

Air pollution is the **biggest environmental health risk**, claiming the lives of **8.8 million people** each year. Its toll on health costs **\$8.1 trillion each year**, equivalent to **6.1% of global GDP**.

Studies reveal a troubling **decline** in global air quality, particularly in **developing countries**.

Prolonged exposure to air pollution increases the risk of:

- Lung cancer (LC)
- Stroke
- Chronic obstructive pulmonary disease (COPD)
- Ischemic heart disease (IHD)
- Lower respiratory infections (LRI)

Major factors contributing to air pollution

Emission-related factors

- Natural: e.g., volcanic activity
- Human-made: e.g., burning fossil fuels, deforestation, road traffic

Climate-related factors

- Include atmospheric activities, e.g., El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD)

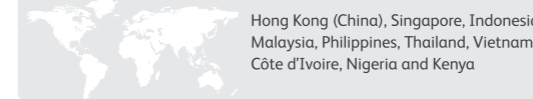
Air pollution is closely linked to climate change

- Air pollutants and greenhouse gases often come from same sources
- Changes in climate can influence air quality

Prudential EOS Climate Impacts Initiative

Prudential and the Earth Observatory of Singapore, Nanyang Technological University, conducted a study on **10 Asian and African countries/cities** to explore the effects of air pollution on health.

10 countries/cities studied across Asia and Africa



- This study examines air pollution in the form of:**
- Black carbon (BC), like soot and dark-coloured particles from high-temperature burning and combustion
 - Organic carbon (OC), which are lighter-coloured particles also produced during burning and combustion
 - Fine particulate matter less than 2.5 microns wide (PM_{2.5}), which mostly comes from burning petrol, oil, diesel and wood

- Research objectives**
- Contribute to public policy discussions on health impacts of climate change
 - Expand Prudential's focus on the intersection of climate change and health
 - Support idea generation and market evaluation of investments and products linked to climate resilience and better health outcomes

Phase 1

- Review historical records of air quality and health impacts from 2000 to 2020
- Analyse past trends of air quality incorporating climate or weather events
- Estimate health impacts of exposure to the air pollutants in terms of morbidity and premature mortality from the cardiovascular disease, COPD, IHD, LRI and LC

Phase 2, 2024

Project future air quality and its health impact on individuals that consider several emission scenarios including SSP3-7.0 and SSP5-8.5. Projection years include 2025 to 2035 and 2045 to 2055.

Singapore (Southeast Asia)

Findings

- Strongly affected by both ENSO and IOD - episodes in 2002 and 2015 coincided with the simultaneous occurrence of ENSO and positive IOD, episodes in 2006 and 2019 coincided with positive IOD
- Given Singapore's small size, spatial distribution of air pollution varied marginally and was more susceptible to influences from neighbouring countries
- Often severely affected by haze and wildfires
- Almost all SO₂ emissions came from the energy sector so to diversify, Singapore started using natural gas in 1992

Health outcomes

- IHD, stroke and LRI were the top three contributors to the premature deaths due to PM_{2.5}
- Premature deaths and incidence were volatile, with a total of six distinct waves
- Five waves corresponded to high polluted weather caused by El Niño and positive IOD events, one wave was influenced by the Indonesian wildfires
- Public health more sensitive to severe and extreme weather

Malaysia (Southeast Asia)

Findings

- Strongly affected by ENSO and IOD - episodes in 2002 and 2015 coincided with simultaneous occurrence of ENSO and positive IOD; episodes in 2006 and 2019 coincided with the occurrence of positive IOD
- Air pollutant is higher in Peninsular Malaysia than in East Malaysia because of higher population density
- Southerly winds from June to August provide favourable conditions for the transport of PM_{2.5} from Sumatra northward to Peninsular Malaysia and El Niño made the regional haze pollution problem even worse
- Transportation (road, rail, air and sea) was a significant source of air pollution

Health outcomes

- IHD, stroke and LRI are the top three contributors to the premature deaths

Indonesia (Southeast Asia)

Findings

- Showed significant episodes in September 2002, October 2006, October 2015, September 2019
- Affected by climate phenomena: higher in fall of 2002 and 2015 (simultaneous El Niño and positive IOD) and in 2002 and 2019 (corresponded to positive IOD)
- PM_{2.5} concentration tended to be higher in northern Sumatra and Riau, mainly because of frequent wildfires, while air pollution was more evident in the southern peninsula of Indonesia, i.e., Jakarta and Bandung with active volcano Mount Merapi as one of the major causes affecting its surrounding area

Health outcomes

- Stroke, IHD, and COPD were the top three contributors to the premature deaths due to PM_{2.5}
- Clear upward trends in total premature deaths and incidences due to PM_{2.5}

Thailand (Southeast Asia)

Findings

- Emissions of air pollutants except SO₂ have been increasing
- SO₂ emissions were mainly from the energy and transportation sector; energy production was gradually optimised, probably in relation to renewable energy policies
- No significant relationship between ENSO or IOD events and changes in air pollution
- Air pollution severe in the northern and north-eastern cities, due to exposure to air pollutant emissions of agricultural activities and forest fires

Health outcomes

- Stroke was the largest contributor to premature deaths due to PM_{2.5}
- LRI was the largest contributor in incidences due to PM_{2.5}
- Clear and consistent upward trends in total premature deaths and incidences due to PM_{2.5} during the past two decades

Vietnam (Southeast Asia)

Findings

- Emissions of all air pollutants showed an accelerating trend
- Annual average PM_{2.5} concentration did not show the same trend of emissions despite climate policy and promotion of renewable energy
- No significant relationship between ENSO or IOD events and changes in air pollution
- PM_{2.5} concentration was higher in the north because of agricultural activities and forest fires

Health outcomes

- Stroke was the largest contributor to premature deaths due to PM_{2.5}
- LRI was the largest contributor in incidences due to PM_{2.5}
- Showed clear upward trends in total premature deaths and incidences due to PM_{2.5} during the past two decades

Philippines (Southeast Asia)

Findings

- Air pollution is influenced by complex climate variability - more influenced by individual positive IOD events than individual El Niño events
- Combined effects of El Niño and positive IOD exacerbated air pollution levels in 2015 but the effects were not significant in 2002
- Anthropogenic emissions of BC and SO₂ showed a decreasing trend until 2011, after which emissions increased

Health outcomes

- IHD, stroke, and LRI were the top three contributors to the premature deaths due to PM_{2.5}
- Clear upward trends in total premature deaths and incidences due to PM_{2.5} during the last two decades

Hong Kong (China)*

Findings

- Local emissions are the key contributor to the air pollution in the city
- Road transportation is a particularly important emitter
- Transboundary air pollution, enhanced by La Niña, is another important contributor

***Note:**
Analyses for Hong Kong requires more time to be completed, full results will be presented in the second phase

Health outcomes

- LRI, stroke and IHD were the top three contributors to the total number of premature deaths due to PM_{2.5}
- Incidence due to PM_{2.5} showed a slight upward trend

Nigeria (Africa)

Findings

- Higher PM_{2.5} level in the north
- North is more vulnerable to dust storms from the Sahara Desert, natural grassland fire sources, and marine aerosols brought in by monsoon flow
- Clear seasonality, with January and February being the dry season
- Major direct source of air pollution is anthropogenic biomass burning
- Other sources of air pollution are households, transportation and industry

Health outcomes

- LRI, stroke and IHD were the top three contributors to the total number of premature deaths due to PM_{2.5}
- Incidence due to PM_{2.5} showed a slight upward trend

Côte d'Ivoire (Africa)

Findings

- Higher PM_{2.5} level in the north
- Northern region is also heavily impacted by large amounts of mineral dust from the Sahara, natural savannah fire sources from prevailing winds, and marine aerosols from monsoon flow
- Clear seasonality, with January and February being the dry season
- Major direct source of air pollution is anthropogenic biomass burning; Other sources of air pollutant emissions: residential, transportation, industrial sectors

Health outcomes

- LRI, stroke and IHD were the top three contributors to the premature deaths due to PM_{2.5}
- Clear upward trends in total deaths and incidences

Kenya (Africa)

Findings

- PM_{2.5} concentration had less fluctuation; one distinct episode in 2008 which coincided with a strong La Niña event
- Rapid urbanisation with corresponding increase in vehicle ownership and use of solid fuels as an energy source contributed to deterioration of air quality
- Higher PM_{2.5} concentration level in the west was due to the use of traditional stoves in rural areas
- Air pollutant concentration had a significant decreasing trend especially in the north

Health outcomes

- Stroke was the largest contributor to premature deaths due to PM_{2.5}

