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EXECUTIVE SUMMARY

Everyone is exposed to air pollution throughout their lives, no matter where they live in the world. Its impacts are far-reaching—from causing and exacerbating ill health, to loss of life and many other areas of health, lower-income countries bear a disproportionate burden. Regions outside of the Americas and Europe experienced the most significant rises in IHD and stroke deaths attributable to ambient air pollution from 2010 to 2019, with Europe seeing declines in deaths from both conditions during the same period. Lower-income countries experience far greater health impacts from household air pollution. World Health Organization (WHO) estimates that over 2 billion people worldwide still rely on polluting fuels, such as wood, coal, crop waste, or charcoal, paired with inefficient stoves for cooking. The Global South’s burden is exacerbated by gaps in air pollution monitoring, policy, and health interventions and heightened vulnerabilities to the climate crisis and its environmental events—phenomena that both worsen and are worsened by air pollution.

Despite the awareness of air pollution harms, particulate matter (PM2.5) concentration levels—the key pollutant for human health—declined globally by just 1% annually between 2010 and 2019. Global levels remained alarmingly high at 31.7 µg/m³ in 2019, far above the 2021 WHO recommended air quality guidance level of 5 µg/m³. While hitting these targets is paramount for countries to protect the health and wellbeing of their populations, few countries have reached or are even close to reaching recommended levels. Worse, while 64% of countries have in place legislation that includes ambient air quality standards, none of these align with WHO air quality guidelines.

It is an understatement to say that the need is urgent for comprehensive strategies that mitigate air pollution and its profound health, societal, and economic consequences. There are bright spots and exemplary air pollution tackling initiatives at city and national level, as this report shows—but these are too few and far between. Many air pollution interventions will also help tackle the climate crisis and the health benefits of reducing air pollution far outweigh the economic requirements to achieve them. A long-term vision is needed to realise these benefits, but the commitment to address them is needed now.
All countries must adopt the new WHO global guidelines on air quality. This includes making a roadmap of strategies to meet the interim targets outlined by WHO whilst progressing to the overall guideline level. Policies should be multifaceted and multi-sectoral, encompassing, among others, health, housing, city design, transport, and agriculture.

WHF supports the implementation of a global fossil fuel non-proliferation treaty. Country commitments to these treaties must be maintained, ideally through legally binding agreements, and suitable implementation strategies must be employed to rapidly reduce the use of fossil fuels.

Countries and technical bodies, particularly in low- and middle-income countries (LMICs), should urgently empower as air pollution monitoring and modeling where there are gaps. This includes expansion of the stationary monitoring network in both rural and urban areas that will help provide more accurate estimates of air pollution levels and trends.

Countries, multilaterals, and philanthropies must increase funding into multidisciplinary air pollution research and technological innovations to improve air quality and strategies to implement interventions to reduce air pollution.

Health and research agencies at country, regional, and global levels should conduct additional studies into the cardiovascular effects of air pollution and CVD linked to ambient and household air pollutants in addition to the role of the cardiovascular system in the disease of other organs. This should include the study of the cardiovascular effects of less well-researched air pollutants, so that policies and interventions can target the air pollutants that are most harmful. This will support the design and implementation of health interventions.
Despite the awareness of air pollution harms, PM$_{2.5}$ concentrations—the key pollutant for human health—declined globally by just 1% annually between 2010 and 2019.

Over 2 billion people worldwide still rely on polluting fuels. These include coal, crop waste, and charcoal, paired with inefficient stoves for cooking.
This second World Heart Report is aimed at equipping policymakers and advocates around the world with a consolidated analysis of the interplay between air pollution and CVDs, with the goal of identifying areas for concrete action that will mitigate air pollution’s harms not only on cardiovascular health but also overall health.

The report begins by exploring what exactly constitutes ambient air pollution and the latest evidence regarding PM2.5 trends and levels globally, before moving on to the relationship between air pollution (both ambient and household) and health and CVDs. In addition to presenting and analysing the most recent publicly available data in this area, the report will briefly examine interactions between air pollution and susceptible population groups, the dynamic between air pollution and climate change, and policy efforts (international, country, and local levels) to curb air pollution’s harms.

Global, regional, and country WHO estimates for PM2.5 and ambient and household air pollution attributable mortality (overall and CVD) are presented in this report. Data on air quality guidelines and policies are from the United Nations Environmental Programme’s (UNEP) global assessment of air pollution legislation, WHO health and environment scorecards, and Clean Air Fund’s assessment of country commitments related to the Paris Climate Agreement. In places where air pollution is referred to without either ambient or household preceding it, this refers to ambient air pollution.

In 2021, the World Heart Federation (WHF) established its Air Pollution Expert Group with a remit to convey the serious threat of air pollution to WHF members and the cardiovascular community, inform stakeholder groups and the public, and advocate for change to improve air quality. The group’s work has led to high-profile statements in major cardiovascular journals [4,5], the publication of a policy brief [6], and collaborations with WHO to develop a toolkit to educate and train health practitioners with guidance for their patients [7]. This report continues WHF’s commitment to highlighting the threat of air pollution to cardiovascular health.
Ambient (outdoor) air pollution is a complex mixture of individual pollutants composed of many thousands of different chemicals that have negative effects on the environment and human health.

Anthropogenic sources of air pollution include industrial emissions, vehicle exhaust, household energy, waste burning, and agricultural burning. Naturally produced sources of air pollution include sea spray, volcanic eruptions, and desert dust.

Household (indoor) air pollution will be addressed later in this report.

PM comes from a wide variety of sources and can have very different compositions and particle sizes (Figure 1). It is composed of different chemicals, the most harmful of which are yet to be fully identified. However, elemental and organic carbon, reactive transition metals, and polyaromatic hydrocarbons are anticipated to be key drivers of toxicity.

PM is most commonly measured as PM10 and PM2.5 (particles with a diameter of less than 10 and 2.5 micrometres, respectively) across the world by air quality monitors, including both governmental stationary monitoring networks and non-reference grade monitors. PM2.5 is the indicator of air pollution most consistently associated with detrimental effects on human health. It can deposit deep in the alveoli of the lungs.

Ultrafine particles (particles with a diameter of less than 100 nanometres) cannot be routinely measured by reference grade monitors. However, these particles may be especially harmful to human health due to their large reactive surface area and ability to carry surface chemicals into the body. Inhaled ultrafine particles can also penetrate the circulatory system. Combustion is a major source of these particles, e.g., vehicle exhaust.
GLOBAL LEVELS AND TRENDS OF AMBIENT AIR POLLUTION

PM$_{2.5}$ TRENDS
From 2010 to 2019, PM$_{2.5}$ global levels remained largely stable (Figure 2), with an annual reduction of 1% (from 35.3 µg/m$^3$ in 2010 to 31.7 µg/m$^3$ in 2019).

In this period, the largest PM$_{2.5}$ decline was recorded in Europe (2.1% average annual change).

While PM$_{2.5}$ levels increased annually by 0.3% in Africa.

ONLY 14% OF COUNTRIES EXPERIENCED LARGE DECLINES (BETWEEN 5 µg/m$^3$ AND 10 µg/m$^3$) FROM 2010 TO 2019, WHILE OTHERS SHOWED NO CHANGE OR INCREASES.

Source: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/concentrations-of-fine-particulate-matter-(pm2-5)
Countries with the largest absolute decrease from 2010 to 2019 were Tajikistan (9.8 µg/m³), North Macedonia (9.4 µg/m³), and China (9.0 µg/m³), while the largest absolute increases were observed in Mauritania (3.1 µg/m³) and Sierra Leone (3.1 µg/m³).

**FIGURE 2.1** Trends in mean PM₂.₅ concentrations by WHO regions, 2010-2019

Source: https://www.who.int/data/gho/

The largest relative declines were observed in most European countries (between 25% and 38% relative change), while the largest relative increases were recorded in Angola (22.2%), Cabo Verde (10.2%), Liberia (9.5%), Sierra Leone (8.5%), and Palau (8.2%) (Figure 2).

All countries in the Europe and South-East Asia regions experienced a decline in PM₂.₅ levels between 2010 and 2019, while 50% of the countries in Africa observed an increase. In the Eastern Mediterranean, Americas, and Western Pacific regions, 30%, 40%, and 41% of countries, respectively, recorded an increase in the level of PM₂.₅ concentration.

It should be noted that some trends in PM₂.₅ levels are countries (represented by the shaded area in Figure 2) owing to the differing strength of regional data sets available. The Africa (50%), and Eastern Mediterranean regions have notably sparse and limited data.

**PM₂.₅ LEVELS**

In 2021, WHO established air quality guidance (8) that set the recommended level of annual average concentration of PM₂.₅ at no more than 5 µg/m³. In 2019—the most recent WHO data on record—no country in the world had PM₂.₅ concentrations below this threshold (Figure 4).

Average regional PM₂.₅ concentration levels in 2019 could be grouped into three clusters: South-East Asian and Eastern Mediterranean regions, which recorded an annual PM₂.₅ concentration of around 15 µg/m³; Africa and Western Pacific regions around 32 µg/m³; and Eastern Europe and Americas, which recorded 15 µg/m³ (12.1 µg/m³ and 14.3 µg/m³, respectively) (Figure 2).

The highest levels of annual average PM₂.₅ concentrations were recorded in the Global Souths, with the highest levels in Kuwait (41.4 µg/m³; CI 36.3-46.5), Russia (36.2 µg/m³; CI 32.5-40.1 and 32.5-40.1), and Lebanon (32.3 µg/m³; CI 28.9-36.8). Countries with the lowest levels of PM₂.₅ concentrations were the Bahamas (5.1 µg/m³; CI 4.3-6.1), Estonia (5.5 µg/m³; CI 5.2-5.8), Botswana (5.4 µg/m³; CI 5.1-5.8), and Gabon (6.3 µg/m³; CI 5.7-7.4).

**FIGURE 3** Changes in PM₂.₅ concentrations between 2010 and 2019 (selected countries; overall and city-level)

Note: See Online Appendix for the full list of countries.
NO COUNTRIES IN THE AFRICA, EASTERN MEDITERRANEAN, OR SOUTH-EAST ASIA REGIONS RECORDED AN AVERAGE ANNUAL PM$_{2.5}$ CONCENTRATION BELOW 10 µg/m$^3$.

The top three countries in the Africa and Eastern Mediterranean regions recorded values up to three times higher than the top three countries in the Americas region (Table 1).

Most Pacific island countries in the Western Pacific region had relatively low levels of average annual PM$_{2.5}$ concentration (below 10 µg/m$^3$).
With a population exceeding 1 billion and increasing urbanization in many countries, Africa faces a growing threat of air pollution and its resulting health impacts. By 2035, half of Africa’s population is expected to live in urban settings, and Sub-Saharan Africa is in a position to host five of the world’s 41 megacities [9].

Africa faces significant challenges in addressing the consequences of air pollution, with distinct vulnerabilities at both population and individual levels, including socio-economic risk factors, limited access to quality healthcare, and the coexistence of chronic and infectious diseases. Exacerbating this challenge is a scarcity of robust air quality monitoring data, with the partial data available revealing elevated air pollution levels in certain urban areas in Africa.

As highlighted in IQAir’s 2023 World Air Quality Report, which looked at PM2.5 air quality data across 7,812 cities globally, only 24 of 54 African countries have the ability to monitor air quality in some of their monitoring stations concentrated in the western and southern regions of the continent, (Figure 5) [10]. Where monitors exist in Africa, they do not always measure all air pollutants that are considered key to health.

While satellite estimates provide valuable data on key air pollutants such as PM2.5 and NO2 in areas lacking ground monitors, these estimates have limitations, such as spatial resolution and assumptions that ground-level pollutants will reflect the column of air.

There is an urgent need to improve the quality of air pollution monitoring and data gathering in Africa, as is needed for every region and country. Enhanced air quality monitoring is essential to comprehensively understand the issue, design public health interventions, and implement sustainable practices to combat air pollution for protecting people’s health.

In 2019, over 1 million deaths in Sub-Saharan Africa were attributed to cardiovascular diseases (CVDs). Addressing air pollution monitoring gaps is a critical step to mitigating the future impact of pollution on cardiovascular health in the region.

**BOX 1 – AFRICA: THE NEED TO IMPROVE AIR POLLUTANT MONITORING**

**TABLE 1**

<table>
<thead>
<tr>
<th>WHO Region</th>
<th>Lowest µg/m³</th>
<th>Highest µg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>1.14 [0.65-2.28]</td>
<td>35.64 [22.04-57.68]</td>
</tr>
<tr>
<td>South Asia</td>
<td>16.09 [7.61-45.32]</td>
<td>49.09 [36.75-61.20]</td>
</tr>
<tr>
<td>Europe</td>
<td>6.96 [5.70-8.52]</td>
<td>31.09 [23.16-40.15]</td>
</tr>
<tr>
<td>Middle East</td>
<td>10.50 [5.10-20.84]</td>
<td>81.48 [59.42-110.81]</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>6.01 [2.93-13.98]</td>
<td>34.38 [26.49-44.04]</td>
</tr>
</tbody>
</table>

**FIGURE 5**

Global distribution of PM2.5 monitoring stations

**Source:** https://www.iqair.com/us/newsroom/waqr-2023

**Note:** Government-operated stations | Independently operated monitoring stations
Ambient air pollution is currently the sixth biggest risk factor for mortality globally, the seventh for DALYs, and the number one environmental risk factor [1].

In 2019, ambient air pollution caused 4.2 million deaths and over 100.4 million DALYs. The number of deaths was almost 140,000 more than the number recorded in 2010, a rise mostly driven by the South-East Asia (152,000 more deaths), Western Pacific (54,000 more deaths) and Eastern Mediterranean (47,000 more deaths) regions. Europe recorded over 8,000 fewer deaths in 2019 compared to 2010.

While the number of deaths increased globally, the five-cause (IHD, stroke, chronic obstructive pulmonary disease, acute lower respiratory infections, and lung cancer) age-standardized death rate attributable to air pollution declined globally from 70.7 deaths per 100,000 people to 59.7 deaths per 100,000 people, with all regions experiencing an average annual decline between 1% and 3% (Figure 6).

As evidenced by the high number of deaths and morbidity, the complex nature of air pollutants means that their health impacts are far-reaching and connected to myriad diseases. Air pollution has been linked to the burden of respiratory (RS, COPD, and asthma), and chronic obstructive respiratory disease (COPD, and asthma) over the last decade has found associations between air pollutants and conditions of most organs of the body [11] (Figure 7). Some estimates suggest the number of annual deaths from air pollution could be as high as 8.9 million [12]. Nearly all existing estimates are likely to be conservative, as they only quantify the impact of long-term exposures to PM2.5 rather than all air pollutants, and for only a limited number of disease categories.

With the growing awareness that air pollution has deleterious effects on most organ systems, regard should be given to the consequences of air pollution where there is multimorbidity. This is especially important given that life expectancy is increasing, and with an older population, it is more likely that people will suffer from more than one condition as they become elderly. The cardiovascular system plays an integral role in the function and regulation of multiple organ systems. Therefore, different biomedical specialties must work with cardiovascular researchers to understand the role of the cardiovascular system in disease of other organs. Areas of potential interest include diabetes, dementia, kidney disease, cancer, and pregnancy.

FIGURE 6
Number of deaths (left panel) and age-standardized mortality rates (deaths per 100,000 people) (right panel) attributable to ambient air pollution for both sexes and WHO regions

Source: WHO Global Health Observatory

FIGURE 7

EXPANDING RESEARCH ON AIR POLLUTION AND MULTIMORBIDITY
AMBIENT AIR POLLUTION AND CARDIOVASCULAR HEALTH

There is expansive literature linking air pollution to most cardiovascular conditions, with most studies run in high-income countries [13]. Limited data exists from LMICs.

Cardiovascular conditions linked to air pollution include:
- IHD/Coronary artery disease
- Cerebrovascular disease
- Stroke
- Heart failure
- Cardiovascular arrhythmia and arrest
- Venous thromboembolism and peripheral artery disease such as pulmonary hypertension
- Dilated cardiomyopathy
- Congestive heart disease
- Pulmonary hypertension

CONSIDERABLE PROGRESS HAS BEEN MADE IN ESTABLISHING HOW AIR POLLUTION NEGATIVELY IMPACTS THE CARDIOVASCULAR SYSTEM [14] (FIGURE 8), WITH THE EFFECTS INCLUDING:

- Endothelial dysfunction
- The generation of oxidative stress
- Loss of endothelial-derived nitric oxide bioavailability
- Increases in circulating vasoconstrictive mediators
- Platelet activation
- Impaired fibrinolysis
- Endothelial cell inflammation
- Promotion of inflammatory pathways in endothelial cells
- Emerging evidence for pathways such as epigenetic modification, circulating microRNA and changes to circulating stem cell populations

Long-term exposure to air pollution has also been shown to accelerate atherosclerosis (narrowing of the arteries) and promote plaque instability [13,15].
1. Pollutants inhaled into lung

Penetration into lungs depends on pollutant and particle size

2. Transmission to CV system

Neural and endocrine pathways

3. Impaired CV function

Cardiovascular morbidity and mortality

4. Disease exacerbation

Air pollutants

Inflammation and oxidative stress in the lung

Transmission of inflammatory and oxidative mediators

Heart
- Altered rhythm
- Increased susceptibility to ischaemia

Blood vessels
- Constriction
- Poor relaxtion
- Increased blood pressure

Blood
- Increased coagulation
- Decreased fibrinolysis

Accelerated development of cardiovascular disease

Triggering of a cardiovascular event, e.g., heart attack or stroke

Most large-scale meta-analyses show clear associations between exposure to both short-term (Figure 9) and long-term (Figure 10) air pollutants and the increased risk of CVDs.

In many cases, various CVDs are associated with more than one pollutant. While there will be some overlap in risk estimates from closely related pollutants, combined air pollutant mixtures will compound risks. Regardless, the risk estimates for even single pollutants are substantial and especially concerning given the prevalence of CVDs globally.
The developed biological understanding of the complex interplay between air pollution and cardiovascular health is helping to determine which pollutants may be most harmful and who may be particularly susceptible. This offers the promise that effective interventions—including health and policy-based measures—could be implemented to mitigate the health effects of air pollution for people who live in areas with unavoidably high air pollution.

**FIGURE 10**
Long-term percentage increase in the risk of cardiovascular diseases (selected outcomes) by type of air pollutant

Source: See Online Appendix for the full set of data

Of the 4.2 million deaths globally attributed to ambient air pollution in 2019, almost 70% were caused by cardiovascular conditions, notably IHD (1.9 million deaths) and stroke (900,000 deaths) (Figure 13).

**REGIONAL ANALYSIS AND TRENDS**
In 2019, the number of air pollution attributable deaths from IHD and stroke combined was highest in the Western Pacific (957,000 deaths) and South-East Asia (762,000 deaths) regions. China and India, respectively, belong to these regions. Overall, nearly 30% of all global ambient air pollution IHD deaths were recorded in the Western Pacific region (by both males and females). The lowest percentages were observed in Africa and the Americas for both males and females. Between 13% (in the Americas) and 25% (in the South-East Asia and Eastern Mediterranean regions) of deaths due to IHD were attributable to ambient air pollution. For stroke between 9% (in the Americas and Europe regions) and 18% (in the Eastern Mediterranean region) of deaths were attributable to air pollution.

The global number of IHD deaths attributable to air pollution increased by almost 200,000 from 2010 to 2019. Most regions experienced an increase in IHD deaths of 20-27% in this period, except for the Americas and Europe, where the number of IHD deaths attributable to air pollution increased 2.4% and decreased 19.2%, respectively. The trend of age-standardized IHD mortality rates (deaths per 100,000 people) attributable to air pollution remained mostly stable or showed a very limited decline from 2010 to 2019 across regions, except for Europe, which experienced a decline of 28% over the entire period.

The levels of age-standardized stroke mortality rates attributable to air pollution declined in all regions from 2010 to 2019, with the Eastern Mediterranean, Africa and South-East Asia regions recording an average annual reduction around 1%. The remaining regions experienced annual average reductions of 2.6-3.3% (Figure 11).

It is important to remember that the greater number of deaths in one region over another is down to different factors, including air pollution exposure and the population size. For example, Africa and the Western Pacific had similar levels of air pollution exposure in 2019 (see Figure 2), yet the latter region had a higher number of deaths due to a larger population.

There is no significant difference between males and females in the regional distribution of IHD deaths attributable to air pollution, except in the Europe region where the proportion of female IHD deaths was higher (22.5%) than males (17%) (Figure 12).
The global number of deaths from stroke attributable to air pollution increased only 0.3% from 2010 to 2015. There was significant regional variation in these numbers, with the highest decreases observed in the Africa, South-East Asia, and Eastern Mediterranean regions, while Europe experienced a 2.3% decline, and the Americas and Western Pacific regions saw lesser reductions. Levels of age-standardized stroke mortality rates attributable to air pollution declined in all regions from 2010 to 2019, with the Eastern Mediterranean, Africa, and South-East Asia regions recording an average annual reduction of around 2%. The remaining regions experienced smaller annual average reductions of 2.6–3.3% (Figure 12).

It is important to note that the greater number of deaths in some regions may be due to different factors, including air pollution exposure and population size. For example, Africa and the Eastern Pacific had similar levels of air pollution exposure, yet the latter had a higher number of deaths due to larger population.

There is no significant difference between males and females in the regional distribution of IHD deaths attributable to air pollution, except in the Europe region, where the proportion of female IHD deaths was higher (23.3% of female male deaths (17%) (Figure 12)).

Regarding deaths from stroke attributable to air pollution, almost 50% of all total global male deaths occurred in the Western Pacific, compared to 40% of total global female deaths. In total, the proportion of female stroke mortality attributable to air pollution in the European region was higher than the male proportion (14% compared to 8.8%) (Figure 12).

*Note: Data for DALYs is available in Online Appendix.

FIGURE 11
Number of IHD and stroke deaths (left panels) and age-standardized mortality rates (per 100,000 people) (right panels) attributable to ambient air pollution for both sexes and WHO regions.

Source: WHO Global Health Observatory

FIGURE 12
Percentage of (a) ischaemic heart disease and (b) stroke mortality attributable to ambient air pollution by sex and WHO regions, 2015.

Source: Data for 2015 is available in Online Appendix.

FIGURE 13
Proportion of ambient air pollution deaths attributable to different causes.

Note: Data for DALYs is available in Online Appendix.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower respiratory infections</td>
<td>13%</td>
<td>13.8%</td>
</tr>
<tr>
<td>Trachea, bronchus, lung cancer</td>
<td>4.6%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>26.3%</td>
<td>28.1%</td>
</tr>
<tr>
<td>Stroke</td>
<td>24.5%</td>
<td>25.4%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>7.3%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>4.6%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Lower respiratory infections</td>
<td>13%</td>
<td>13.8%</td>
</tr>
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<td>Chronic kidney disease</td>
<td>4.6%</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

Lower respiratory infections
Trachea, bronchus, lung cancer
Chronic obstructive pulmonary disease
Stroke
Diabetes
Chronic kidney disease

Lower respiratory infections
Trachea, bronchus, lung cancer
Chronic obstructive pulmonary disease
Stroke
Diabetes
Chronic kidney disease
Exposure to household air pollution is among the top 10 risk factors for disease, with the poorest communities in LMICs most affected [1]. WHO estimates that over 2 billion people worldwide rely on polluting fuels such as wood, crop waste, animal dung, or charcoal paired with inefficient stoves for cooking [16] (Figure 16). Considerable evidence indicates the role of household air pollution in contributing to a broad range of respiratory, cardiovascular, and maternal conditions, among others [17]. Estimates in 2019 showed that household air pollution contributed to 3.2 million deaths annually, a similarly high level to the estimated deaths from exposure to ambient air pollution [18,19]. Over half of these 3.2 million deaths were due to cardiovascular disease, with 1 million from IHD and 700,000 from stroke.

In 2019, the three countries with the highest age-standardized IHD mortality attributable to household air pollution (deaths per 100,000 people) were Vanuatu (103 deaths; CI 79-126), Solomon Islands (100 deaths; CI 77-122) and the Federal State of Micronesia (94 deaths; CI 69-116). The lowest levels, outside of the high-income countries where no burden for household air pollution is estimated, were recorded in Argentina (0.3 deaths; CI 0.0-2.6), Jordan (0.4 deaths; CI 0.0-3.2) and Tunisia (0.8 deaths; CI 0.0-5.0) (Figure 17).

The burden of disease (including CVDs) attributable to household air pollution has declined globally over the past two decades; however, there is clear geographical variation [20]. LMICs experience most of the burden, due to comparatively limited access to electricity or gas cooking. In 2021, the proportion of the population with primary reliance on polluting fuels and technologies for cooking was highest in Africa (Sub-Saharan region), with South Sudan (88% of the population; CI 85.2-90.7), Somalia (86.7% CI 83.6-89.7), and Tanzania (86.5% CI 83.4-89.5) recording the highest values.
However, in many regions, particularly across LMICs, progress remains slow. Acknowledging these challenges, WHO guidelines recommend expansion of the use of clean fuels and technologies including solar, electricity, biogas, liquefied petroleum gas (LPG), natural gas and alcohol fuels.

It should be noted that while the longer-term goal should be a transition away from non-renewable fuels, in the short term the use of LPG should be promoted as a scalable, transitional clean household energy solution. Where access to clean fuels remains limited, more advanced combustion cookstoves that meet the emission targets in the WHO Guidelines may be prioritized in the transition to clean cooking solutions.

**GOVERNMENT INTERVENTION VIA POLICY AND TARGETED INVESTMENTS CAN ACCELERATE THE ADOPTION OF CLEAN COOKING SOLUTIONS AND HAS BEEN SUCCESSFUL IN COUNTRIES SUCH AS CHINA, INDIA, AND INDONESIA [21].**

When countries are grouped by income level, the impacts of ambient (outdoor) and household (indoor) air pollution on people’s health differ significantly (Figure 18).

Countries in the low-income group experience higher levels of age-standardized stroke and IHD mortality attributable to both household and ambient air pollution than those in the middle- and high-income groups, with the exception of IHD mortality attributable to ambient air pollution. A larger gap is observed in levels of stroke and IHD mortality attributable to household air pollution, with most of the countries in the high-income group having no deaths attributable to household air pollution (except for Guyana, Panama, and Romania).

**THE DISPROPORTIONATE IMPACT OF AMBIENT AND HOUSEHOLD AIR POLLUTION ON LOWER-INCOME COUNTRIES**

Countries in the low-income group experience higher levels of age-standardized stroke and IHD mortality attributable to both household and ambient air pollution than those in the middle- and high-income groups, with the exception of IHD mortality attributable to ambient air pollution. A larger gap is observed in levels of stroke and IHD mortality attributable to household air pollution, with most of the countries in the high-income group having no deaths attributable to household air pollution (except for Guyana, Panama, and Romania).

**FIGURE 18**

Ischaemic heart disease and stroke age-standardized mortality rates (deaths per 100,000 people) attributable to household air pollution (a) and ambient air pollution (b), by income level for both sexes, 2019

Note: Each dot represents a country. Countries are classified as low-, middle- and high-income based on the World Bank classification. Countries denoted red or blue in the upper or lower half of the graph have experienced a decrease or increase in deaths attributable to household and ambient air pollution, respectively.

Source: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/ambient-air-pollution-attributable-death-rate-(per-100-000-population-age-standardized)*


**GOVERNMENT INTERVENTION VIA POLICY AND TARGETED INVESTMENTS CAN ACCELERATE THE ADOPTION OF CLEAN COOKING SOLUTIONS AND HAS BEEN SUCCESSFUL IN COUNTRIES SUCH AS CHINA, INDIA, AND INDONESIA [21].**
Indoor air pollution still poses an issue in more affluent areas/countries and modern buildings. Cooking and heating can produce high levels of pollutants with spikes in pollution often orders of magnitude higher than ambient levels, while there is a plethora of indoor sources of pollution such as house dust, volatile organic compounds from chemically treated surfaces, cleaning products and body-care products, and biofilms from mould and pet fur (Figure 19).

At present, there is a notable absence in our understanding of the cardiovascular effects of indoor-derived air pollution in modern buildings. As the world transitions towards net-zero, a concern is that energy efficiency measures will make buildings more air-tight, reducing the egress of pollutants via ventilation and increasing the build-up of pollutants from indoor sources. Research into indoor air pollution in domestic housing, schools, workplaces, and social care is gaining momentum. However, the complexity of indoor air pollutants, buildings and user behaviour is vast, making it vital to learn from scientific knowledge of outdoor air pollution to understand modern indoor settings. Further research is needed into the cardiovascular conditions that result in elevated risk for the effects of air pollution, so that tailored guidance and interventions can be provided to these individuals and groups.

**Figure 19: Sources and types of indoor pollution in homes.**

- **Bedrooms**: Dust and dust mites, bacteria and viruses, pet dander, VOCs from personal care products.
- **Bathrooms**: Mould and mildew, bacteria, VOCs and other chemicals from cleaning products.
- **Living areas**: Radon from soil/bedrock, CO and NO₂ from fires and wood-burning stoves, VOCs and formaldehyde from carpets, paints, glues, furniture and air fresheners, tobacco smoke, pet dander.
- **Garage**: CO from car exhaust, mould and mildew, VOCs from stored paints and solvents, pesticides and herbicides.
- **Kitchen**: CO, NO₂ and particulates from gas cookers/stoves, VOCs from household cleaning products.
- **ATTIC**: Man-made mineral fibres, asbestos, formaldehyde, dust.

Please note that these lists are not exhaustive and that the actual pollutants present, and their amounts, will vary from household to household.
Exposure to air pollution during pregnancy is linked with effects on the mother [22], including hypertensive disorders in pregnancy and gestational diabetes, and is associated with adverse birth outcomes such as pre-term birth, low birth weight and, in some settings, still-birth [23]. Meta-analyses show that associations with adverse birth outcomes are strongest for PM2.5, although gaseous pollutants, such as NOx, SO2 and VOCs, also contribute to the burden [24]. The negative impacts of air pollution on birth outcomes are particularly prominent in low income regions where household air pollution from solid fuel use is a major risk and contributor.

In utero exposure to air pollution has been linked to health effects in the child in later life, including the risk of developing CVDs [25]. There is growing evidence that air pollution is linked with both obesity and diabetes, including that people living with these conditions are more susceptible to air pollution. In human studies [26], exposure to air pollution is associated with impaired glucose handling, insulin resistance, as well as increased prevalence of diabetes and risk of death from diabetes due to long-term exposure to pollution. Studies [26] show that PM2.5 can increase fasting glucose levels, impair insulin signalling at multiple levels, promote changes to the build-up of fat inside our body, and cause inflammation in internal fat. Given the prevalence of cardiovascular conditions in patients with diabetes and obesity, the effects of air pollution on obese and diabetic individuals are likely to indirectly cause significant levels of morbidity and mortality.

Air pollution is the second leading cause of death from non-communicable diseases (NCDs) after tobacco smoking, according to WHO [29]. Studies suggest that air pollution and smoking build on one another to have combined cardiovascular effects [26], though further research is warranted to clarify this.

Air pollution and cigarette smoke are closely related in how they impair cardiovascular function, including endothelial dysfunction, oxidative stress, inflammation,, impaired fibrinolysis, and deregulation of heart rhythm [31]. There are similarities between the pollutants in certain sources of air pollution (particularly those from combustion) and those emitted in tobacco smoke. There are also gases such as carbon monoxide, nitrogen dioxide, and ultraviolet particles. Within these constituents, there are many other reactive chemicals, including benzene, aldehydes, aromas, polycyclic hydrocarbons and reactive metal species [32]. A substantial reduction in cardiovascular events—including beyond people who smoke—has been observed following the ban on smoking in public places in many countries [33, 34]. These positive health outcomes and the broad public appreciation for these policy interventions could provide lessons for implementing policies to cut air pollution more broadly. Further information on gains in tobacco policymaking to date and ways in which these can be strengthened can be found in WHF’s Roadmap for Reducing Cardiovascular Mortality Through Tobacco Control [35].
NOISE, LIGHT, TEMPERATURE AND MICROPLASTICS

It is estimated that 113 million people live in settings with levels of traffic noise that are harmful to health [36]. Exposure to noise has been associated with increased cardiovascular mortality and morbidity, including IHD, heart failure, and stroke. Exposure to high noise levels also interacts with other conditions, such as diabetes and mental health conditions, further exacerbating cardiovascular risk [37].

There is an increasing recognition of the cardiovascular health benefits of sunlight, but artificial light pollution, particularly at night, has detrimental effects on health. Studies have shown that light pollution is associated with coronary heart disease hospitalization and death [38].

The relationship between temperature and CVD mortality and morbidity is usually U-shaped, with cold temperatures associated with increased risk of cardiovascular events [39, 40, 41]. See the Air Pollution and Climate Change section of this report for a discussion on the interactions between temperature and air pollution.

As well as being found in water and the food chain, micro-/nano-plastics have also been found in the air [42]. A recent study identified micro-plastics in atheromatous plaques, which was associated with a higher risk of cardiovascular events and death [43]. Air pollution interacts with the above environmental risk factors, with both noise and pollutant emissions from vehicles, and higher levels of both contributing to cardiovascular morbidity [44].

Evidence suggests sex and age differences in temperature-related CVD mortality, with older females being more sensitive to heat and older males being more sensitive to cold [45].

*Evidence for age and sex differences in temperature-related CVD mortality, with older females being more sensitive to heat and older males being more sensitive to cold.

See the Air Pollution and Climate Change section of this report for a discussion on the interactions between temperature and air pollution.
MITIGATING AIR POLLUTION HARMs

DIET

Several studies show that diets rich in fruit, vegetables, fibre and protein, as well as the antioxidant rich Mediterranean diet,* can ameliorate some of the cardiovascular effects of air pollution [44].

SUPPLEMENTS

While there is uncertainty as to the benefits of antioxidant supplements in preventing cardiovascular morbidity and mortality, studies in preclinical models with various antioxidant compounds and omega-fatty acid supplements in humans, suggest that some antioxidants may offset the detrimental cardiovascular effects of air pollution [45].

MEDICATIONS

While reduction of air pollution emissions should remain the key priority for the prevention of the cardiovascular effects of air pollution, there may be benefits of tailoring therapeutic treatment of patients with CVDs who have largely unavoidable high exposure to air pollution, until an effective means to reduce exposure can be implemented [45].

A stronger evidence base is needed to support the limited evidence that various pharmacological medicines (e.g., statins and beta blockers) used for CVDs can also ameliorate the cardiovascular effects of air pollution.

PHYSICAL ACTIVITY

Research is needed to better determine the benefits and trade-offs of exercising in air pollution. Exercise increases the volume of air breathed, increasing air pollution exposure; however, the cardiovascular benefits of physical activity are well documented.

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*Plant-based with fish and poultry, and minimal dairy.
Climate change and air pollution are interlinked. Most of the major drivers of air pollution, such as fossil fuel combustion and other anthropogenic activities, are also sources of greenhouse gas emissions, thereby driving climate change, while major environmental events caused by climate change increase air pollution, creating a vicious cycle [50].

**AIR POLLUTION'S CONTRIBUTIONS TO CLIMATE CHANGE**
In addition to contributing to greenhouse gas emissions, fossil fuels lead to the generation of black carbon particles, which can absorb heat, with a higher global warming potential than carbon dioxide. This is not the case for all particulate matter, as some absorb heat and some reflect it, meaning that the net warming/building effect on the planet will depend on the source and composition of PM, as well as atmospheric conditions and co-pollutants [51]. Further evidence is needed to understand the complexity of the science and establish effects on health.

**CLIMATE CHANGE'S CONTRIBUTIONS TO AIR POLLUTION**
Climate change leads to an increase in the intensity, frequency, and duration of extreme weather events, including storms, floods, droughts and extreme temperatures, ecosystem collapse, declines in global food production, and nutritional quality of major crops [52]. Climate change can exacerbate air pollution through events like wildfires, desertification and dust storms, and the longer window of warmer and drier temperatures that contribute to an increase in ozone production [53].
The indirect health impacts of climate change are exacerbated by certain socio-economic factors, including, poverty, access to healthcare and health inequalities, underlying susceptibilities (e.g., age or sex related), disruption of social services, and the capacity of health systems to resist and manage climate hazards.

Similarly, air pollution has health inequities both in terms of the level of exposure (with those of lower socio-economic status likely to have higher exposure) and effect (with those that are already vulnerable being more biologically susceptible to the effects of pollutant exposure). The impact of climate change will exacerbate these inequalities and compound efforts for those at greatest risk to live healthily and seek medical help [59].

It is undeniable that the environmental and social consequences of climate change will increase the prevalence and severity of CVDs over this century without strong health and socio-economic interventions. Because they are closely interconnected, mitigation and other interventions targeting and tackling air pollution have the co-benefit of acting on climate change [60].

There is a need to be cautious that policies and interventions to tackle one environmental risk do not have inadvertent consequences on another. In the early twenty-first century, some manufacturers and governments pushed the adoption of diesel cars to reduce greenhouse gases; however, this overlooked the greater levels of ultrafine particles produced by these vehicles compared to other fuel types. The focus on reducing the reliance on fossil fuels is likely to have mutual benefits in slowing climate change and improving air quality [61]. Understanding the science behind these crucial environmental risk factors, and how they impact NCDs like CVDs, will maximize these gains.

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AIR QUALITY GUIDELINES 
AND POLICIES

National and local governments have a critical role in playing in reducing air pollution through policy implementation. The 2023 WHO global air quality guidelines provide policymakers with recommended levels for air pollutants based on the evidence of their impact on health, along with niche policies to guide progress towards recommended levels.

A range of evidence-based policies to reduce air pollution exist in these targets exist in many countries. At the city level, these include steps to reduce air pollution by reducing traffic congestion and expanding public transport, improved public transport infrastructure for cycling and walking, zoning laws to prevent development of sensitive areas, and infrastructure for cycling and pedestrian pathways. At the national level, governments can provide policy support and legal frameworks for the implementation of national and local air quality guidelines.

The WHO Health and Environment programme, together with its partners, aim to promote and support the implementation of WHO guidelines in the field, the development of national guidelines and the integration of air quality into national policies and programmes. The WHO guidelines provide a framework for the implementation of national and local policies to improve air quality and reduce the adverse health effects of air pollution.

However, the standards included in national air quality policy and legislation overwhelmingly do not align with the values set in the WHO global air quality guidelines.

The WHO Health and Environment Country Scorecards (34), which evaluate 121 countries’ management of air pollution and other environmental risks, show that while many countries have legal standards for specific pollutants, few have such standards for indoor air pollution. The WHO guidelines recommend that countries consider the specific pollutants that are most relevant to their populations and that they align their legal standards with the WHO guidelines.

However, the standards included in national air quality policy and legislation overwhelmingly do not align with the values set in the WHO global air quality guidelines.

WHO RESOURCES ON AIR POLLUTION INTERVENTIONS

Interventions to reduce emissions and exposure to air pollution are key. However, it is important to identify those that are most efficient, assess the logistics of implementation, and showcase the benefits of policies to increase political and public support. The Global Climate and Health Partnership has developed a range of resources to support policy makers and health professionals in their work to reduce air pollution. These resources include toolkits, guidance documents, case studies, and data on air pollution trends.

The Global Climate and Health Partnership (GCP) is a multi-stakeholder initiative that brings together governments, international organizations, and civil society to address the health impacts of climate change and to support action on climate change. GCP works with a range of partners to develop and implement interventions to reduce air pollution, including policies and programs that address Source: Global Climate and Health Partnership
**Evolving Air Pollution Guidelines**

Agriculture is a significant source of air pollution. The gas ammonia is emitted into the air from livestock waste and fertiliser use. Although ammonia may reach waterbodies and soils in the atmosphere, it is not a significant source of particulates. These secondary particulates can travel hundreds of kilometres and even to continents. However, 20-40% of PM, which can be emitted from ammonia conversion to nitric acid, can be secondary particulate matter. Another source of agricultural-derived emissions, and one that is likely to increase with technological innovation in this sector, is dust and particulate matter. For instance, wind erosion of soils and slurry store covers can result in particulate matter being emitted into the atmosphere.

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Another source of agricultural-derived emissions includes chemical and biological compounds from crop residues and animal waste. Chemical compounds such as pesticides and fertilisers can be emitted into the atmosphere through dust and particulate matter. Biological compounds such as those from animal waste can be emitted through manure management practices.

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CASE STUDIES OF AIR QUALITY INTERVENTIONS

BARCELONA, SPAIN: GREENING URBAN SPACES

In the initial eight years since 2013 when targeted policies were introduced in Barcelona to “green” urban zones, reduce vehicle congestion, and combat air pollution, the city saw a 30% decrease in NO2 emissions. Measures introduced to achieve this result include the employment of new air quality monitoring stations, the creation of a new bus network, and the expansion of the metro and bicycle lane networks, resulting in 56% more bicycle journeys. The changes to the urban environment have also helped incentivize journeys on foot, with more pedestrian-friendly streets and spaces. The activation of the Low Emission Zone (LEZ) in 2017 also resulted in a reduction in the initial measurement period of 600,000 journeys by vehicles that pollute the most, while the gradual switch to electric vehicles for the municipal fleet of the City Police and cleaning and waste collection vehicles has helped cut pollutant emissions [90].

ENVIRONMENTAL INJUSTICE: ADDRESSING INEQUITIES THROUGH FUTURE POLICIES

Environmental injustice is the inequitable and disproportionate exposure of poor, racial and ethnic minorities, and disenfranchised populations to toxic chemicals, air and water pollution, unsafe workplaces, and other environmental hazards. The concept of environmental injustice was first used in the 1980s by Black and Latino communities in the United States exposed to hazardous waste sites and has since developed in other areas of the world [86]. The idea of environmental injustice is correlated with the unequal exposure to pollution, and other factors linked to poverty, such as inadequate access to medical and preventive care and other conditions like malnutrition or the lack of pollution healthcare in the workplace [87]. In LMICs, heating and cooking by biomass and the relocation of polluting industries from high-income countries are emblematic of the disparities in air pollution exposure [88].

Under the coordination of the Autonomous University of Barcelona, the Environmental Justice Global Atlas collates almost 4,000 environmental “conflicts” around the world, whereby civil society actors have mobilized against a socio-environmental issue [89]. Conflict projects include ammonia-coal co-firing in efforts to prolong coal plant lifespans in Asia, a waste incinerator close to populated areas in North America, the development of industrial areas with high environmental impact in South America, and the creation or expansion of airports and motorways. These are examples of environmental justice conflicts involving air pollution that can be found on every continent, with the majority most likely to have a greater impact on vulnerable populations with little capacity to enforce their rights.

URBAN PLANNING AND INFRASTRUCTURE

Over 50% of the world’s population lives in cities [80]. While cities can provide greater access to amenities and healthcare, they are also likely to have higher levels of harmful air pollutants. Innovative city design and development can help reduce both emissions of air pollution and exposure to it. Better housing may reduce the ingress of ambient air pollution into indoor spaces, while creating more green spaces for outdoor activities that mitigate the effects of indoor air pollutants out of the home [81]. Reducing the reliance on vehicles for transport will also have significant benefits, not only reducing vehicle emissions, but also improving the health gains of active travel (see section on Air Pollution Interactions with other Risk Factors and Conditions) [82].

City design can reduce car journeys by providing the necessary amenities within walking or cycling distance. Safe active travel space and improved public transport will be essential for this to be effective. The provision of parks and greenspaces will provide fewer air pollution areas for exercise, and a means to improve mental well-being [82]. The transition to “20-minute neighbourhoods,” where necessary amenities can be reached within a 20-minute walk or cycle, while avoiding taking a private vehicle, will take considerable time and resources to achieve. However, projects are taking shape in this direction, with cities including Bogotá, Melbourne, Milan, Paris, and Portland cited as good practice examples [84].

The gradual move towards healthier cities will be rewarded through gains in physical and mental health, as well as economic and environmental sustainability [85].

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ULAANBAATAR, MONGOLIA: PHASING OUT RAW COAL

Ulaanbaatar is recognized as both the coldest and most polluted capital city in the world. Multiple projects have helped shift heating and energy production from the burning of raw coal to other, cleaner sources. A recent two-phase investment by the Asian Development Bank focused on 1) the piloting of coal briquettes and the burning of raw coal to other, cleaner sources. A recent two-phase investment by the Asian Development Bank focused on 1) the piloting of coal briquettes and 2) implementing the world’s first large-scale 1,600MW wind power plant in Ulaanbaatar, the country’s capital city.

BUENOS AIRES, ARGENTINA: COMPREHENSIVE PLAN FOR INCLUSIVE REDUCTION OF AIR POLLUTION

According to the 2022 IQAir report, Buenos Aires ranked sixteenth among capitals with the highest levels of air pollution, despite Argentina having relatively low levels of air pollution when compared with other countries. Buenos Aires City has been working on a Climate Action Plan—currently in its third phase—to be recognized as a carbon neutral, resilient and inclusive city by the year 2050. The programme, which seeks to reduce greenhouse gases by 50% by the year 2030 and 84% by the year 2050, includes efforts to become a proposed city (infrastructure and green space development), a nearby city (promote non-motorized transportation), a pedestrian-friendly polycentric city (equitable distribution of the benefits of climate action). If this effort is implemented in full, it could reduce CO2-related to air pollution in the coming years [94].

CAMEROON, AFRICA: GRASSROOTS ADVOCACY FOR CLEAN AIR AND DISEASE PREVENTION

In 2018, the Global State of the Air Report ranked Cameroon eighth among the top 30 countries with the highest population-weighted annual average PM2.5 concentration level (65 µg/m³). In 2020, the Global State of the Air Report ranked Cameroon eighth among the top 10 countries with the highest levels of air pollution when compared with other countries. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. The Cameroon government has acknowledged the Global Youth Strategy on Air Pollution and Climate Health as an organization in 2022 over 500 medical students from different universities in Cameroon. APYLAV and the Cameroon government have continued to work together to help curb the burden of air pollution on the health of youths in Cameroon and beyond [92].

BEIJING, CHINA: MAJOR ACTION AND INVESTMENT FOR RAPID AIR POLLUTION REDUCTION

In the early 2000s, Beijing faced a rise in air pollution, prompting temporary measures during the 2008 Olympic Games. However, severe pollution episodes persisted in the winter of 2012, leading the government to recognize air pollution as a critical issue. In response, Beijing introduced a comprehensive five-year action plan in 2013, acknowledging the severity of air pollution and aiming for substantial improvements in public health and sustainable growth. The plan included specific targets, stringent emissions standards, and measures to address loopholes in enforcement, with a notable focus on the transport sector. Initiatives such as a city-wide licence plate lottery for fossil fuel-burning vehicles and incentives for electric vehicles aimed to reduce vehicular pollution. Additionally, efforts to control truck traffic through the city were implemented. Beijing, once known as the “Kingdom of the Bicycle”, reintroduced bike-sharing schemes to promote cleaner modes of transportation. Beyond transport, initiatives to improve the use of cleaner household fuels, restructure industry, close urban centre power stations, and repair neighbouring ecosystems to prevent dust pollution were all implemented. Following significant financial investment, the budget to combat air pollution soaring from 2 billion yuan (approximately US$480 million) in 2013 to over 18 billion yuan (approximately, US$2.7 billion) in 2017, the improvements in air quality were significant. By the end of 2017, the annual average PM2.5 concentration in Beijing had decreased by 25%, sulphur dioxide by over 53%, and nitrous dioxide by nearly 38%. Heavy pollution episodes became less frequent and less intense, showcasing the success of Beijing’s comprehensive action plan [94].
SECONDARY RECOMMENDATIONS

WHF encourages the healthcare sector to take a leading stance in reducing emissions of air pollution as part of sustainability strategies. Currently the healthcare sector accounts for almost 5% of global greenhouse gas emissions.

WHF encourages cardiologists, cardiovascular scientists, health practitioners in general, cardiovascular communities and health foundations to advocate for the need to recognize air pollution as a major risk factor for cardiovascular health, engage with stakeholders, and help prioritize resources and political will to tackle this issue.

Greater efforts must be made to improve education on the health impacts of air pollution, including at secondary, undergraduate, and postgraduate levels, for health professionals and through training programmes for disciplines essential for research in the field, e.g., toxicology and epidemiology.

More studies on the cardiovascular effects of air pollution are required in LMICs, where stationary monitoring is limited or lacking. The use of low-cost monitors and in situ measurement of health parameters by portable devices could help to increase research into the cardiovascular effects of air pollution in these settings.

KEY RECOMMENDATIONS

All countries and stakeholders must urgently work together to accelerate efforts to curb air pollution levels and implement policy and health interventions to protect people from its most harmful effects. These actions will be critical to achieving Sustainable Development Goals related to cutting non-communicable disease mortality, as well as having broader benefits with regard to tackling the climate crisis.

To help promote urgent action against air pollution and its impacts on cardiovascular disease and health more broadly, the World Heart Federation recommends the following:

PRIMARY RECOMMENDATIONS

1. All countries must adopt the new WHO global guidelines on air quality. This includes making a roadmap of strategies to meet the interim targets outlined by WHO whilst progressing to the overall guideline level. Policies should be multi-faceted and multi-sectoral, encompassing, among others, health, housing, city design, transport, and agriculture.

2. WHF supports the implementation of a global fossil fuel non-proliferation treaty. Country commitments to these treaties must be maintained. A legally binding agreement, and suitable implementation strategies, must be employed to rapidly reduce the use of fossil fuels.

3. Countries and technical bodies, particularly in LMICs, should urgently improve air pollution monitoring and modelling where these are gaps. This includes expansion of the stationary monitoring network in both rural and urban areas that will help provide more accurate estimates of air pollution levels and trends.

4. Countries, multilateral, and philanthropist must increase funding into multidisciplinary and multi-sectoral innovations to improve air quality and strategies to implement interventions for reducing air pollution.

5. Health and research agencies at country, regional, and global levels should conduct additional studies into the cardiovascular effects of air pollution and CO2 emission to better inform air pollution policies in addition to the role of the cardiovascular system in the disease of other organs. This should include the study of the cardiovascular effects of less-well-researched air pollutants, so that policies and interventions can target the air pollutants that are most harmful. This will support the design and implementation of health interventions.