KNOWLEDGE BRIEF
AIR POLLUTION: THE INVISIBLE KILLER

Air pollution and climate change are "two sides of the same coin." The air quality in densely populated regions is likely to worsen with current development trajectories, creating a catastrophic impact on human health. "Air pollution is denying billions of their rights." Air pollution is invisible yet- more widespread, and almost the entire world population is at health risk from air pollution.

Air Pollution: Definition and Types

Air pollution refers to the presence of harmful substances in the air that we breathe, including particulate matter, ozone, nitrogen oxides, sulfur dioxide, and carbon monoxide. These pollutants can have negative impacts on human health, including respiratory and cardiovascular diseases, and can also damage the environment. Air pollution is caused by human activities such as the burning of fossil fuels for energy and transportation, industrial activities, agriculture, and deforestation. It can also be caused by natural events such as dust storms and wildfires. The World Health Organization (WHO) sets guidelines for safe levels of air pollution, and many countries have their own air quality standards. Major air pollutants include particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), ozone (O_3), lead, sulfur dioxide (SO_2) and nitrogen oxides (NOx), that are termed as the criteria air pollutants (CAP). Among the pollutants, particulate matter $PM_{2.5}$ is the most critical one and generally monitored globally for assessing air quality status (1).

Air pollution is of two distinct types - indoor air pollution (IAP), and ambient or outdoor air pollution (AAP). The Lancet Commission on pollution and health termed outdoor air pollution, as the "modern form of pollution" that has become the most severe; nearly offsetting the combined impact of indoor air and water pollution (2).

Major Sources of Air Pollution

Air pollution may originate from primary or secondary sources. Primary air pollutants are directly emitted to the atmosphere, and secondary pollutants are formed through chemical reactions and microphysical processes from precursor gases in the atmosphere. Air pollutants generate from a natural, anthropogenic or mixed origin sources; most of the pollution takes place due to the human actions. Cigarette smoking is also considered as air pollution (3). Some of the major sources of air pollution include:

- **Transportation:** Cars, buses, trucks, and other vehicles emit pollutants such as carbon monoxide, nitrogen oxides, and particulate matter.
- **Industry:** Industrial activities such as manufacturing, construction, and mining can release pollutants into the air, including sulfur dioxide, nitrogen oxides, and particulate matter. Brick industry is particularly responsible for the polluted air in Dhaka city.

- **Agriculture:** Agricultural activities such as the use of fertilizers and pesticides and raising of livestock can release pollutants into the air, including ammonia and particulate matter.
- **Power Generation:** The burning of fossil fuels such as coal, oil, and natural gas to generate electricity releases pollutants.
- **Household activities:** The use of certain products and appliances, such as cleaning supplies and wood-burning stoves, can release pollutants into the air.
- **Natural sources:** Dust storms, wildfires, volcanic eruptions and other natural events can also contribute to air pollution.

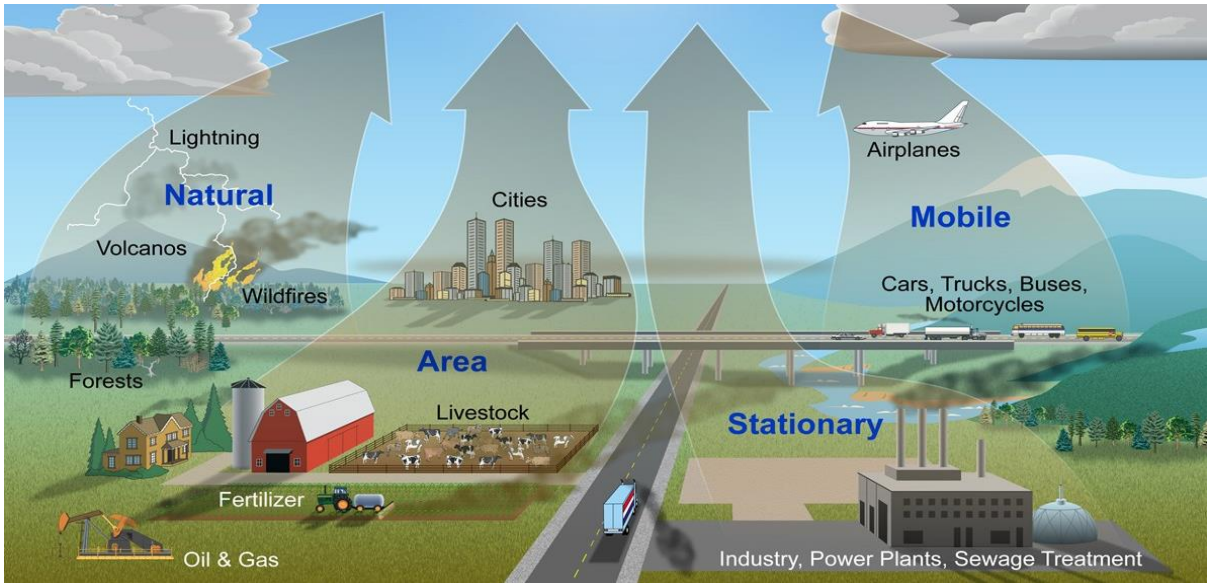

Figure 1: Major sources of air pollution: mobile (cars, buses, planes, trucks, and trains, etc.) stationary (power plants, oil refineries, industrial facilities, and factories, etc.) area (agricultural areas, cities, and waste burning facilities), and natural (wind-blown dust, wildfires, and volcanoes, etc.). (Source: NPS.gov)

Global Scenario of Air Pollution

Figure 2: Numbers of deaths attributable to total air pollution in 2019 (4).

More than one in every nine fatalities worldwide are caused by air pollution. In 2019, air pollution was responsible for 6.7 million deaths as well as India and China continue to endure the highest burdens of disease. More than 90% of the world's population still lives in areas where $PM_{2.5}$ concentrations don't satisfy the WHO guideline for healthy air. Box represents the top 10 countries with the highest average ozone exposures in 2019 were in Asia and the Middle East. According to State of Global Air

Country	Tropospheric Ozone (ppb)	95% Uncertainty Intervals*
Qatar	67.2	62.3 to 72.4
Nepal	67.0	65.5 to 68.6
India	66.2	66.0 to 66.3
Bangladesh	64.6	63.9 to 65.3
Bahrain	64.0	51.7 to 75.9
Pakistan	63.3	62.8 to 63.8
Kuwait	62.1	57.6 to 67.1
Iraq (Islamic Republic of)	59.5	58.8 to 60.2
Republic of Korea	57.9	56.4 to 59.3
Saudi Arabia	58.2	57.7 to 58.6

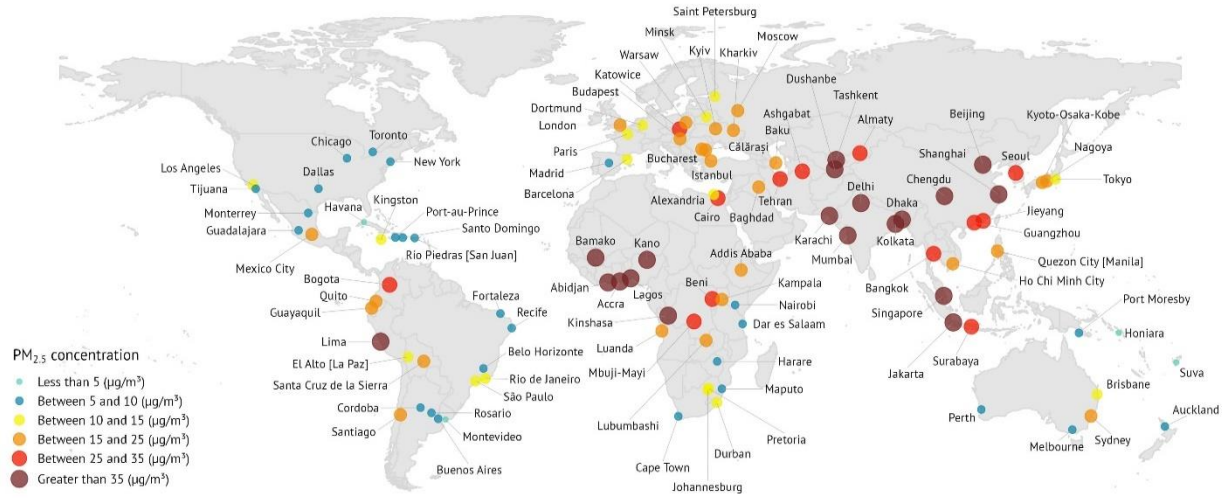

Figure 3: Population-weighted annual average pollutant concentrations in the five most populous cities in each region in 2019 (5).

2020 ozone exposures vary from a low of about 12.2 ppb to a high of 67.2 ppb across the globe. About 80% of air pollution's burden is attributed to noncommunicable diseases (6). For example, $PM_{2.5}$, household air pollution, and ozone together contribute as much as 40% of deaths from COPD, a highly debilitating lung disease. Air pollution also contributes to as much as 30% of lower-respiratory infection as well as 20% of infant mortality in the first month of life. Water pollution, lead, toxic occupational hazards were responsible for 1.4 million, 900,000 and 870,000 premature deaths respectively (7).

Air Pollution Scenario of Bangladesh

Key Facts (Health Effects Institute, 2022)

- In 2019, air pollution was one of the top five risk factors for death in Bangladesh, causing around 20% of all deaths (approximately 174 thousand).
- Ambient particulate matter (PM) was the second leading risk factor for deaths, while household air pollution (HAP) ranked first.

Key Statistics

100% of Bangladesh's population lives in places where PM levels exceed the WHO interim Target for Healthy Air (35 g/m).

34% of outdoor PM comes from fossil-fuel combustion (i.e., coal, oil and gas)

18% of deaths due to air pollution are in children under 5.

Source: Sate of Global Air (8)

Health Impacts (Health Effects Institute, 2022)

- Air pollution is **among the top 5 risk factors** for death in Bangladesh.
- Bangladesh has **145 deaths** per 100,000 people because of air pollution, which is **higher than** the global average (86 deaths per 100,000).
- Children under the age of five account for **18%** of total air-pollution-related deaths in Bangladesh, while adults over the age of 70 account for **22%.**
- In Bangladesh, air pollution shortened life expectancy by **2.9 years.**

Percentage of deaths due to Air pollution in Bangladesh in 2019 (8)

34%	25%	33%	61%	33%	44%	20%
of stroke deaths	of diabetes death	of ischemic heart disease deaths	of COPD deaths	of lung cancer deaths	of lower respiratory infection deaths	of neonatal deaths

Sources of $PM_{2.5}$ and Associated Health Burden in Bangladesh in 2019 (8)

	Residential	Industry	Agriculture	Energy	Dust
Outdoor $PM_{2.5}$ contribution	28%	12%	12%	12%	9%
Number of deaths linked with $PM_{2.5}$	17,841	7,646	7,646	7,646	5,735

GOOD NEWS: Aiming to protect environmental health, The Ministry of Environment, Forest and Climate Change officially published the Air Pollution (Control) Rules 2022 based on section 20 of the Bangladesh Environment Conservation Act, 1995.

Health and Economic Burden of Air Pollution

In 2015, the Lancet commission on pollution and health indicated that a total of 261,000 people in Bangladesh died from pollution related disease which is twelve times more than deaths from HIV, TB and malaria combined (9).

In 2015, Global Alliance on Health and Pollution (GAHP) reported that diseases caused by air, water and soil pollution were responsible for 9 million premature deaths, that is 16% of all global deaths.

The major health impacts of air pollution includes cardiovascular disease (10), stroke (11) and respiratory diseases (12) such as lung cancer (13, 14) childhood asthma (15) and atopic dermatitis (16). Perinatal exposure has been demonstrated to have a negative impact on neuropsychological development in children (17). Risk of diabetes has also been found to be increased substantially with $PM_{2.5}$ exposure in a moderate rate above WHO guideline value of 10 $\mu g/m^3$. Ambient $PM_{2.5}$ is also a major risk for premature death; average global life expectancy at birth reduced by ~1 year globally with reductions of ~1.2–1.9 years in more polluted countries of Asia and Africa (18). Air pollution also negatively impacted embryo development at genetic and epigenetic level and thus influenced the reproductive capacity of exposed populations; however, the direct

contribution from $PM_{2.5}$ is yet to be explored (19). Maternal exposure to ambient fine particulate material has been identified as a risk factor for adverse pregnancy outcome (20); exposure to $PM_{2.5}$ was found to be associated with preterm birth (PTB), low birth weight and small-for-gestational age (SGA) births (21). The most vulnerable regions for PM2.5 associated preterm birth were found to be South and East Asia, North Africa/Middle East and West sub-Saharan Africa (20).

Global Alliance on Health and Pollution (GAHP) estimated that pollution in the air, water and soil was responsible for 26.6% of all deaths in Bangladesh.

Air pollution-related healthcare costs are projected to increase from USD 21 billion to USD 176 billion and welfare costs associated with the premature deaths from outdoor air pollution from USD 3 trillion to USD 18 - 25 trillion between 2015 and 2060 globally (22). The association of meteorological conditions and $PM_{2.5}$ suggests that, climate change will have significant impact on $PM_{2.5}$ (23) and thus the future global mortality burden of air pollution is likely to increase even if the air pollution can be controlled to certain extent (24).

Pollution is costly-Welfare losses due to pollution are estimated at **$4.6 trillion** per year **6.2%** of global economic output (GAHP)

Total pollution deaths of the highest ten countries (25)

Country	Number of Deaths
India	2,326,771
Indonesia	232,974
Bangladesh	207,922
Myanmar	65,790
North Korea	51,391
Nepal	46,149
Thailand	43,538
Sri Lanka	11,016
Timor-Leste	1,137
Bhutan	666

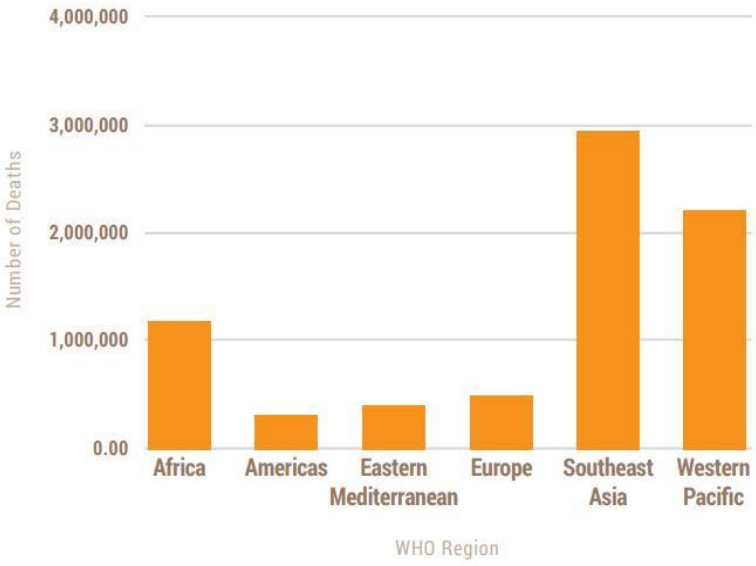

Figure 4: Deaths from combined pollution risk factors by WHO region (25).

About 62% of global pollution-related deaths occur in Southeast Asia and Western Pacific that reflecting the situation of India and China (26).

icddr,b Research on Air Pollution

icddr,b and the University of Chicago collaborate on a joint study of USD 1.5 million under the GEOHealth Hub (https://geohealth.urb-bd.org/). The research team established a research hub in Bangladesh, called the Bangladesh Center for Global Environmental and Occupational Health. The program aimed to improve understanding of the interactions between the environment and health, with a particular focus on low- and middle-income countries. The icddr,b team worked on indoor air pollution and explored feasibility of improved cooking systems to minimize the air pollution and reduce the health burden from the pollution.

Under the GEOHealth team has produced multiple journal articles and conference proceedings. The study "Association of household air pollution with cellular and humoral immune responses among women in rural Bangladesh" has assessed the impact of household air pollution on the immune system of women in rural Bangladesh (27). The study likely measured exposure to household air pollution using methods such as monitoring levels of particulate matter 2.5 or specific air pollutants (black carbon and carbon monoxide) and measured immune profile using personal monitors RTI MicroPEM and Lascar CO logger respectively and analyzed by flow cytometry, plasma IgE by immunoassay analyzer. These values were likely compared between women with high and low levels of exposure to household air pollution to determine the relationship between exposure and immune function. Publications from the study are available at: https://geohealth.urb-bd.org/Publications.

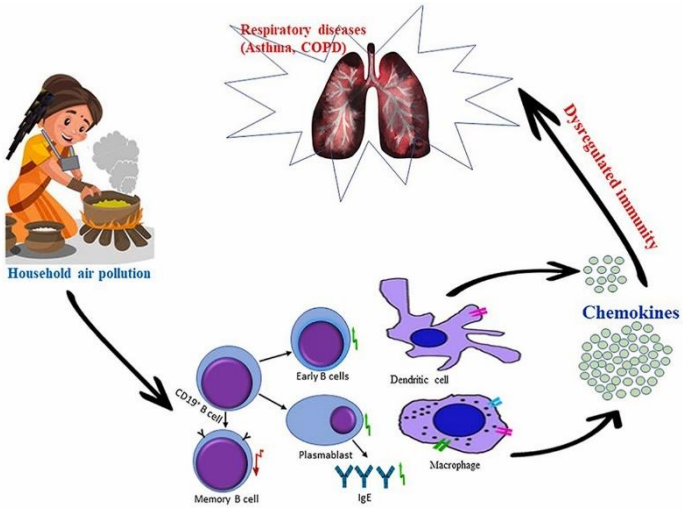

Figure 5: Graphical representation of the research (27)

The climate change and health initiative at icddr,b has recently completed another important study on outdoor air pollution. The study published at the journal of Climate change and Health has identified that, air pollution levels remain in 'Unhealthy' to 'Extremely Unhealthy' levels for almost half of the year in Dhaka city and a certain increase in the prevalence of low birth weight (LBW) and preterm births (PTB) is evident with increasing cumulative air pollution exposure. The study further found significant gender differentiated impact on LBW and PTB due to air pollution where female fetuses are at higher risk of LBW and males are more prone to PTB; suggesting second trimester exposure could potentially be the most vulnerable period of pregnancy (28).

icddr,b provides real time data and information on air pollution levels for Mohakhali and surrounding areas Dhaka city. icddr,b believes that the information is critical from a public health perspective and should enhance research capacity and program implementation. To air quality data is available at icddr,b's climate change and health resources website (https://cch.icddrb.org/) and under iQAir website's climate change and health_icddrb, Dhaka (https://www.iqair.com/bangladesh/dhaka/climate-change-and-health_icddrb).

Air Pollution Data Source

There are many sources of air pollution data, including:

- **Government agencies:** such as the Environmental Protection Agency (EPA) in the United States, the European Environment Agency (EEA) in Europe and the Department of Environment (DoE), Ministry of Environment, Forest and Climate Change (MoEFCC) in Bangladesh. The DoE's Clean Air and Sustainable Environment (CASE) project presently operate 11 Continuous Air Monitoring Stations (CAMs) in Bangladesh with a plan to expand.
- **Non-profit organizations:** such as the World Health Organization (WHO) and the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) which provides location specific data and information on air pollution levels.
- **Crowd-sourced data platforms:** such as AirVisual and PurpleAir, which use sensors and user-submitted data to provide real-time air quality information in cities and communities around the world.
- **Satellite data:** such as that provided by NASA's Ozone Monitoring Instrument (OMI) and the European Space Agency's Sentinel-5P satellite, which provides global air quality data and maps.

The Clean Air and Sustainable Environment (CASE) project (http://case.doe.gov.bd/) run by Department of Environment (DoE), Ministry of Environment, Forest and Climate Change (MOEFCC). The World Bank funded CASE project has started in 2014 and reports data by Air Quality Index (AQI). AQI constitutes of six air quality parameters: Particulate matter ($PM_{2.5}$ and PM_{10}), Sulfur dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3), and Carbon monoxide (CO) that have been used to prepare Ambient Air Quality Standard (AAQS) for Bangladesh. In Dhaka city, the project has three Continuous Air Monitoring Stations (CAMs) at Mirpur Dar us Salam, Farmgate and National Parliament building.

Major Global and Country specific Air pollution data source links:

1. Climate Change and Health, icddr,b: https://cch.icddrb.org/air-polution
2. The Clean Air and Sustainable Environment (CASE) project: http://case.doe.gov.bd/
3. World Bank's Air Quality Data: https://data.worldbank.org/indicator
4. Our World in Data: https://ourworldindata.org/air-pollution
5. Global Health Data Exchange: https://ghdx.healthdata.org/

Recommendation

Air pollution in Bangladesh is a major public health concern. To mitigate the health impacts of air pollution in Bangladesh, it is recommended to take a multi-faceted approach and real-time monitoring system that includes reducing emissions from transportation and industry, increasing the use of clean energy sources, and promoting public awareness about the dangers of air pollution and ways to reduce exposure. Additionally, collaborating with neighboring countries to address regional air pollution can also help to improve air quality in Bangladesh.

References

1. CDC. Air Pollutants: Centers for Disease Control and Prevention; 2021 [Available from: https://www.cdc.gov/air/pollutants.htm.
2. Fuller R, Landrigan PJ, Balakrishnan K, Bathan G, Bose-O'Reilly S, Brauer M, et al. Pollution and health: a progress update. The Lancet Planetary Health. 2022.
3. NPS. Where Does Air Pollution Come From? : NPS.gov; 2018 [Available from: https://www.nps.gov/subjects/air/sources.htm.
4. State of Global Air 2020. Data source: Global Burden of Disease Study 2019 [Internet]. IHME Washington. 2020. Available from: https://www.stateofglobalair.org/data/#/health/map.
5. HEI. State of global air 2020, special report. Health Effects Institute. 2020.
6. Institute HE. State of Global Air 2020. Special report 2020. Report No.: ISSN 2578-6873
7. Fuller R, Landrigan PJ, Balakrishnan K, Bathan G, Bose-O'Reilly S, Brauer M, et al. Pollution and health: a progress update. Lancet Planet Health. 2022;6(6):e535-e47.
8. Health Effects Institute. Bangladesh
Air Pollution and Health Factsheet: State of global air 2022 [Available from: https://www.stateofglobalair.org/resources/countryprofiles.
9. Landrigan PJ, Fuller R, Acosta NJR, Adeyi O, Arnold R, Basu N, et al. The Lancet Commission on pollution and health. The Lancet. 2018;391(10119):462-512.
10. Cosselman KE, Navas-Acien A, Kaufman JD. Environmental factors in cardiovascular disease. Nature Reviews Cardiology. 2015;12(11):627-42.
11. Shah AS, Lee KK, McAllister DA, Hunter A, Nair H, Whiteley W, et al. Short term exposure to air pollution and stroke: systematic review and meta-analysis. bmj. 2015;350.
12. Atkinson R, Kang S, Anderson H, Mills I, Walton H. Epidemiological time series studies of PM2. 5 and daily mortality and hospital admissions: a systematic review and meta-analysis. Thorax. 2014;69(7):660-5.
13. Avila E. Systematic Review of Associations Between Particulate Matter (PM2. 5 PM10) and Cancer Risk. 2017.
14. Lemjabbar-Alaoui H, Hassan OU, Yang Y-W, Buchanan P. Lung cancer: Biology and treatment options. Biochimica et Biophysica Acta (BBA)-Reviews on Cancer. 2015;1856(2):189-210.
15. Jassal MS. Pediatric asthma and ambient pollutant levels in industrializing nations. International health. 2015;7(1):7-15.
16. Ahn K. The role of air pollutants in atopic dermatitis. Journal of Allergy and Clinical Immunology. 2014;134(5):993-9.
17. Suades-González E, Gascon M, Guxens M, Sunyer J. Air Pollution and Neuropsychological Development: A Review of the Latest Evidence. Endocrinology. 2015;156(10):3473-82.
18. Apte JS, Brauer M, Cohen AJ, Ezzati M, Pope CA, III. Ambient PM2.5 Reduces Global and Regional Life Expectancy. Environmental Science & Technology Letters. 2018;5(9):546-51.
19. Carré J, Gatimel N, Moreau J, Parinaud J, Léandri R. Does air pollution play a role in infertility?: a systematic review. Environmental Health. 2017;16(1):82.
20. Malley CS, Kuylenstierna JCI, Vallack HW, Henze DK, Blencowe H, Ashmore MR. Preterm birth associated with maternal fine particulate matter exposure: A global, regional and national assessment. Environment International. 2017;101:173-82.
21. Shah ASV, Lee KK, McAllister DA, Hunter A, Nair H, Whiteley W, et al. Short term exposure to air pollution and stroke: systematic review and meta-analysis. BMJ. 2015;350:h1295.

22. OECD. The Economic Consequences of Outdoor Air Pollution2016.
23. Tai APK, Mickley LJ, Jacob DJ. Correlations between fine particulate matter (PM2.5) and meteorological variables in the United States: Implications for the sensitivity of PM2.5 to climate change. Atmospheric Environment. 2010;44(32):3976-84.
24. Silva RA, West JJ, Lamarque JF, Shindell DT, Collins WJ, Dalsoren S, et al. The effect of future ambient air pollution on human premature mortality to 2100 using output from the ACCMIP model ensemble. Atmos Chem Phys. 2016;16(15):9847-62.
25. IHME. Global Health Data Exchange Tool: Institute for Health Metrics and Evaluation; 2019 [Available from: https://vizhub.healthdata.org/gbd-results/.
26. GAHP. Bangladesh & Pollution Health Impact, Economic Impact, Injustice, and Solutions: Global Alliance on Health and Pollution 2021 [Available from: http://www.pureearth.org/wp-content/uploads/2021/04/Bangladesh-Pollution-Health-and-Economic-Impacts-The-Lancet-Report.pdf.
27. Raqib R, Akhtar E, Sultana T, Ahmed S, Chowdhury MAH, Shahriar MH, et al. Association of household air pollution with cellular and humoral immune responses among women in rural Bangladesh. Environmental Pollution. 2022;299:118892.
28. Nahian MA, Ahmad T, Jahan I, Chakraborty N, Nahar Q, Streatfield PK. Air pollution and pregnancy outcomes in Dhaka, Bangladesh. The Journal of Climate Change and Health. 2023;9:100187.

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SCAN ME

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

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

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

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