

ENVIRONMENTAL DETERMINANTS OF CARDIOVASCULAR AND METABOLIC DISEASE AMONG PERSONS EXPOSED TO HYDROCARBON POLLUTION- A SYSTEMATIC REVIEW.**Authors:** Essiet, Akanimo Gordon¹, Gordon, Anietie A², Uredo, Augustina², Essien, Atim²**Affiliations:** ¹Basic Science Department, Federal College of Medical Laboratory Science and Technology Jos.²Environmental Health Science Department, Federal College of Medical Laboratory Science and Technology Jos**Citation:** Essiet, Akanimo Gordon¹, Gordon, Anietie A, Uredo, Augustina and Essien, Atim (2025) Environmental determinants of cardiovascular and metabolic disease among persons exposed to hydrocarbon pollution- a systematic review. *Frontline Professionals Journal* 2(3), 8-27**ABSTRACT**

The environmental factors of most cardiovascular and metabolic disorders in people exposed to hydrocarbon pollution are examined in this comprehensive study. The growing worldwide burden of disease linked to environmental variables, especially air pollution, serves as the impetus for the study. Growing urbanisation increases exposure to contaminants like hydrocarbons, especially PAHs, particularly in developing nations. A considerable fraction of deaths globally from cardiovascular disease (CVD) are associated with this exposure. The search strategy employed was PRISMA Extension for Scoping Reviews guidelines applied for selection procedures and presentation of the results. The main Search strategy for this review was the identification and use of Electronic search machines. We searched PubMed, SCOPUS, Google Scholar, MEDLINE, ISI Web of Science (Science Citation Index), Africa Wide Information, African Index Medicus (AIM), and AFROLIB databases for published studies on environmental pollution, and e-Library, as well as determinants of cardiovascular and metabolic diseases among persons exposed to pollution and more specifically hydrocarbon pollution. The review complies with the PRISMA Extension for Scoping Reviews criteria and searches numerous databases thoroughly for research up to January 31, 2023. The result reveals that a total of 820 publications were identified: PubMed, n = 7; Scopus, n = 3; Google Scholar, n= 780; MEDLINE, n=5; ISI Web of Science (Science Citation Index),n=3; Africa Wide Information, n=2; African Index Medicus (AIM),n=3 and AFROLIB Web of Science, n = 9; eLIBRARY.RU, n = 8; After removing duplicates (n = 470), 350 articles were evaluated by title, resulting in eliminating of 210 of them. Abstracts of the remaining articles were analyzed, and 121 papers were excluded. The full text of 19 articles were assessed by two authors: the main author and a second author. This study is anticipated to provide light on the silent public health problem that is air pollution and its connection to metabolic and cardiovascular disorders. Particularly in emerging nations with high levels of hydrocarbon pollution, the findings will be extremely important for shaping public health policies and interventions.

Keywords: Air pollution, Hydrocarbon exposure, cardiovascular disease, metabolic disease, Environmental pollution, Environmental determinants and Epidemiological evidence

INTRODUCTION

Based on concerted studies, ‘Environmental Burden of Disease in European Countries’ project report, has shown that particulate matter air pollution especially those exposed to hydrocarbons pollution, together with other pollutions such as traffic noise pollution, contribute to .75% of the encumbrance of disease attributable to environmental factors.(Heninen *et al* 2014). Due to increasing urbanization, people are more exposed simultaneously to these factors to a higher degree, and this is most likely able to further intensify the disease conditions in future, particularly in developing countries in which Nigeria is one. Presently, 17 megacities in Asia rank among the top 30 cities in terms of premature cardiovascular mortality and account for 7% of the global burden of disease attributable to outdoor air pollution (with specific note on hydrocarbons) alone (Levelevald *et al.*, 2015). Above twenty percent of all cardiovascular disease (CVD) deaths are caused by air pollution, especially those with hydrocarbon contents. More than three million deaths every year, and these figures will continue to rise unless the global community takes bold steps to reduce them. Nine out of ten people worldwide breathe polluted air, which disproportionately affects those living in low-resource settings. Based on this, the World Heart Federation (WHF) is dedicated to reducing the impact of air pollution on people’s health and has made this a priority area of its global advocacy efforts. According to studies carried out in October 2018, World Health Organization (WHO) Director-General Dr Tedros Adhanom Ghebreyesus made headlines in and around the world by asserting that “No one, rich or poor, can escape air pollution, claiming it is a silent public health emergency” (Taylor and Corringthorn 2018). According to a statement, together with the prominence of the first ever WHO Global Conference on Air Pollution and Health that it was published to promote, and render the issue ‘silent’ no more. Overnight, air pollution was propelled to the top of the global public health agenda. For three days, a diverse and high-level group of Member State representatives, major city mayors, non-governmental organizations, and academics presented the latest findings linking air pollution and ill health effects such as cardiovascular diseases as well as metabolic disease (WHO, 2018). While there has been a marked surge of attention in recent years, the health impacts of air pollution have been observed, measured, and to some extent mitigated for centuries, but not much is been said about the environmental determinants of cardiovascular and metabolic diseases among persons exposed to hydrocarbon pollution, especially in developing cities in low and middle income countries such as Nigeria and more specifically Port Harcourt with high hydrocarbon emission from different sources.

Objective:

The objective of this systematic review is to outline the environmental determinants of cardiovascular and metabolic diseases among persons exposed to hydrocarbon pollution, with the view to proffer interventions that can be carried out with minimal cost and personnel implications.

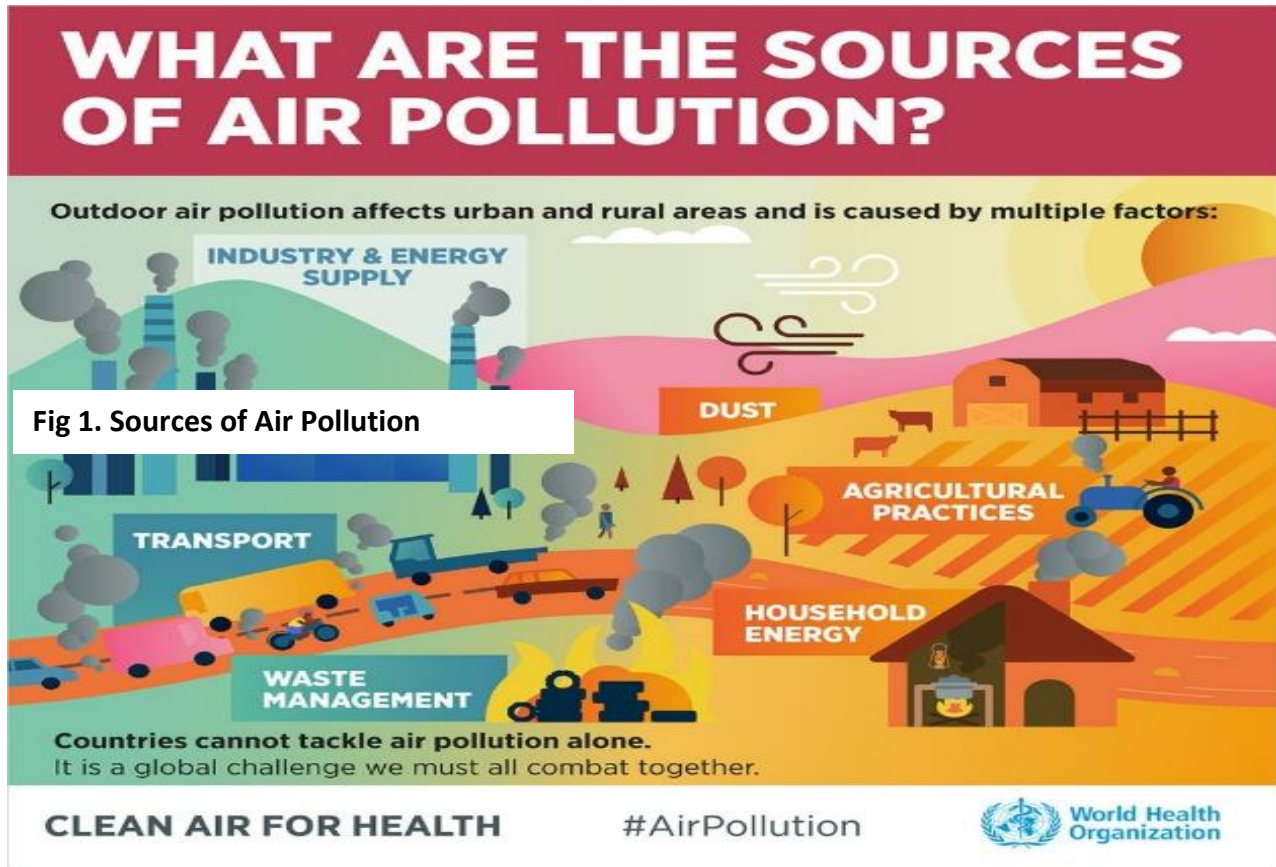


Fig 1. Sources of Air Pollution

MATERIALS AND METHOD

Search Strategy

PRISMA Extension for Scoping Reviews guidelines (Tricco *et al.*, 2018) were applied for selection procedures and presentation of the results. The main Search strategy for this review was the identification and use of electronic searches machines. We searched PubMed, SCOPUS, Google Scholar, MEDLINE, ISI Web of Science (Science Citation Index), Africa Wide Information, African Index Medicus (AIM), and AFROLIB databases for published studies on environmental pollution, and eLirary, as well as determinants of cardiovascular and metabolic diseases among persons exposed to pollution and more specifically hydrocarbon pollution. The search included studies up to January to the 31st 2023. This search was conducted using a predefined comprehensive and sensitive search strategy combining relevant terms with names of countries in Africa and the globe to obtain the maximum possible number of studies.

Record Screening

Duplicates were removed manually. The remaining titles and abstracts were entered into Microsoft Excel as a table for the selection process. Full-text papers were evaluated.

Selection

The publication was considered eligible if it contained information on:

- (i) Environmental pollution.
- (ii) Air pollution
- (iii) Determinants of cardiovascular and metabolic diseases among persons exposed to pollution.
- (iii) General pollution which include hydrocarbons.

Data Extraction

Information on study was extracted by the author into an Excel spreadsheet. The second author cross checked the data extracted from each publication.

RESULTS

Publication selection

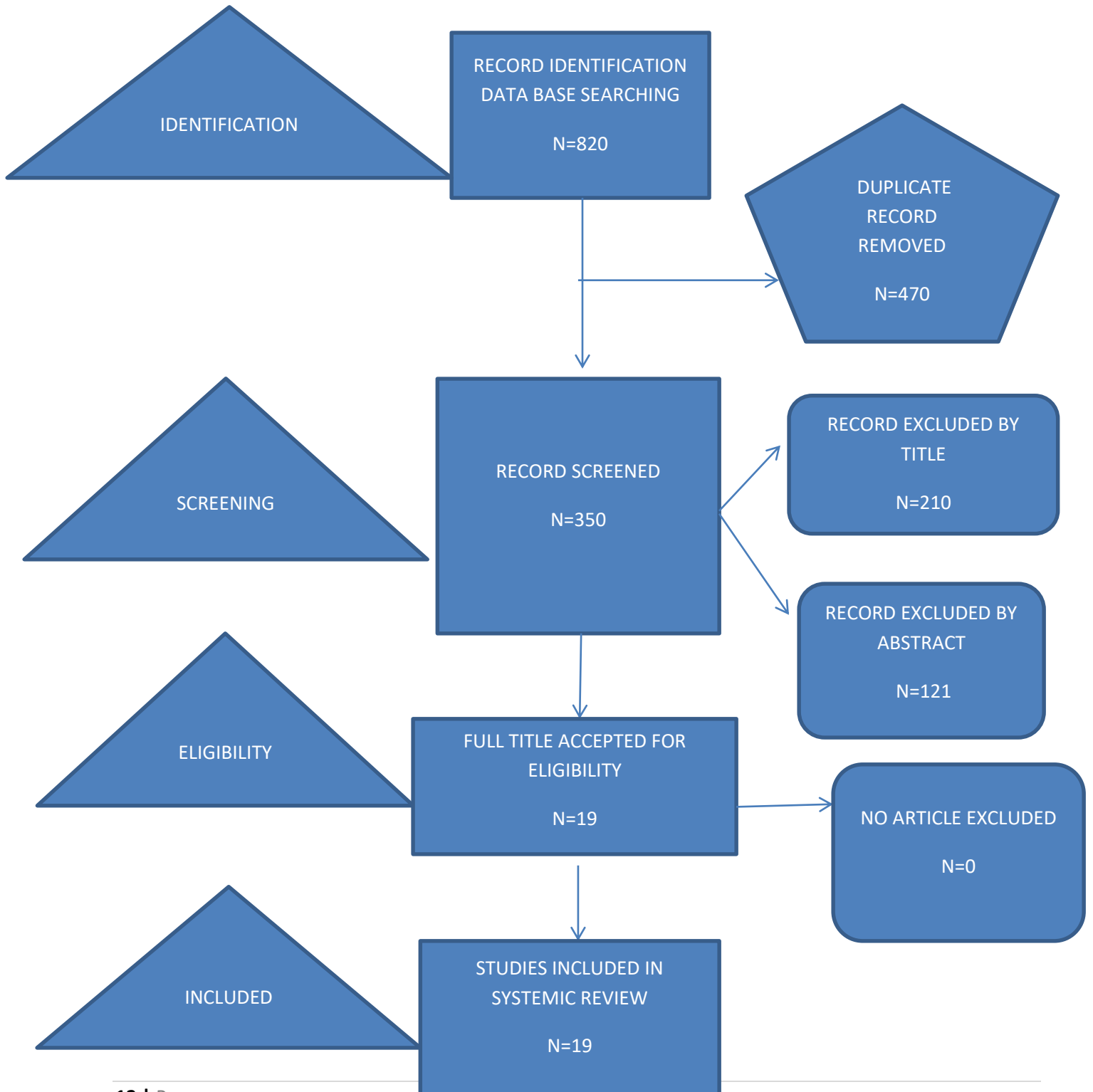
Altogether, 820 publications were identified: PubMed, n = 7; Scopus, n = 3; Google Scholar, n= 780; MEDLINE, n=5; ISI Web of Science (Science Citation Index),n=3; Africa Wide Information, n=2 ;African Index Medicus (AIM),n=3 and AFROLIB Web of Science, n = 9; eLIBRARY.RU, n = 8; After removing duplicates (n = 470), 350 articles were evaluated by title, resulting in eliminating of 210 of them. Abstracts of the remaining articles were analyzed, and 121 papers were excluded. The full text of 19 articles were assessed by two authors the main author and a second author. With no conflicts, and consultations with the last second author (A.M.G). After this assessment, 19 articles were selected for the final qualitative synthesis.



Fig 2. Typical Hydrocarbon Pollution

(Figure 3).

PROTOCOL SUMMARY FOR STUDY SELECTION



Environmental air pollution can be made up of complex mixture of thousands of particulate and gaseous components. Roughly 98% of the pollutant mass is directly characterized by gases or vapour-phase compounds such as CO, non-methane hydrocarbons or volatile organic carbons (VOCs), NO₂, NO, O₃, and SO₂, all of which can have independent and potentially synergistic or antagonistic effects. Particulate matter (PM) is broadly categorized based on its aerodynamic diameter: <10 μm (thoracic particles (PM₁₀)), <2.5 μm (fine particles (PM_{2.5})), <0.1 μm (UFP), and between <2.5 and 10 μm (coarse (PM_{2.5-10})). Prior European, American, and World Health Organization(WHO) air pollution statements have reviewed the size fractions, chemical constituents, and the main gaseous air pollutants and their impact on health.(Brooks *et al.*, 2010;WHO, 2005; Newby *et al.*, 2015).



Fig 2 – An Oil Polluted Environment

Prolonged exposure to environmental air pollution and cardiac arrhythmias

There seems to be an unknown relationship between air pollution and cardiac arrhythmias as researchers are still investigating. Bases on studies on some papers and reports, there seems to be conflicting results depending on the study design, the strength of statistical relationships between the investigated air pollutants, the levels of air pollutants at which a harmful health effect is observed, and definition of outcomes. According to research carried out by , Tsai *et al.*, (2009) a description of a significant positive relationship between a single pollutant model of long-term exposure to nitrogen dioxide, ozone, and particulate matter which also include hydrocarbons, regardless of air temperature and emergency room visits for arrhythmias in inhabitants of a subtropical city in Taiwan. For a two-pollutant model, the results were significant for ozone and nitrogen dioxide. Invetigations on the results of another cohort study, the Danish diet cancer and health study involving 57,053 participants aged 50–64 years also showed a pro-arrhythmic effect of long exposure to nitrogen dioxide and nitrogen oxides and higher risk of atrial fibrillation (Monrad *et al.*, 2017) but this study did not specify hydrocarbons. Some investigators suggested that nitrogen dioxide is a surrogate for P M_{2.5} rather than exerting a causal direct effect on the heart (Billionnet *et al.*, 2012). Other investigators have indicated positive associations between long-term exposure to P M_{2.5} and increased risk of supraventricular

arrhythmias. Another study which included a nationwide cohort study of 432,587 population from the Korean National Health Insurance Service National Sample Cohort also reported a link between prolonged exposure to air pollution and atrial fibrillation. A 10- $\mu\text{g}/\text{m}^3$ increase of $\text{PM}_{2.5}$ was associated with a 17.9% increase in the risk of atrial fibrillation ($p < 0.001$). In these studies effects were more profound in men, obese individuals, participants aged ≥ 60 years, and those with previous cardiovascular issues such as myocardial infarction (Kim *et al.*, 2019). Shin, in a cohort study of 5,071,956 subjects aged 35–85 years conducted in Canada, also established that long-term exposure to $\text{PM}_{2.5}$ was positively associated with the incidence of atrial fibrillation even at very low levels (Shin *et al.*, 2019). On the other hand, Kwon *et al.* (2019) revealed no significant evidence for a connection between environmental air pollution and cardiac arrhythmias in long-term exposure. A recent analysis of a prospective cohort of 4,105 subjects aged 45–76 at baseline, including 52.5% of women, from the Heinz Nixdorf Recall study conducted in Germany revealed that exposure to traffic-specific particulate matter which includes hydrocarbons, had a more potent effect on the risk of stroke than industry-specific $\text{PM}_{2.5}$ during 14 years follow-up (hazard ratio, 2.53; 95% confidence interval, 1.07–5.97 and hazard ratio, 1.27; 95% confidence interval, 1.03–1.56, respectively, per 1 $\mu\text{g}/\text{m}^3$ increase) (Rodins *et al.*, 2020). This study included numerous confounders, which improves its quality.

Heart failure and the Effect of chronic exposure to environmental air pollution,

Researches investigating environmental pollution as it relates cardiovascular disease in their reports/studies showed a positive relationship of prolonged exposure to particulate matter and selected gaseous pollutants with the risk of death or hospitalization from heart failure. This gives a general consensus that the pathomechanisms underlying heart failure worsening associated with exposure to air pollution have not been fully illuminated. Furthermore, studies have also shown that there is a possibility that chemical pollutants irritate the lower airways, consequently enhancing pulmonary vasoconstriction and increasing right ventricular diastolic filling pressures. This on the other hand, can result in pressure surplus, which may be central to the deterioration of heart failure. Apart from this, when selected pollutants enter the bloodstream, they can escalate peripheral vascular resistance and blood pressure, thus leading to increased cardiac afterload, prothrombotic state, and secondary hypoxia. All of these pathomechanisms can contribute to the exacerbation of heart failure. The relationship between long-term exposure to environmental air pollution and heart failure has been confirmed in several, mostly cohort, studies. In a large cohort of 836,557 patients aged 40–89 years and registered in general practices in England, researcher Atkinson *et al.*, (2013) found a positive correlation between air pollutant exposure and incidence of heart failure. After adjusting for confounders, a 3 $\mu\text{g}/\text{m}^3$ increase in coarse particulate matter and a 10.7 $\mu\text{g}/\text{m}^3$ increase in nitrogen dioxide resulted in a hazard ratio for heart failure of 1.06 (95% confidence interval, 1.01–1.11). Of note, the study follow-up was 5 years, and the mean 1 year average concentrations of coarse particulate matter and nitrogen dioxide were 19.7 and 22.5 $\mu\text{g}/\text{m}^3$, respectively (Atkinson *et al.*, 2013). The association between long-term exposure to ultrafine particulate matter and nitrogen dioxide and an increased incidence of heart failure was also reported in another cohort study by Bai *et al.*, (2019a). The authors found that each interquartile range increase in exposure to ultrafine particulate matter, nitrogen dioxide was related to an increased incidence of heart failure (hazard ratio, 1.03; 95% confidence interval, 1.02–1.05 and hazard ratio, 1.04; 95% confidence interval, 1.03–1.06, respectively). Danesh Yazdi *et al.*, (2019), in a large cohort of 11,084,660 subjects from the USA aged 65 years or older, showed that chronic exposure to $\text{PM}_{2.5}$ and ozone led to a higher rate of hospitalizations for exacerbation of pre-existing heart failure.

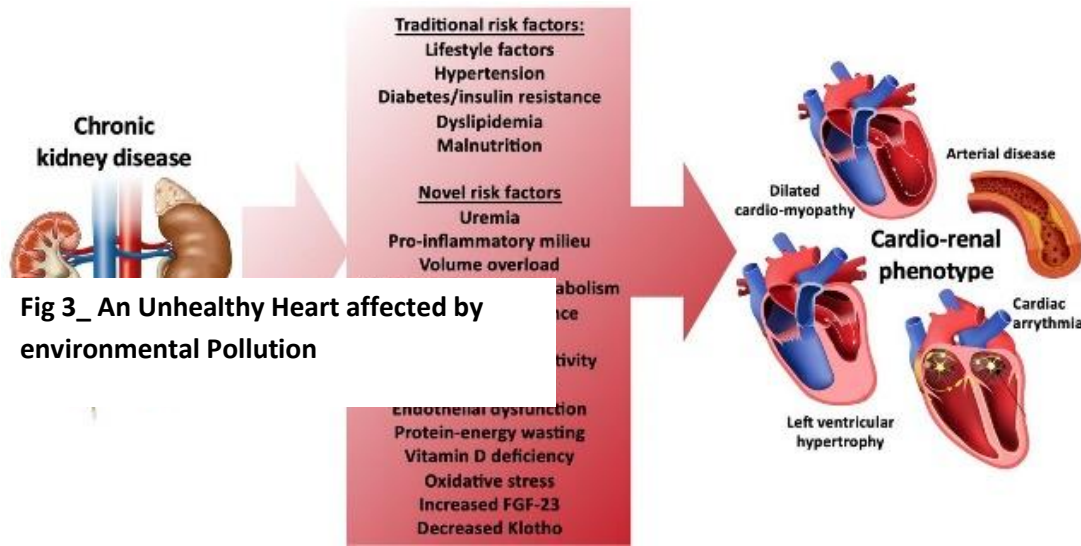


Fig 3_ An Unhealthy Heart affected by environmental Pollution

Associations between chronic environmental air pollution and cardiovascular diseases in the era of COVID-19

The words, Severe acute respiratory syndrome coronavirus 2 (SARS- CoV-2) first appeared in December 2019 in Wuhan, China, before it spread worldwide within 2–3 months, causing the COVID-19 pandemic, the largest pandemic ever recorded since 1918 (Chen *et al.*, 2021; Dutta *et al.*, 2021; Han *et al.*, 2020; Khan *et al.*, 2021; Parczewski and Ciechanowicz 2021; Sławiński and Lewicka 2020). Data from the World Health Organization (WHO) indicate that as of December 27, 2021, nearly 280 million COVID-19 cases and above 5 million COVID-19 deaths have been documented globally (WHO 2021a). There has been reports that both indoor and outdoor air pollution increase the risk of SARS-CoV-2 infection and its cardiovascular complications (Ali and Islam 2020) while this was on the one hand, on the other hand, there seemed to be evidence that preventive measures to reduce the spread of SARS-CoV-2 can be a source of environmental pollution, including air pollution, and have adverse health effects (Akter *et al.*, 2021; Ufnalska and Lichtfouse 2021). The SARS-CoV-2 transmission can either occur via direct, or indirect, or by close contact with infected individuals, through infected secretions including saliva and respiratory secretions or their respiratory droplets (> 5–10 μm in diameter) that are brought out when an infected patient sneezes, coughs, talks, or sings (WHO 2021b). Even though some previous disagreement occurred (WHO 2021b; Chen *et al.*, 2021; Wang Q *et al.*, 2021), airborne transmission has recently been confirmed as a most likely route of COVID-19 transmission. It has also been established that environmental air pollution could play an important role in the airborne transmission of SARS-CoV-2 (Ali *et al.*, 2020). Works by Setti *et al.*, have provided the initial confirmation that SARS-CoV-2 RNA can be present on outdoor particulate matter under some conditions of atmospheric or environmental stability and at elevated coarse particulate matter levels (Setti *et al.*, 2020). In some countries, the presence of SARS- CoV-2 in the air was directly correlated with the presence of high particulate matter concentrations, which resulted in increased mortality (Dutta *et al.*, 2021). Although studies on the association between prolonged exposure to $\text{PM}_{2.5}$ and COVID-19 infections as well as COVID-19-related deaths have been limited and their results was inconsistent, it has been shown that $\text{PM}_{2.5}$ exposure weakens host defenses and, more specifically, alters macrophage function, which accelerates respiratory infection by SARS-CoV-2 (U.S. EPA. 2021).

The impact of environmental air pollution on cardiovascular disease and the role of the global CVD community

World Heart Federation led the January 2021 publication of a Joint Opinion with the American College of Cardiology, American Heart Association, and the European Society of Cardiology: Taking a Stand Against Air Pollution – The Impact on Cardiovascular Disease (Breuer,2021). This initiative was based on the fact that while the impacts of air pollution on respiratory diseases is widely recognized, 50% of the estimated 6.7 million deaths attributable to air pollution in 2019 are due to cardiovascular diseases, and globally more than 20% of cardiovascular disease deaths were attributable to air pollution, with a disproportionate burden borne by low- and middle-income countries (WHO, 2018).



Metabolic effect of environmental air pollution

Just over the last decade most researchers have focused their efforts on finding the links between air pollution and risk factors, with proofs to date indicating a link between exposure and enhancement of risk factors such as hypertension and type 2 diabetes mellitus. Quite a number of panel studies worldwide have also demonstrated a link between ambient levels of PM_{2.5}, black carbon alongside other hydrocarbons, and other traffic-related pollutants with an increase in blood pressure occurring within hours to days, (Brook *et al.*, 2009; Mordukhovich *et al.*, 2009;Baccerelli *et al.*, 2011). Following a large cohort of non-hypertensive individuals, every 10-mg/m³ increase of PM_{2.5} was linked with an odds ratio of 1.13 for the development of hypertension,(Chen *et al.*, 2014). The outcome estimates for hypertension tended to be higher with traffic-related air pollutants such as hydrocarbons, was shown by several studies on the relationship between black carbon/hydrocarbons, as a marker of anthropogenic air pollution, and blood pressure, as well as other measures such as NO₂ after adjusting for noise and concomitant medications (10-mg/m³ increase in NO₂ levels was linked with 1.34 mmHg (95% CI: 0.14, 2.55) higher systolic blood pressure). (Foraster *et al.*, 2014) A Controlled contact studies have confirmed an effect of acute exposure to diesel exhaust and a rapid surge in blood pressure within a few hours, (Cossellman *et al.*, 2012) Comparable, environmental air pollution has been associated with insulin resistance, diabetes, and obesity. Following a meta-analysis of cohort studies involving a total of 2 371 907 participants and 21 095 incident cases of T2DM, the

comparative risk for diabetes surged by 39% per 10mg/m³ of PM_{2.5}.(Wang *et al.*, 2014). In another very recent meta-analysis that involved 13 studies, PM_{2.5} and NO₂ increased risk of diabetes with HR of 1.10 (95% CI: 1.02, 1.18) and 1.08 (95% CI: 1.00, 1.17) per 10 mg/m³ increase in PM_{2.5} and NO₂, respectively,(Eze *et al.*, 2015). Also an increased incidence of insulin resistance and obesity among children, gave a pointer to possible future development of diabetes, has also been shown, but whether diabetes may represent a central mechanism for the increased long-term CV mortality associated with air pollution remains unclear, (Pope *et al.*, 2015)

The social and environmental determinants of cardiometabolic Disease.

Nutrition

Recently, the increase in cardiometabolic disease has been strongly correlated with the rises in obesity. In a study that included subjects in Africa, found that the age-standardized mean body mass index (BMI) increased from 21.9 to 24.9 in women and from 21 to 23 in men, also a positive association was observed between BMI and diabetes prevalence in 1980 and 2014. (NCD RisC, 2017) it has also been recently discovered that most of the BMI increases are predominantly in rural areas. Data has also shown that between 1975 and 2016, there was an increase of between 3% to 11% in the global prevalence of obesity among 100 men while among women the increase was between, (NCD RisC, 2017) this shows different patterns of change through different world regions. This rise in obesity also varies between countries in association with socio-economic status and gender (Jacks *et al.*, 2019) It is noteworthy, that the increase in obesity is not just focused on adults, but has also increased among children and adolescents on a global scale, from below 1% in 1975 to between 6-8% in 2016,(NCD RisC, 2017).

Air pollution

A major key source of metabolic load in most countries is environmental air pollution. This contributes to adult morbidity and mortality through the manifestation of chronic obstructive pulmonary disease (COPD), stroke and ischaemic heart disease, which also manifests in young children as acute lower respiratory infections, (Munnici & Franchini, 2017) thereby undermining metabolic capacity in early life. Already, environmental air pollution is submitted to account for 19% of all cardiovascular deaths and 21% of all stroke deaths worldwide,(Schraufnagel 2019) and 87% of this burden occurs in low and middle income countries (LMICs), concentrated in particular in sub-Saharan Africa (of which Nigeria is found), as well as south and east Asia which are also densely populated,(WHO,2016). Burning biomass for household fuel has long been a key source of air pollution in LMICs, (Bonjour 2013; GDB 2017) and more recently there has been rapid increases in the volume of vehicle traffic in many cities which are an additional burden on human health and in urban areas where road vehicle emissions including hydrocarbons are further concentrated, (Grote *et al.*, 2016; Quadrelli & Peterson 2007; Takeshita 2011; WHO, 2005). Based on reports by the International Energy Agency, transport accounted for one quarter of total global CO₂ emissions in 2016, a level 71% higher than in 1990.86. The highest absolute increase was in road transport, and while the Americas historically had the highest transport emission levels of all regions, and this has continued over recent years, Asia is quickly closing the gap with annual growth rates in emissions five times larger than the Americas(IEA,2023). Importantly, urban planning in LMICs has lagged behind the rapidly rising traffic volumes,(Kenny *et al.*, 2011; Wang *et al.*, 2019), and the typical vehicles in LMICs are more polluting than those in high income countries (HICs),(WHO,2018). it has been increasingly postulated and acknowledged that environmental air pollution damages almost every organ in the body, and is for example linked with dementia ,heart disease, and diabetes

morbidity and mortality,(Schraufnagel *et al.*, 2019) environmental air pollution also shows a dose-response association with ill-health, but beyond that, those already affected by NCDs are also more susceptible to the harmful effects of air pollution, (UNDESA,2010) obviously, exposure to air pollution lies largely outside individuals control and represents a nonspecific toxic environment (UNDESA, 2014).

Urbanization

One of the most important demographic shifts worldwide during the past century is Urbanization. More than half of the world's population today resides in urban areas, representing more than the world's total population in 1960, (UNDESA, 2010). Between 2015 and 2030 to come the world will add 1.1 billion new city dwellers, growing the global urban population by a unit of 28 per cent, from 4.0 billion to 5.1 billion (UNDESA2015; UNDESA2014). Additionally, the majority of projected urban population growth will be in Africa and Asia, followed by the Latin America and the Caribbean region(UNDESA2015; UNDESA2014). Inside cities in LMICs, the majority of individuals simultaneously experience economic, political, housing, and ecological vulnerability(Simone, 2018).Given the large number of individuals residing in urban areas, these vulnerabilities translate into the majority of the population being exposed to an environment that directly impacts their risk of cardiometabolic disease and furthermore, within this environment there is inequitable access to opportunities for healthy eating, active living and unpolluted environments; an inequity that exists both within countries and compared to the same context within HICs. The historical contexts adjoining which cities in LMICs have developed have influenced the vulnerabilities that persist, and continue to influence the nature of urbanisation in LMICs and hence the risk of cardiometabolic disease development. First, the urban centres of many cities in Africa, Asia and Latin America are entrenched in colonial legacies of sociopolitical segregation that manifest today as some form of three-dimensional inequalities that become evident in terms of proximity to aspects of the city that are meant to confer an urban advantage, e.g. infrastructure and amenities, and are therefore closely connected to health inequities(Cook, 1986). Second, accidental and improper growth in LMIC, with cities that are rapidly growing, creates opportunities to live but with little or no opportunities for employment, coupled with high rates of poverty, resulting in an urban form overwhelmingly characterized by conditions of informality, for example, 62% of urban dwellers live in slum conditions in Africa,(UN-Habitat , 2015). Finally, the population pyramids of LMICs focuses on a distortion in urban versus rural populations with an accumulative proportion of adolescents and young people found staying in cities, exposed to environments that are not conducive to health-promoting behavior such as environmental air pollution.

Commercial determinants of health

Cardio metabolic diseases has an etiology that is complex and influenced by different individual, social, environmental and private sector determinants,(Knai et al 2018). The recent amplified risks of developing most of the major cardio metabolic diseases are related with the production, marketing, and consumption of commercially produced products, food and drinks such as those containing sugar, salt and trans-fats, alcohol as well as tobacco.

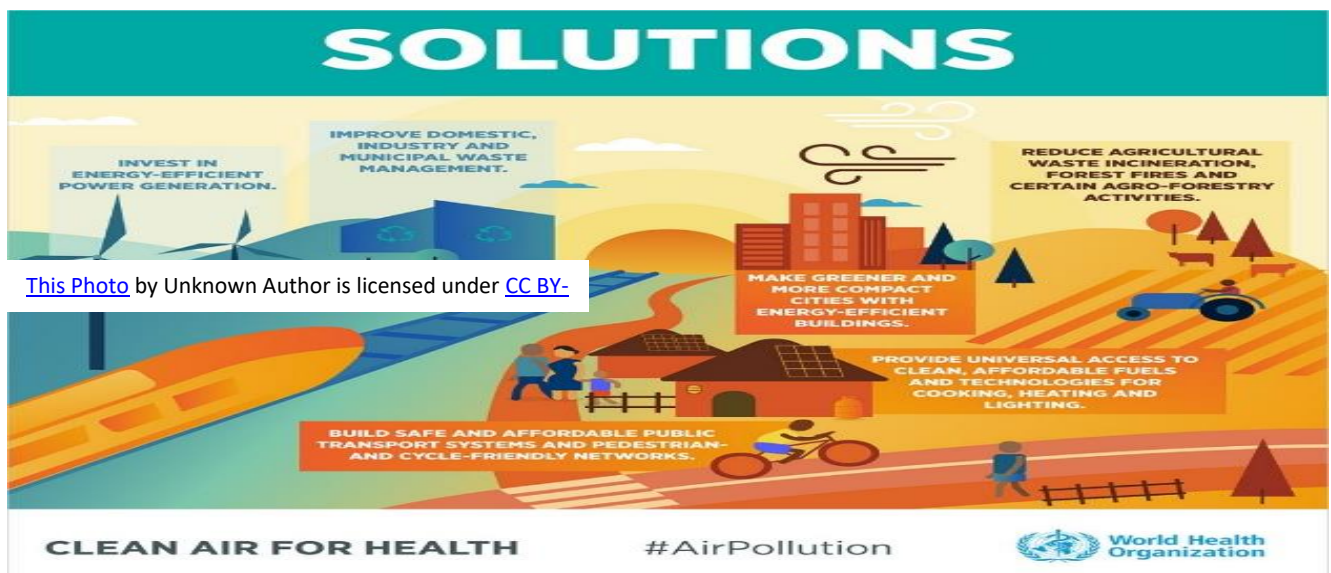
DISCUSSION

The review has found that environmental determinants of cardiometabolic disease among people exposed to air pollution with hydrocarbon contents or pollutants has not been well researched into especially in Africa. Secondly the review has also placed a demand on strategies that can directly

address these conditions especially in low and middle income countries (LMICs) that have high rate or poverty and very few health equipment in heavily populated regions for fast and easy detection. This study has also shown that the more developed a region is the higher the prevalence level of cardiometabolic diseases probably due to intense pollution of the environment. This review has also shown that despite the outlining of beautiful policies that can ameliorate this situation and reduce the pollution levels in many countries, most of the countries especially in sub Saharan Africa do not have key players and partners to effect implementation of these policies. While considering relevant strategies, principal ideas must be placed side by side interventions. Stakeholders, as well as Partners, must come together and accept that environmental air pollution is a major environmental risk factor for cardiovascular and metabolic diseases and should be addressed as appropriate by professionals. There is need for policy brief on environmental air pollution and cardiovascular as well as metabolic diseases, disseminating the WHO capacity-building module on air pollution that will ensure that mitigating the health impacts of air pollution is prominent on the global health, development, environmental, and general political agendas. This can easily be achieved by ensuring visible contributions in high-level international fora, such as UNGA and COP, which has the ability to drive dialogue on air pollution as a public health priority in addition to an environmental one, and highlighting fiscal policies as a powerful solution to reduce air pollution. Therefore, there is a need also for interventions that can be carried out on each disease state, viz: cardiovascular and metabolic interventions

Interventions

One major intervention for hydrocarbon specific pollution is remediation which can take many forms ranging from chemical, bioremediation and mechanical remediation.



Cardiovascular interventions

Major interventions can come in various ways and could involve health education and awareness creation through mass media, mobile phones as well as information, communication and education materials, Van *et al.*, 2016; Daivadanan *et al.* 2018, workshops trainings and lectures, Nishtar *et al.*, 2007; Jafaar *et al.*, 2009; lifestyle changes and counseling Ayakrishnan *et al.*, 2006; Ramachandran *et al.*, 2013; other interventions could include: environmental and structural changes in policies,

infrastructure or institution of restrictions Kelishadi *et al.*, 2011; Azizi *et al.*, 2013; Anthony *et al.*, 2015. The intervention can be delivered by healthcare workers, community health workers, peers and volunteers, local leaders and resource persons, and researchers and experts, Huang *et al.*, 2011.

Metabolic intervention

For the metabolic intervention, it is important to consider that the major aim is to help the heart to be more healthy even in the face of heavy environmental pollution. Heart-healthy eating should be the first intervention which may include the DASH (Dietary Approaches to Stop Hypertension) eating plan. A heart-healthy eating plan includes fruits, vegetables, and whole grains in adequate quantity and limits saturated fats, sodium (salt), added sugars, and alcohol. Secondly, Overweight and obesity can make the heart work harder. If overweight is observed, aiming at losing just 3% to 5% of current weight can help manage some risk factors, such as high blood cholesterol and diabetes, that can raise the risk of heart disease. Regular physical activity can help manage risk factors for heart disease such as high blood cholesterol, high blood pressure, and overweight and obesity. Before starting any exercise program, understanding that there is no one cap fits all, is needful hence a professional should be consulted. Finally management of stress, relaxing and getting enough good quality sleep (about 7-9 hours of sleep) over time can help reduce physical and mental health problems, (<https://www.nhlbi.nih.gov/health>)

CONCLUSION

Persons exposed to hydrocarbon pollution, have the tendencies of death due to cardiometabolic diseases within about five years if not properly managed, the rate and frequency of exposure determines the extent of the disease among the population, but this can be reversed if the necessary actions and interventions are carried out with the appropriate professionals interplay to ensure maximum health outcome. No doubt, early detection stands out as the marker for timely intervention. Disease-specific interventions are the best in the management of people exposed to hydrocarbon pollution. Similarly, Studies offering data on air pollution, environmental pollution, and the risk factors for cardiovascular and metabolic disorders in individuals exposed to pollution—especially hydrocarbons—are included in the selection criteria. The review also examines how environmental air pollution contributes to heart failure and cardiac arrhythmias over an extended period, as well as its significance during the COVID-19 pandemic. The results of this assessment will help groups like the World Heart Federation, which are committed to lessening the negative effects of air pollution on health, in their global lobbying activities. Concerning hydrocarbon pollution in particular, this study is anticipated to provide light on the silent public health problem that is air pollution and its connection to metabolic and cardiovascular disorders. Particularly in emerging nations with high levels of hydrocarbon pollution, the findings will be extremely important for shaping public health policies and interventions.

REFERENCES

- Akter, S., Zakia, M. A., Mofijur, M., Ahmed, S. F., VO, D. N., Khandaker, G., & Mahlia, T. M. I. (2021). SARS-CoV-2 variants and environmental effects of lockdowns, masks and vaccination: A review. *Environmental Chemistry Letters*, 1–12. <https://doi.org/10.1007/s10311-021-01323-7>
- Ali, N., & Islam, F. (2020). The effects of air pollution on COVID-19 infection and mortality: A review on recent evidence. *Frontiers in Public Health*, 8, 580057. <https://doi.org/10.3389/fpubh.2020.580057>

- Anthony, D., Dyson, P. A., Lv, J., Thankappan, K. R., Fernández, M. T., & Matthews, D. R. (2015). Reducing health risk factors in workplaces of low and middle-income countries. *Public Health Nursing, 32*(5), 478–487. <https://doi.org/10.1111/phn.12189>
- Atkinson, R. W., Carey, I. M., Kent, A. J., van Staa, T. P., Anderson, H. R., & Cook, D. G. (2013). Long-term exposure to outdoor air pollution and incidence of cardiovascular diseases. *Epidemiology, 24*, 44–53. <https://doi.org/10.1097/EDE.0b013e318276ccb8>
- Aung, M. N., Yuasa, M., Moolphate, S., Lorga, T., Yokokawa, H., & Fukuda, H. (2019). Effectiveness of a new multi-component smoking cessation service package for patients with hypertension and diabetes in Northern Thailand: A randomized controlled trial (ESCAPE study). *Substance Abuse Treatment, Prevention, and Policy, 14*(1), 10. <https://doi.org/10.1186/s13011-019-0197-2>
- Baccarelli, A., Barreta, F., Dou, C., Zhang, X., McCracken, J. P., Díaz, A., Bertazzi, P. A., Schwartz, J., Wang, S., & Hou, L. (2011). Effects of particulate air pollution on blood pressure in a highly exposed population in Beijing, China: A repeated-measure study. *Environmental Health, 10*, 108.
- Bai, L., Weichenthal, S., Kwong, J. C., Burnett, R. T., Hatzopoulou, M., Jerrett, M., van Donkelaar, A., Martin, R. V., Van Ryswyk, K., Lu, H., Kopp, A., & Chen, H. (2019). Associations of long-term exposure to ultrafine particles and nitrogen dioxide with increased incidence of congestive heart failure and acute myocardial infarction. *American Journal of Epidemiology, 188*, 151–159. <https://doi.org/10.1093/aje/kwy194>
- Baltensperger, U., Geiser, M., El Haddad, I., Jaffrezo, J.-L., & Prévôt, A. S. H. (2020). Sources of particulate-matter air pollution and its oxidative potential in Europe. *Nature, 587*, 414–419.
- Bonjour, S., (2013). Solid fuel use for household cooking: country and regional estimates for 1980-2010. *Environmental Health Perspectives, 121*(7), 784–790.
- Brauer, M., Casadei, B., Harrington, R. A., Kovacs, R., Sliwa, K., & Expert Group the WAP. (2021). Taking a stand against air pollution – The impact on cardiovascular disease: A joint opinion from the World Heart Federation, American College of Cardiology, American Heart Association, and the European Society of Cardiology. *Global Heart, 16*(1), 8. <https://doi.org/10.5334/gh.948>
- Brook, R. D., Rajagopalan, S., Pope, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A., Holguin, F., Hong, Y., Luepker, R. V., Mittleman, M., Peters, A., Siscovich, D., Smith, S. C., Whitsel, L., & Kaufman, J. D. (2010). Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation, 121*, 2331–2378.
- Brook, R. D., Urch, B., Dvonch, J. T., Bard, R. L., Speck, M., Keeler, G., Morishita, M., Kaciroti, N., Harkema, J., Corey, P., Silverman, F., Wellenius, G., Mittleman, M., Rajagopalan, S., & Brook, J. R. (2009). Insights into the mechanisms and mediators of the effects of air pollution exposure on blood pressure and vascular function in healthy humans. *Hypertension, 54*(4), 659–667.
- Chen, B., Jia, P., & Han, J. (2021). Role of indoor aerosols for COVID-19 viral transmission: a review. *Environmental Chemistry Letters, 1–18*. <https://doi.org/10.1007/s10311-020-01174-8>
- Chen, H., Burnett, R. T., Kwong, J. C., Villeneuve, P. J., Goldberg, M. S., Brook, R. D., van Donkelaar, A., Jerrett, M., Martin, R. V., Kopp, A., Brook, J. R., & Copes, R. (2014). Spatial associations between ambient fine particulate matter and incident hypertension. *Circulation, 129*(5), 562–569.

- Cosselman, K. E., Krishnan, R. M., Oron, A. P., Jansen, K., Peretz, A., Sullivan, J. H., Larson, T. V., & Kaufman, J. D. (2012). Blood pressure response to controlled diesel exhaust exposure in human subjects. *Hypertension*, 59(5), 943–948.
- Daellenbach, K. R., Uzu, G., Jiang, J., Cassagnes, L.-E., Leni, Z., Vlachou, A., Stefenelli, G., Canonaco, F., Weber, S., Segers, A., Kuenen, J. J. P., Schaap, M., Favez, O., Albinet, A., Aksoyoglu, S., & Dommen, J. (2021). Characterizing particulate matter from various emission sources: insights from a multi-site study. *Environmental Science & Technology*, 55(5), 3021–3030.
- Daivadanam, M., Wahlström, R., Ravindran, T. S., Sarma, P. S., Sivasankaran, S., & Thankappan, K. (2018). Changing household dietary behaviours through community-based networks: A pragmatic cluster randomized controlled trial in rural Kerala, India. *PLoS One*, 13(8), e0201877. <https://doi.org/10.1371/journal.pone.0201877>
- Danesh Yazdi, M., Wang, Y., Di, Q., Zanobetti, A., & Schwartz, J. (2019). Long-term exposure to PM2.5 and ozone and hospital admissions of Medicare participants in the Southeast USA. *Environmental International*, 130, 104879. <https://doi.org/10.1016/j.envint.2019.05.073>
- Dutta, D., Arya, S., Kumar, S., & Lichtfouse, E. (2021). Electronic waste pollution and the COVID-19 pandemic. *Environmental Chemistry Letters*, 1–4. <https://doi.org/10.1007/s10311-021-01286-9>
- Eze, I. C., Hemkens, L. G., Bucher, H. C., Hoffmann, B., Schindler, C., Kunzli, N., Schikowski, T., & Probst-Hensch, N. M. (2015). Association between ambient air pollution and diabetes mellitus in Europe and North America: Systematic review and meta-analysis. *Environmental Health Perspectives*, 123(4), 381–389.
- Foraster, M., Basagaña, X., Aguilera, I., Rivera, M., Agis, D., Bouso, L., Deltell, A., Marrugat, J., Ramos, R., Sunyer, J., Vila, J., Elosua, R., & Kunzli, N. (2014). Association of long-term exposure to traffic-related air pollution with blood pressure and hypertension in an adult population-based cohort in Spain (the REGICOR study). *Environmental Health Perspectives*, 122(4), 404–411.
- GBD 2017 Risk Factor Collaborators. (2018). Global, regional, and national comparative risk assessment of 84 behavioral, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, 392(10159), 1923–1994.
- Grote, M., Williams, I., Preston, J., & Kemp, S. (2016). Including congestion effects in urban road traffic CO2 emissions modelling: Do Local Government Authorities have the right options? *Transportation Research Part D: Transport and Environment*, 43, 95–106.
- Han, J., Zhang, X., He, S., & Jia, P. (2020). Can the coronavirus disease be transmitted from food? A review of evidence, risks, policies, and knowledge gaps. *Environmental Chemistry Letters*, 2020, 1–12. <https://doi.org/10.1007/s10311-020-01101-x>
- Hanninen, O., Knol, A. B., Jantunen, M., Lim, T. A., Conrad, A., Rappolder, M., Carrer, P., Fanetti, A. C., Kim, R., Buekers, J., Torfs, R., Iavarone, I., Classen, T., Hornberg, C., & Meekel, O. C. (2014). Environmental burden of disease in Europe: Assessing nine risk factors in six countries. *Environmental Health Perspectives*, 122, 439–446.

Huang, S., Hu, X., Chen, H., Xie, D., Gan, X., & Wu, Y. (2011). The positive effect of an intervention program on the hypertension knowledge and lifestyles of rural residents over the age of 35 years in an area of China. *Hypertension Research*, 34(4), 503–508. <https://doi.org/10.1038/hr.2010.265>

International Energy Agency. (2023). CO2 emissions. Retrieved from <https://www.iea.org/statistics/co2emissions/>

Jaacks, L. M., et al. (2011). The obesity transition: Stages of the global epidemic. *The Lancet*.

Jafar, T. H., Hatcher, J., Poulter, N., Islam, M., Hashmi, S., & Qadri, Z. (2009). Community-based interventions to promote blood pressure control in a developing country. *Annals of Internal Medicine*, 151(9), 593–601. <https://doi.org/10.7326/0003-4819-151-9-200911030-00004>

Jayakrishnan, R., Uutela, A., Mathew, A., Auvinen, A., Mathew, P. S., & Sebastian, P. (2013). Smoking cessation intervention in rural Kerala, India: Findings of a randomized controlled trial. *Asian Pacific Journal of Cancer Prevention*, 14(11), 6797–6802. <https://doi.org/10.7314/apjcp.2013.14.11.6797>

Kelishadi, R., Sarrafzadegan, N., Sadri, G. H., Pashmi, R., Mohammadifard, N., & Tavasoli, A. A. (2011). Short-term results of a community-based program on promoting a healthy lifestyle for the prevention and control of chronic diseases in a developing country setting. *Asia-Pacific Journal of Public Health*, 23(4), 518–533. <https://doi.org/10.1177/1010539509348241>

Khan, A. H., Tirth, V., Fawzy, M., Mahmoud, A. E. D., Khan, N. A., Ahmed, S., Ali, S. S., Akram, M., Hameed, L., Islam, S., Das, G., Roy, S., & Dehghani, M. H. (2021). COVID-19 transmission, vulnerability, persistence, and nanotherapy: A review. *Environmental Chemistry Letters*, 2021, 1–15. <https://doi.org/10.1007/s10311-021-01229-4>

Kim, I. S., Yang, P. S., Lee, J., Yu, H. T., Kim, T. H., Uhm, J. S., Pak, H. N., Lee, M. H., Joung, B. (2019). Long-term exposure of fine particulate matter air pollution and incident atrial fibrillation in the general population: A nationwide cohort study. *International Journal of Cardiology*, 283, 178–183. <https://doi.org/10.1016/j.ijcard.2018.12.048>

Kinney, P. L., et al. (2011). Traffic impacts on PM(2.5) air quality in Nairobi, Kenya. *Environmental Science & Policy*, 14, 369–378.

Knai, C., et al. (2018). Systems thinking as a framework for analyzing commercial determinants of health. *The Milbank Quarterly*, 96(4), 472–498.

Kwon, O. K., Kim, S. H., Kang, S. H., Cho, Y., Oh, I. Y., Yoon, C. H., Kim, S. Y., Kim, O. J., Choi, E. K., Youn, T. J., Chae, I. H. (2019). Association of short- and long-term exposure to air pollution with atrial fibrillation. *European Journal of Preventive Cardiology*, 26, 1208–1216. <https://doi.org/10.1177/2047487319835984>

Lakey, P. S., Berkemeier, T., Tong, H., Arangio, A. M., Lucas, K., Poschl, U., & Shiraiwa, M. (2016). Chemical exposure-response relationship between air pollutants and reactive oxygen species in the human respiratory tract. *Scientific Reports*, 6, 32916.

Lelieveld, J., & Poschl, U. (2017). Chemists can help to solve the air-pollution health crisis. *Nature*, 551, 291–293.

- Lelieveld, J., Evans, J. S., Fnais, M., Giannadaki, D., & Pozzer, A. (2015). The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature*, 525, 367–371.
- Lv, J., Liu, Q.-M., Ren, Y.-J., He, P.-P., Wang, S.-F., & Gao, F. (2014). A community-based multilevel intervention for smoking, physical activity, and diet: Short-term findings from the Community Interventions for Health Programme in Hangzhou, China. *Journal of Epidemiology & Community Health*, 68(4), 333–339. <https://doi.org/10.1136/jech-2013-203356>
- Mannucci, P. M., & Franchini, M. (2017). Health effects of ambient air pollution in developing countries. *International Journal of Environmental Research and Public Health*, 14.
- Monrad, M., Sajadieh, A., Christensen, J. S., Ketzel, M., Raaschou-Nielsen, O., Tjønneland, A., Overvad, K., Loft, S., & Sorensen, M. (2017). Long-term exposure to traffic-related air pollution and risk of incident atrial fibrillation: A cohort study. *Environmental Health Perspectives*, 125(4), 422–427. <https://doi.org/10.1289/EHP392>
- Mordukhovich, I., Wilker, E., Suh, H., Wright, R., Sparrow, D., Vokonas, P. S., & Schwartz, J. (2009). Black carbon exposure, oxidative stress genes, and blood pressure in a repeated-measures study. *Environmental Health Perspectives*, 117, 1767–1772.
- NCD Risk Factor Collaboration (NCD-RisC) – Africa Working Group. (2017). Trends in obesity and diabetes across Africa from 1980 to 2014: An analysis of pooled population-based studies. *International Journal of Epidemiology*. <https://doi.org/10.1093/ije/dyx078>
- NCD Risk Factor Collaboration (NCD-RisC). (2017). worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *The Lancet*, 390, 2627–2642.
- NCD Risk Factor Collaboration (NCD-RisC). (2019). Rising rural body-mass index is the main driver of the global obesity epidemic in adults. *Nature*, 569, 260–264.
- Newby, D. E., Mannucci, P. M., Tell, G. S., Baccarelli, A. A., Brook, R. D., Donaldson, K., Forastiere, F., Franchini, M., Franco, O. H., Graham, I., Hoek, G., Hoffmann, B., Hoylaerts, M. F., Kunzli, N., Mills, N., Pekkanen, J., Peters, A., Piepoli, M. F., Rajagopalan, S., ... Storey, R. F. (2015). Expert position paper on air pollution and cardiovascular disease. *European Heart Journal*, 36(2), 83–93.
- Nishtar, S., Badar, A., Kamal, M. U., Iqbal, A., Bajwa, R., & Shah, T. (2007). The Heartfile Lodhran CVD Prevention Project: End of project evaluation. *Promotion & Education*, 14(1), 17–27. <https://doi.org/10.1177/175797590701400103>
- Pan American Health Organization/World Health Organization. (2018). Ambient and household air pollution and health: Frequently asked questions. Retrieved from https://www.paho.org/hq/index.php?option=com_content&view=article&id=14454
- Parczewski, M., & Ciechanowicz, A. (2020). Molecular epidemiology of SARS-CoV-2: A review of current data on genetic variability of the virus. *Polish Archives of Internal Medicine*, 131(1), 63–69. <https://doi.org/10.20452/pamw.15550>

- Patz, J. A., Campbell-Lendrum, D., Holloway, T., & Foley, J. A. (2005). Impact of regional climate change on human health. *Nature*, 438, 310–317.
- Pope, C. A. III, Turner, M. C., Burnett, R. T., Jerrett, M., Gapstur, S. M., Diver, W. R., Krewski, D., & Brook, R. D. (2015). Relationships between fine particulate air pollution, cardiometabolic disorders, and cardiovascular mortality. *Circulation Research*, 116(1), 108–115.
- Poschl, U., & Shiraiwa, M. (2015). Multiphase chemistry at the atmosphere-biosphere interface influencing climate and public health in the Anthropocene. *Chemical Reviews*, 115(10), 4440–4475.
- Quadrelli, R., & Peterson, S. (2007). The energy–climate challenge: Recent trends in CO₂ emissions from fuel combustion. *Energy Policy*, 35(11), 5938–5952. <https://doi.org/10.1016/j.enpol.2007.07.008>
- Rajagopalan, S., Al-Kindi, S. G., & Brook, R. D. (2018). Air pollution and cardiovascular disease: JACC state-of-the-art review. *Journal of the American College of Cardiology*, 72(17), 2054–2070.
- Ramachandran, A., Snehalatha, C., Mary, S., Mukesh, B., Bhaskar, A. D., & Vijay, V. (2006). The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia*, 49(2), 289–297. <https://doi.org/10.1007/s00125-005-0097-5>
- Ramachandran, A., Snehalatha, C., Ram, J., Selvam, S., Simon, M., & Nanditha, A. (2013). Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: A prospective, parallel-group, randomised controlled trial. *Lancet Diabetes & Endocrinology*, 1(3), 191–198. [https://doi.org/10.1016/S2213-8587\(13\)70067-6](https://doi.org/10.1016/S2213-8587(13)70067-6)
- Rodins, V., Lucht, S., Ohlwein, S., Hennig, F., Soppa, V., Erbel, R., Jöckel, K. H., Weimar, C., Hermann, D. M., Schramm, S., Moebus, S., Slomiany, U., & Hoffmann, B. (2020). Long-term exposure to ambient source-specific particulate matter and its components and incidence of cardiovascular events – The Heinz Nixdorf recall study. *Environmental International*, 142, 105854. <https://doi.org/10.1016/j.envint.2020.105854>
- Setti, L., Passarini, F., De Gennaro, G., Barbieri, P., Perrone, M. G., Borelli, M., Palmisani, J., Di Gilio, A., Torboli, V., Fontana, F., Clemente, L., Pallavicini, A., Ruscio, M., Piscitelli, P., & Miani, A. (2020). SARS-CoV-2 RNA found on particulate matter of Bergamo in Northern Italy: First evidence. *Environmental Research*, 188, 109754. <https://doi.org/10.1016/j.envres.2020.109754>
- Shin, S., Burnett, R. T., Kwong, J. C., Hystad, P., van Donkelaar, A., Brook, J. R., Goldberg, M. S., Tu, K., Copes, R., Martin, R. V., Liu, Y., Kopp, A., & Chen, H. (2019). Ambient air pollution and the risk of atrial fibrillation and stroke: A population-based cohort study. *Environmental Health Perspectives*, 127(8), 87009. <https://doi.org/10.1289/EHP4883>
- Shonkoff, S. B., Krewski, D., Pope, C. A. III, Thun, M. J., & Thurston, G. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: Health implications of short-lived greenhouse pollutants. *Lancet*, 374(9707), 2091–2103. [https://doi.org/10.1016/S0140-6736\(09\)61742-1](https://doi.org/10.1016/S0140-6736(09)61742-1)
- Simone, A., & Pieterse, E. (2018). *New urban worlds: Inhabiting dissonant times*. John Wiley & Sons.
- Slawiński, G., & Lewicka, E. (2020). What should a cardiologist know about coronavirus disease 2019? *Kardiologia Polska*, 78(4), 278–283. <https://doi.org/10.33963/KP.15302>

Smith, K. R., Jerrett, M., Anderson, H. R., Burnett, R. T., Stone, V., Derwent, R., Atkinson, R. W., Cohen, A., Schraufnagel, D. E., et al. (2019). Air pollution and noncommunicable diseases: A review by the Forum of International Respiratory Societies' Environmental Committee, Part 1: The damaging effects of air pollution. *Chest*, 155(2), 409–416.

Takeshita, T. (2011). Global scenarios of air pollutant emissions from road transport through to 2050. *International Journal of Environmental Research and Public Health*, 8(8), 3032–3062. <https://doi.org/10.3390/ijerph8083032>

Taylor, D., & Carrington, M. (2018, October 27). Air pollution is the new tobacco, warns WHO head. *The Guardian*. <https://www.theguardian.com/environment/2018/oct/27/air-pollution-is-the-new-tobacco-warns-who-head>

The International Union Against Tuberculosis and Lung Disease (The Union). (2018, November 5). WHO global conference on air pollution and health. The Union. <https://theunion.org/news/who-global-conference-on-air-pollution-and-health>

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., et al. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*, 169(7), 467–473. <https://doi.org/10.7326/M18-0850>

Tsai, S. S., Chiu, H. F., Wu, T. N., & Yang, C. Y. (2009). Air pollution and emergency room visits for cardiac arrhythmia in a subtropical city: Taipei. *Inhalation Toxicology*, 21(13), 1113–1118. <https://doi.org/10.3109/08958370902758939>

Ufnalska, S., & Lichtfouse, E. (2021). Unanswered issues related to the COVID-19 pandemic. *Environmental Chemistry Letters*, 19(1), 1–2. <https://doi.org/10.1007/s10311-021-01249-0>

UN-Habitat. (2015). *The State of African Cities 2014: Re-Imagining Sustainable Urban Transitions*. UN-Habitat.

United Nations, Department of Economic and Social Affairs, Population Division. (2010). *World Urbanization Prospects: The 2009 Revision*. United Nations.

United Nations, Department of Economic and Social Affairs, Population Division. (2014). *World Urbanization Prospects: The 2014 Revision*. United Nations.

United Nations, Department of Economic and Social Affairs, Population Division. (2015). *Population 2030: Demographic challenges and opportunities for sustainable development planning*. United Nations.

Van de Vijver, S., Oti, S. O., Gomez, G. B., Agyemang, C., Egondi, T., & van Charante, E. M. (2016). Impact evaluation of a community-based intervention for prevention of cardiovascular diseases in the slums of Nairobi: The SCALE-UP study. *Global Health Action*, 9(1), 30922. <https://doi.org/10.3402/gha.v9.30922>

Vearey, J., Luginaah, I., Magitta, N. F., Shilla, D. J., & Oni, T. (2019). Urban health in Africa: A critical global public health priority. *BMC Public Health*, 19, 340. <https://doi.org/10.1186/s12889-019-6640-9>

Wang, B., Xu, D., Jing, Z., Liu, D., Yan, S., & Wang, Y. (2014). Effect of long-term exposure to air pollution on type 2 diabetes mellitus risk: A systematic review and meta-analysis of cohort studies. *European Journal of Endocrinology*, 171, R173–R182. <https://doi.org/10.1530/EJE-14-0387>

Wang, J., et al. (2019). Vehicle emission and atmospheric pollution in China: Problems, progress, and prospects. *PeerJ*, 7, e6932. <https://doi.org/10.7717/peerj.6932>

Wang, Q., Han, J., Chang, H., Wang, C., & Lichtfouse, E. (2021). Society organization, not pathogenic viruses, is the fundamental cause of pandemics. *Environmental Chemistry Letters*, 2021, 1–7. <https://doi.org/10.1007/s10311-021-01346-0>

World Bank. (2023). *World Bank Open Data*. Retrieved March 2, 2023, from <https://data.worldbank.org/>

World Health Organization. (2005). *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: Summary of risk assessment*. Retrieved from http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf

World Health Organization. (2005). Health effects of transport-related air pollution. World Health Organization, Regional Office for Europe.

World Health Organization. (2016). Ambient air pollution: A global assessment of exposure and burden of disease. World Health Organization.

World Health Organization. (2018, May 2). Ambient (outdoor) air pollution. Retrieved from [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

World Health Organization. (2020). *Air pollution*. Retrieved from <http://who.int/health-topics/air-pollution>

World Health Organization. (2021a). *Transmission of SARS-CoV-2: Implications for infection prevention precautions*. Retrieved December 28, 2021, from <https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions>