Environmental Factors and Heart Health: Considering Environmental Influences as aspect of sustainable development

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Abstract. Heart health research is increasingly focusing on the effects of the environment on cardiovascular function. This review discusses the role of various environmental factors, such as air quality, noise levels, access to green space, and environmental urban planning strategies, in shaping heart health. Both direct and indirect mechanisms through which the environment may influence the development of cardiovascular disease are discussed, including inflammation, stress, physical activity, and sleep quality. Understanding these relationships is important for the development of effective programs for the prevention and management of cardiovascular diseases, based on consideration and improvement of environmental quality.

1 Introduction

This passage highlights the significant impact of non-communicable diseases (NCDs), particularly cardiovascular diseases (CVDs), chronic respiratory diseases, and metabolic diseases, on global health. CVDs, including conditions such as coronary artery disease, heart failure, stroke, and hypertension, contribute substantially to the burden of NCDs, accounting for a majority of global deaths annually.

The World Health Organization (WHO) projects a further increase in NCD-related deaths by 2030, with CVDs playing a predominant role. Alarmingly, low- and middle-income countries bear the brunt of premature NCD-related deaths. The economic consequences of NCDs are staggering, with projected costs amounting to trillions of dollars over the next two decades.

Environmental factors play a significant role in the development of NCDs, with up to a quarter of cases of ischaemic heart disease attributed to an unhealthy environment, particularly air pollution. Despite this, environmental risk factors have been historically overlooked in global health policies, such as the WHO NCD Global Action Plan of 2030. Furthermore, research and funding for the prevention and treatment of environmentally triggered NCDs have been insufficient relative to their impact on public health.

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Air pollution, a longstanding issue since ancient times, has undergone significant evolution in its sources and composition, particularly with the rise of industrialization and urbanization. Today, anthropogenic (combustion-derived) air pollutants pose a major public health concern, necessitating new classification criteria to account for their complex chemical makeup.

The majority of urban air pollutants, over 90%, consist of gases or vapors such as O3, NO2, volatile organic compounds (e.g., benzene), CO, and SO2. Of particular concern are combustion emissions containing ultrafine particles (UFPs) or PM0.1, which exhibit potent cardiovascular toxicity due to their high number, reactive surface, and ability to penetrate the alveoli and circulate systemically, causing damage to various organs.

CO, although not typically present in ambient air at toxic levels, poses a unique threat by displacing oxygen in hemoglobin, leading to organ oxygen deprivation. Unlike other pollutants that induce oxidative stress, CO's effects are not additive with other pollutants. However, oxidants such as NO2, O3, and PM2.5 can generate reactive oxygen species, warranting further toxicological, modeling, and epidemiological studies.

Moreover, air pollution is significantly influenced by climate change, as highly reactive pollutants are formed under conditions of hot weather and high UV radiation. Conversely, air pollution itself can contribute to global warming, potentially exacerbating cardiovascular health issues. This interconnectedness underscores the importance of addressing both air pollution and climate change in efforts to safeguard public health.

Addressing this gap, emerging fields like "exposome" research are gaining attention, aiming to understand the lifelong effects of environmental exposures on health outcomes. Additionally, initiatives such as "healthy cities" campaigns are focusing on creating environments conducive to better health outcomes, thereby emphasizing the importance of considering environmental factors in combating NCDs.

2 Research methodology

Light pollution, a relatively novel environmental risk factor, has raised concerns due to its potential significant impact on non-communicable diseases (NCDs). Anthropogenic sources of artificial nighttime sky brightness, prevalent in urban areas but extending to rural regions such as national parks, affect a large portion of the global population. The progression of light pollution, documented through satellite images over several decades, highlights its widespread nature and persistence.

The adverse effects of light pollution extend beyond human health, impacting biodiversity by disrupting the circadian rhythms of insects, animals, and birds. In humans, dysregulation of circadian genes plays a crucial role in the development of NCDs, affecting inflammatory and metabolic pathways. Mutations and expression changes in key circadian genes have been linked to conditions like obesity and hyperglycemia.

Studies have shown associations between artificial light at night and adverse health outcomes in humans, particularly in the elderly population. Elevated outdoor nighttime light pollution has been correlated with increased blood pressure and a higher risk of coronary heart disease (CHD) and mortality. Importantly, there appears to be an additive effect on CHD mortality when high light pollution levels are combined with high air pollution levels, suggesting a synergistic impact on health.

Furthermore, exposure to combined PM2.5 and light at night has been associated with circadian disruptions and epigenetic changes in circadian genes. While these findings are predominantly from studies in East Asia and among older participants, there is a need for replication studies in diverse populations and geographic locations to fully understand the implications of light pollution on human health.

In conclusion, addressing light pollution is imperative not only for preserving natural ecosystems but also for safeguarding human health, particularly against the backdrop of rising NCDs worldwide.

Determining NHS costs and QALYs lost for a single case of cardiovascular disease involved adapting the principles of the Sheffield prevention model and updating unit costs to 2008, with all new costs and inflation indices sourced from Curtis [6]. The expected lifetime costs, life years, and QALYs after a first cardiovascular event were estimated based on age and sex, compared to life expectancy without an event to determine the loss in life years and QALYs. For example, a 65-year-old man with stable angina was considered, combining life expectancy data from the government actuary's department with quality of life data from Sheffield to estimate discounted quality-adjusted life expectancy. Lifetime treatment costs and QALYs lost were estimated using data from Ward et al. This process was repeated for men and women aged 40 to 90 years [7].

Assessing the pattern of prevented or postponed cardiovascular disease cases involved using the Framingham risk equations to generate expected patterns of first cardiovascular events based on age, sex, and risk factors. The effect of an intervention was estimated using a relative risk applied to the annual risk of a first cardiovascular event over a 10-year period.

Combining the results from the first two stages produced estimates of deaths prevented, life years gained, QALYs gained, and cost savings for each group. Output was generated for men and women of all ages and then aggregated to estimate total NHS costs and QALYs gained for the entire population of England and Wales, considering the number of cases over a 10-year horizon and expressing the results on an annual basis. Population effects were calculated using data from the Office for National Statistics, adjusting for individuals eligible for primary prevention. NICE's standard annual discount rate of 3.5% was applied to both costs and outcomes, with total savings converted into annual equivalent savings across each of the 10 years. Full technical details of the model are available in the appendix and on the NICE website.

3 Results and Discussions

Air pollution stands as a significant health hazard, contributing to increased morbidity and mortality rates. The World Health Organization (WHO) identifies gaseous and particulate pollutants as key risk factors for various respiratory infections, chronic diseases such as chronic obstructive pulmonary disease (COPD), lung cancer, and cardiovascular diseases (CVDs), including heart attacks and strokes.

Chronic exposure to low levels of air pollution has been linked to the development of non-communicable diseases (NCDs) like COPD and even all-cause mortality. Even concentrations below current European recommendations for pollutant limits have shown positive associations with health risks. Globally, diseases attributable to air pollution cause more deaths than HIV/AIDS, tuberculosis, and malaria combined, with substantial economic losses.

Recent research has also highlighted the impact of air pollution on the prevalence and severity of COVID-19. While pandemic-induced lockdowns temporarily improved air quality and reduced cardiovascular events, the fear of COVID-19 infection led to decreased hospital admissions for acute cardiovascular conditions, potentially resulting in more acute cardiovascular deaths.

Long-term exposure to fine particulate matter (PM2.5) and ozone (O3) can lead to chronic oxidative stress, inflammation, and a range of respiratory and cardiovascular disorders. Models like the Global Excess Mortality Model (GEMM) estimate excess mortality rates from various diseases attributable to PM2.5 and O3 exposure, with

cardiovascular diseases being a leading cause of excess deaths, especially in middle- and high-income countries.

Mitigating air pollution has been recognized as an effective health promotion intervention, with potential life expectancy gains comparable to those from smoking cessation. The reduction of air pollution not only addresses immediate health risks but also contributes significantly to the prevention of cardiovascular diseases and improves overall public health.

The association between particles from natural sources, such as desert dust, wildfires, and volcano eruptions, and adverse effects on public health is increasingly recognized. These natural sources contribute to a significant portion of global deaths from cardiopulmonary causes, with estimates suggesting around 400,000 to 500,000 premature deaths annually attributable to air pollution.

Asian desert dust, for example, has been linked to an increased risk of cardiovascular disease (CVD) hospital admissions and incidents of acute myocardial infarction (MI). Similarly, forest fires in Southeast Asia and other regions have been associated with higher mortality rates and increased hospitalizations for ischemic heart disease (IHD). Wildfires, which release smoke containing particulate matter (PM), exacerbate respiratory and cardiovascular health issues, particularly due to the smaller particle size and contamination with oxidative and proinflammatory compounds.

As populations grow rapidly in regions like Africa and Southeast Asia, projections suggest more people will face exposure to both natural and human-made air pollution, including increased occurrences of wildfires. This calls for more clinical studies to understand the potential health impacts of natural air pollution sources.

Costs were identified through resource utilization in program administration and implementation, encompassing labor, facilities, food, equipment, curriculum printing, and other expenses. Labor costs were calculated based on staff compensation records, while other costs were estimated using administrative records, surveys, and site-level data. From the societal perspective, participant costs, including the opportunity cost of their time, were considered. From the healthcare sector perspective, estimates of medical costs associated with CVD events were utilized.

These comprehensive analyses provide a detailed understanding of the economic implications of the intervention from multiple perspectives, aiding decision-makers in assessing its cost-effectiveness and potential for broader implementation.

4 Conclusions

The healthcare sector in the world's largest economies contributes around 5% of all CO2 emissions, making it comparable in importance to the food sector. Recognizing this, the Lancet Commission on Health and Climate Change has recommended that greenhouse gas emissions from healthcare be considered as an indicator in evaluations of health and climate.

Climate change, particularly changes in temperature, has been associated with increased cardiovascular diseases (CVDs) such as acute coronary syndrome. Epidemiological studies suggest that both high temperatures, such as those experienced during heat waves and in urban "heat islands," and low temperatures can lead to an increase in cardiovascular mortality and morbidity.

Evidence shows an association between air temperature and acute myocardial infarction (MI), with studies indicating both a cold effect and a heat effect on MI occurrence. Importantly, the risk of MI related to heat exposure has been observed to increase over time, particularly in rural populations.

Several direct and indirect mechanisms may underlie the associations between high temperatures and cardiovascular events. These include increased cardiac strain, blood viscosity, and inflammation due to higher surface blood circulation and sweating, as well as sleep disturbances and reduced physical activity associated with warmer temperatures.

Emerging evidence suggests that rising temperatures, partly triggered by wildfires and greenhouse gas emissions from biomass burning, may increase susceptibility to heat-related MIs, especially when combined with high concentrations of PM2.5. Similar to air pollution exposure, heat exposure should be considered as an acute environmental stimulus for acute coronary syndrome, particularly in the context of global warming.

In our pursuit of a health goal with a focus on CVD, it is crucial to recognize that the health sector alone cannot ensure healthy life expectancy. Collaborative efforts across various sectors, including agriculture, transport, environment, and fiscal policies, are necessary to address factors such as diet, physical inactivity, and tobacco consumption. Only through cooperation and collaboration across sectors can we achieve a positive return on investment in cardiovascular health and encourage countries and businesses to allocate resources to our collective goal.

In conclusion, as negotiations on the SDGs progress, the CVD community stands at a critical juncture. It is incumbent upon us to leverage evidence-based science and advocacy to ensure that health remains central to the UN Global Development Agenda. We urge governments to prioritize health, NCDs, and other critical areas essential for the prevention and control of CVD and stroke. Through concerted efforts, human development can be realized in a sustainable manner.

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