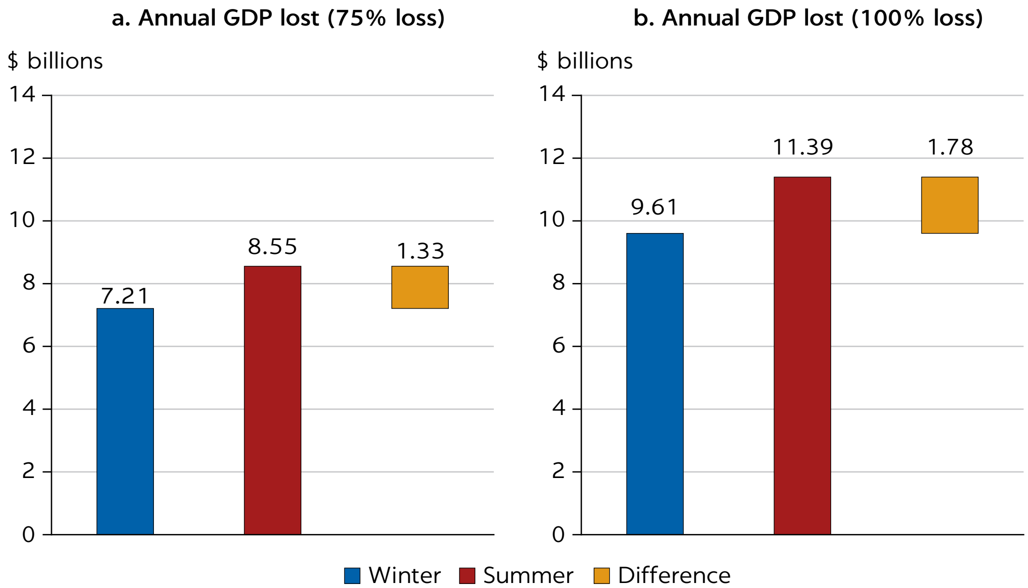


Source: Original figure based on primary data collected for this report.
Note: Figure shows the average number of days of productivity lost among individuals ages 15–64 years based on a 30-day recall from 10,331 individuals surveyed across two rounds.

Assuming a 75 percent cost for each day of productivity loss, this number of lost days equates to approximately $7.21 billion, or 1.57 percent of Bangladesh's gross domestic product (GDP) annually (refer to figure 6.6 and figure 6.7). The economic loss increases to $8.55 billion, or 1.86 percent of Bangladesh's GDP, with a net heat–attributable loss of $1.33 billion, or 0.29 percent of Bangladesh's GDP. If the days of lost productivity are taken at face value, the economic cost increases substantially. The country loses $9.61 billion (2.09 percent of Bangladesh's GDP) in winter, rising to $11.39 billion (2.48 percent of Bangladesh's GDP) in summer, with a heat-attributable cost of $1.78 billion, or 0.39 percent of Bangladesh's GDP. These figures represent the lower bound of the actual economic cost, given the selectivity of conditions explored in this report. It is important to highlight that these figures likely underestimate the true economic impact. The analysis focuses on select physical and mental health conditions, excluding other potential health issues exacerbated by extreme temperatures. Therefore, the actual economic burden of excess heat could be significantly higher, underscoring the need for comprehensive measures to mitigate the effects of heat exposure on public health and productivity.

FIGURE 6.6

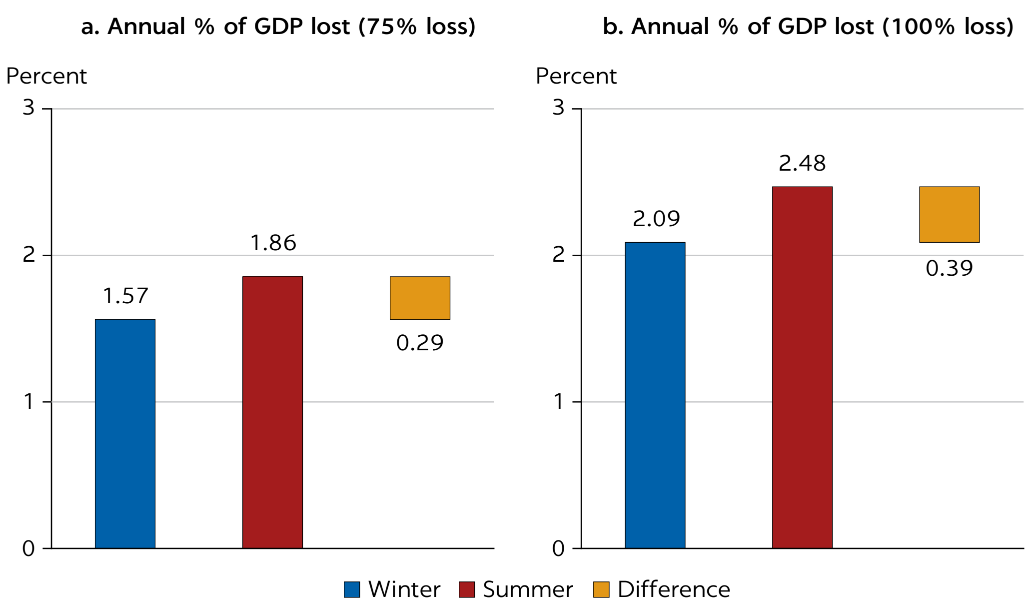
Absolute annualized cost to the gross domestic product



Source: Original figure for this report, based on household surveys conducted January 18, 2024, to February 7, 2024, and May 20, 2024, to June 7, 2024.
Note: Figure shows the average number of days of productivity lost among individuals ages 15–64 years based on a 30-day recall from 10,331 individuals surveyed across two rounds. GDP = gross domestic product.

FIGURE 6.7

Cost as a percentage of the gross domestic product (real 2023)



Source: Original figure based on primary data collected for this report.
Note: Figure shows the average number of days of productivity lost among individuals ages 15–64 years based on a 30-day recall from 10,331 individuals surveyed across two rounds. GDP = gross domestic product.

Part 3

The Way Forward

7 Conclusions and Recommendations

CONCLUSIONS

Consistent with global patterns, the temperature in Bangladesh is rising, with an average increase in maximum temperature of 1.1°C in the 43 years between 1980 and 2023 (using three-year moving averages). Over the same period, the heat index increased by 4.5°C. Across the country, the increased temperatures vary considerably. Dhaka is subjected to the "urban heat island" effect and has recorded increases in the temperature and heat index more than the national averages. In addition, the increments in the temperature and heat index are rapidly accelerating with the past nine consecutive years, 2015–23, being the hottest on record worldwide (WMO 2024) and for Bangladesh, as well. Consequently, the adverse impacts on the health and livelihoods of the Bangladeshi population are insurmountable. Under different scenarios, economic losses caused by heat waves in 2024 were estimated to be 0.3–0.4 percent of Bangladesh's gross domestic product (GDP). The economic damages were caused by adverse impacts on physical and mental health conditions as well as an estimated 25 million days of lost productivity in 2024. These figures represent the lower bound of the actual economic cost, given the selectivity of health conditions covered in this report. Effective strategies and measures need to be devised in dealing with heat waves, which are a relatively new threat for Bangladesh. These interventions can include solutions like self-protective action, early warning systems for heat, urban planning, and heat action plans, which are known to be effective in managing heat-related deaths and diseases (Zachariah et al. 2023).

The government of Bangladesh has taken several steps to mitigate the impact of climate change. The Ministry of Environment, Forest and Climate Change (MoEFCC) has developed the National Adaptation

Plan (NAP) for Bangladesh 2023–50, which has synergies with the other relevant policies. The NAP includes recommendations for dealing with heat waves, particularly heat-related health conditions. In addition, the Ministry of Health and Family Welfare (MoHFW) has developed guidelines for managing heat-related illnesses that provide detailed recommendations for enhancing capacity of the health sector for effective diagnosis and treatment.

With temperatures further projected to rise and heat waves becoming more intense and frequent, the adverse effects on human health will be catastrophic. Although Bangladesh is not one of the largest emitters of greenhouse gases, it bears a high burden of the impacts of global warming. Hence, actions by the public sector and relevant agencies are urgently needed to better prepare to respond to this emergency.

RECOMMENDATIONS

The following policy options are being recommended, linked to the findings of this report.

Recommendation 1: Improve preparedness to deal with heat waves. Evidence-based strategies for mitigating the impact of heat are needed, which should be devised after carefully assessing the benefits and challenges of each measure and contextualizing it to local needs. Lessons should be drawn from other countries that have implemented successful interventions for dealing with heat waves. The following specific actions can be considered to augment preparedness capacities that are needed to minimize the adverse effects on health as documented by the survey findings:

- Identify heat waves in government policy and planning documents as one of the natural disasters. Although the NAP identifies heat as one of the climate-related risks, it is not prioritized in other government documents. This prioritization will ensure adequate measures and financing are made available by the government for dealing with the impact of heat waves, as is done for floods, for example.
- Establish a multisectoral task force to manage heat waves similar to other natural disasters such as floods, activate mobile teams, issue health advisories, prepare health facilities, issue guidance to educational institutions to close down or operate for shorter hours, trigger social protection schemes, and so on.
- Develop standard operating procedures and protocols for dealing with the impacts of heat waves. These should include all relevant sectors including infrastructure, power, health, education, disaster management, local government, urban, and the environment.

- Develop and implement area- or city-specific heat action plans, customized to local needs. Robust, evidence-based, and widely disseminated heat action plans that can be monitored by real-time surveillance are the most effective (Jay et al. 2021). Evidence from Ahmedabad and Odisha in India indicates effective implementation of heat action plans reduces heat-related deaths (Zachariah et al. 2023). When devising heat action plans, the needs of the vulnerable population (particularly the poor to ensure they can access adequate measures) and occupation-related risks should be considered. Urban planning and building design should act as a heat diminisher instead of heat multiplier to provide an effective adaptation to heat (Kim, Henry, and Jain 2023).

Recommendation 2: Strengthen the health sector response. Curative care, particularly delivered through public health platforms, needs to be further strengthened to treat heat-related health conditions. Better health care for these conditions will reduce the additional and incremental burden of health expenditures on the population. In addition, the awareness of health professionals and their capacity to diagnose heat-related illnesses need to be further enhanced. Given the huge adverse impact of heat on health as documented in this report, it is critical to ensure readiness of the health sector to respond to the heat-related morbidities and mortality. The following measures can be implemented as a part of the efforts to strengthen the health care delivery system:

- Ensure health facilities are equipped to deal with heat-related morbidity and mortality. Climate resilience of health facilities can be increased through vulnerability assessments, climate stress tests, and investing in newer technologies and infrastructure (Jay et al. 2021). The MoHFW's national guidelines for management of heat-related illnesses has specific recommendations for strengthening the health system. These measures need to be implemented effectively.
- Provide targeted training for medical professionals to detect and treat heat-related conditions including mental health issues.
- Prioritize vulnerable groups when treating patients affected by heat. These include the elderly, children, women, and people with underlying conditions, among others. As documented by the panel survey administered for this report, these groups are particularly susceptible to heat-related illnesses.
- Mainstream the responses to mental health issues by providing community-based solutions for prevention and treatment. These solutions can include, for instance, the creation of peer support groups at local community levels as well as training nonspecialists to detect and treat common mental disorders. The survey administered for this report documents how heat adversely affects depression, anxiety, and emotional regulation, which is why this recommendation is crucial.

Recommendation 3: Promote preventive measures using advanced technology. Using local government bodies and community mobile teams strategically with the assistance of modern technology can help prevent much of the heat-related mortality and morbidity. The following actions can be considered to achieve that result:

- Develop heat-health early-warning systems using real-time weather data and reliable modeling techniques. This is one of the NAP recommendations. Such early-warning systems should be integrated with surveillance of heat-related health outcomes so that the warning levels can be adjusted based on the actual threat levels (Jay et al. 2021). The goal of the heat-health early-warning systems is to provide reliable information to decision-makers and the public about heat events and implement preventive actions (IFRC 2020).
- Use innovative mechanisms to disseminate information and foster behavior change. Psychosocial messaging can be used for inducing behavior changes and adopting measures to encourage simple mitigating measures like staying indoors, limiting physical exercise, hydrating sufficiently, and so on.
- Issue health advisories with heat alerts and disseminate information strategically to areas and communities most affected by heat. These advisories will ensure that people are better able to prevent heat-related health conditions. The NAP includes a recommendation to develop heat advisories, particularly for urban areas.
- Create urban green spaces to manage the "urban heat island" effect by reducing surface temperature in the cities, limiting heat transmission from the buildings to the air, and providing shade for people to take shelter during extreme heat (IFRC 2020). Such initiatives can include establishing parks and open spaces, planting trees, and adding landscaping (IFRC 2020). Use artificial intelligence to map out potential green zones where trees can be planted. Drones could potentially be used for such mapping. Factors such as the design of green space, types of trees to be planted, and irrigation systems and practices should be considered for urban greening to maximize heat reduction. Adequate budget and maintenance plans for these green spaces should be in place to ensure sustainability (IFRC 2020). As documented in this report, temperature increases in urban cities like Dhaka are more than the national averages. The NAP recommends blue and green infrastructure for dealing with the urban heat island effect. Effective urban planning and smart city design can mitigate the adverse impacts of both urban heat island effect and air pollution (Grigorieva and Lukyanets 2021).
- Mobilize communities, students, and teachers of academic institutions, local leaders, social influencers, and nongovernmental organizations to disseminate knowledge, create awareness about the adverse impacts of heat on human health, and prevent heat-related health hazards.

Recommendation 4: Record more granular and accurate data. This action will ensure that extreme heat events are better tracked and predicted, which in turn will help prevent the adverse impacts on the population.

- Increase the number of weather stations throughout the country to collect more localized information with accuracy. As documented in this report, the Bangladesh Meteorological Department (BMD) currently tracks weather data through a limited number of stations. Accurate and granular weather data are essential for the governments to make climate-informed decisions for planning, preparedness, and responses (Romanello et al. 2023).
- Calculate and use the heat index to classify episodes of heat waves rather than using dry-bulb temperature. Most countries include "feels like" or apparent temperature in addition to near-surface temperature to effectively assess the impact of heat on human health (Zachariah et al. 2023). Heat warnings should include thresholds to trigger response mechanisms based on a careful assessment of local impacts and the capacity of the national systems to deal with the event (Jay et al. 2021). Existing sources of information, coupled with localized ground-level information, should be used to continually monitor the effect of heat on human health. Such evidence should be used for decision-making purposes.

Recommendation 5: Leverage international support and financing. As documented in this report, economic losses from selected physical and mental health conditions caused by extreme heat were about 0.29–0.39 percent of Bangladesh's GDP in 2024. Bangladesh will sustain economic losses of about 4.9 percent of its GDP by 2030 due to heat waves (Ministry of Environment, Forest and Climate Change 2022). Although not a major contributor to global warming, Bangladesh bears a disproportionately high brunt of the adverse impacts. Therefore, it is imperative that the promised assistance is mobilized to mitigate the effects of climate change. To achieve this aim, the following actions can be considered:

- Prepare convincing evidence-based investment cases to leverage resources from the loss and damage funds. Using real-time and accurate data, economic losses and the cost of mitigation should be quantified to make a compelling case.
- Advocate for active actions by the developed countries and the international community for mitigation using cutting-edge research. Conduct high-quality research using household panel surveys over longer periods of time for all relevant sectors to accurately project the effects of heat, mitigate imminent risks, and identify emerging issues.

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APPENDIX A

Operationalizing the Definitions of Heat Exhaustion and Heat Stroke

TABLE A.1 Scoring mechanism used to ascertain the probability of a respondent experiencing heat exhaustion or a heat stroke during two weeks before each survey round

	SCORE	
SYMPTOM	HEAT EXHAUSTION	HEAT STROKE
Weakness	3	1
Syncope	4	5
Fever	n.a.	3
Excessive sweating	3	n.a.
Arrhythmia	3	1
Nausea	3	3
Headache	1	2
Slurred speech	1	1
Muscle cramp	2	n.a.
Disorientation	1	3
Reduced urine volume	1	1
Dry skin	1	3
Light headedness/dizziness	2	2
Total score	25	25
Qualifying threshold	12	13

Source: Original table for this report.
Note: n.a. = not applicable.

APPENDIX B

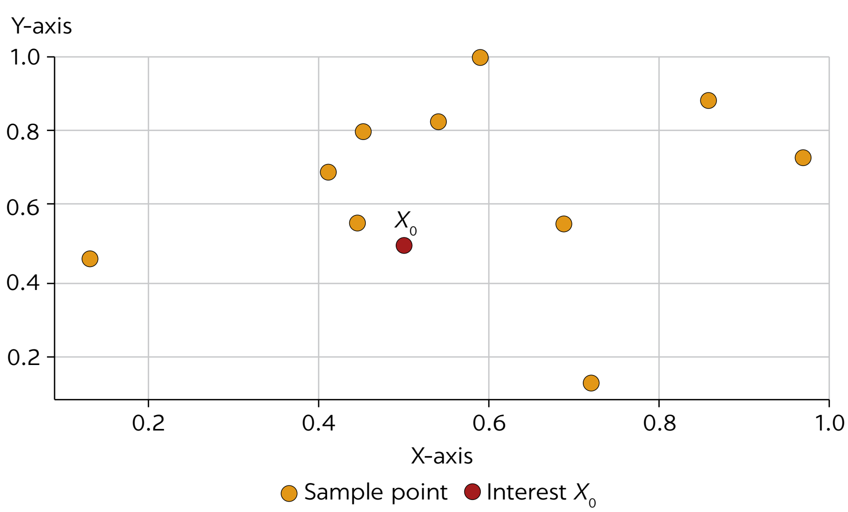
Localization of Temperature Data

To estimate humidity, rainfall, and maximum temperature at 180 specific locations within our project area, data were used from 35 meteorological stations and applied the ordinary kriging method, a geostatistical interpolation technique widely used for its accuracy and reliability in spatial estimation. The meteorological stations' temperature, humidity, and rainfall data were first organized and preprocessed to ensure consistency and accuracy. Precise coordinates were recorded for both the meteorological stations and the target locations.

Ordinary kriging relies on the spatial correlation between observed data points to predict values at unmeasured locations. The study team began by developing an experimental variogram to analyze the spatial dependence and structure of the data. A theoretical variogram model was then fitted to the experimental variogram, selecting the best fit based on criteria such as the spherical, exponential, or Gaussian models.

FIGURE B.1

A domain with irregularly spaced sample points and a location of interest X_0



The ordinary kriging method involves estimating a value at a point (X_0) using the data from n neighboring sample points X_α and combining them linearly with weights w_α. The kriging estimate $Z^*(X_0)$ is given by:

$$Z^*(X_0) = \sum_{\alpha=1}^{n} \omega_\alpha Z^*(X_\alpha) \tag{B.1}$$

where the weights w_α are constrained to sum to one to ensure unbiasedness as we have to constrain the weights to sum up to one because in the extreme ease when all data values are equal to a constant, the estimated value should also be equal to this constant.

$$\Omega_\alpha = 1 \tag{B.2}$$

The ordinary kriging system is derived by minimizing the estimation variance subject to this constraint, leading to the following system of equations:

$$\begin{pmatrix} \gamma(X_1 - X_1) & \dots & \gamma(X_1 - X_n) & 1 \\ \dots & \ddots & \vdots & \vdots \\ \gamma(X_n - X_1) & \dots & \gamma(X_n - X_n) & 1 \\ 1 & \dots & 1 & 0 \end{pmatrix} \begin{pmatrix} \omega_1^{OK} \\ \vdots \\ \omega_n^{OK} \\ \mu^{OK} \end{pmatrix} = \begin{pmatrix} \gamma(X_1 - X_0) \\ \vdots \\ \gamma(X_n - X_0) \\ 1 \end{pmatrix} \tag{B.3}$$

where γ is the variogram function and μ is the Lagrange multiplier.

Using this system, the weights for each data point were calculated to estimate humidity, rainfall, and maximum temperature at the target locations. The kriging system of equations was solved to obtain the best linear unbiased predictions. To ensure the accuracy and reliability of these estimates, cross-validation was conducted by removing one data point at a time, predicting its value using the remaining data, and comparing the predicted values to the observed ones. The performance of the kriging interpolation was assessed using metrics such as the mean squared error (MSE) and the coefficient of determination (R^2).

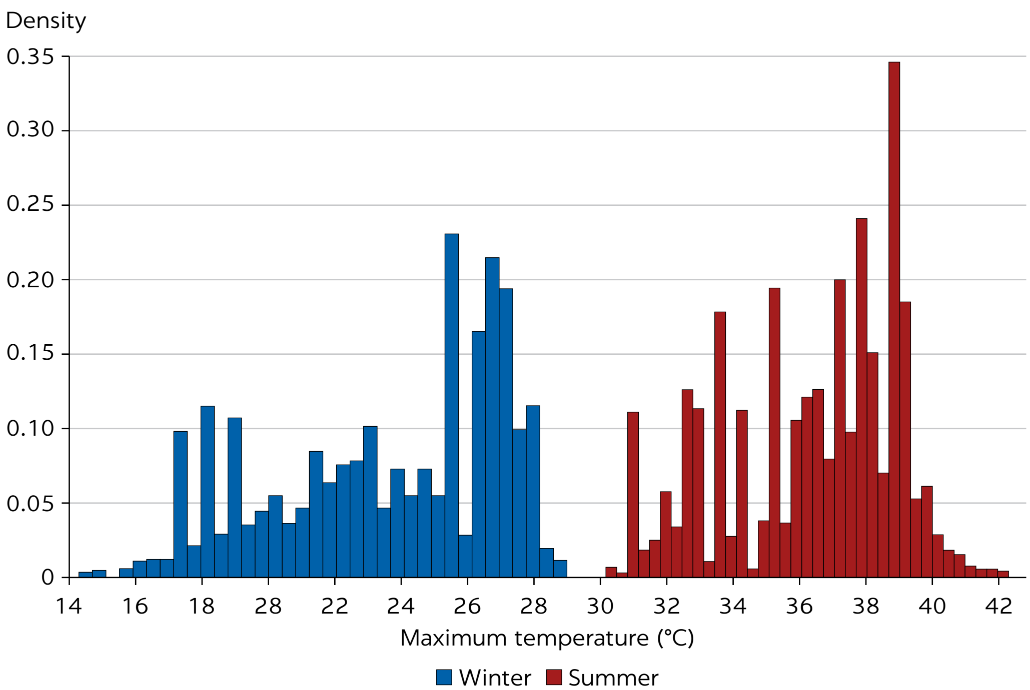
APPENDIX C

Daily Temperature Range by Survey Round

Figure C.1 shows the density of the daily maximum temperature range across the month preceding each of the survey rounds conducted in January and May 2024.

FIGURE C.1

Daily temperature range, by survey round



Source: Original figure for this report, based on data from the Bangladesh Meteorological Department.

Note: Figure shows the density of the daily maximum temperature range across the month preceding each of the survey rounds conducted in January and May 2024.

ECO-AUDIT

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green press INITIATIVE

A manifestation of climate change, temperatures in Bangladesh are increasing at an alarming rate, with frequent bouts of extreme heat events. In 43 years, between 1980 and 2023, maximum temperature in the country increased by 1.1°C, while the "feels like" temperature rose by 4.5°C over the same duration. How does increasing exposure to excess heat affect the physical and mental health outcomes of individuals and their productivity in the short term?

An Unsustainable Life: The Impact of Heat on Health and the Economy of Bangladesh analyzes temperature changes in Bangladesh between 1976 and 2023. The study then uses primary data collected in 2024 from a two-round household survey covering more than 16,000 individuals in Bangladesh to quantify the adverse effects of rising temperatures on specific physical and mental health conditions as well as on productivity losses.

Using the findings, the report serves three main purposes: (1) provide localized evidence that links the effect of heat on health and recommend effective adaptation measures to reduce the vulnerabilities of the Bangladeshi population to heat; (2) quantify economic losses borne by the country due to global warming to assist policy makers in leveraging international support and financing to mitigate the impacts; and (3) add evidence to the global discourse on heat and human physical and mental health, and loss of productivity.

The evidence presented in this report underscores the immediate need for comprehensive strategies to address the escalating health risks posed by climate change, notably heat, in Bangladesh. Interventions that can help individuals moderate the effects of heat on their health are critical to ensure the well-being of the population. Learning from best practices of climate-comparable countries and leveraging localized information, Bangladesh can create a more resilient future to better address the impacts of climate change.

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