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SCOPING REVIEW **OPEN ACCESS**

Public Health Impact of Waste-Related Air Pollution in Africa: Scoping Review

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Abstract:

Background: In the reforming world, with the expeditious development of urbanisation and industrialisation; environmental issues have become a global crisis that requires immediate interventions and has posed a major threat to the health of the population. Air pollution is identified as one of the major environmental health hazards. However, there is a dearth of comprehensive data on the public health impact of waste-related air pollution in Africa. Thus, this scoping review seeks to explore and describe the effects of waste-related air pollution on public health in Africa.

Methods: We followed the 2018 PRISMA Scoping Review Guidelines for reporting this review. We browsed literature from 2014 to 2024 using keywords such as “Air pollution”, “Health impact” and “Africa”. From the yielded potential literature, only 23 studies were eligible for the review.

Results: The review revealed four themes. Among the themes are sources of pollution, pollutants of air pollution, understanding the health impact of air pollution among the vulnerable population, and factors impeding the mitigation of air pollution.

Conclusion: The review revealed the sources and the health effects of air pollution. It underscored the role that socio-economic injustices, corruptions, and political issues have in exacerbating air pollution, particularly in rural areas. Therefore, this study recommends the development and implementation of innovative improvement strategies to remediate air pollution in remote areas of Africa.

Keywords: Air pollution, Public health, Impact, Waste-related, Africa, Scoping review, PRISMA.

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1. INTRODUCTION

In the reforming world, with the expeditious development of urbanisation and industrialisation; environmental issues have become a global crisis that requires immediate interventions and has posed a major threat to the health of the population. The pollutions are solid waste, water and air-related pollution. Waste-related air pollution is identi-fied as the most crucial environ-mental factor contributing to the largest negative health impact, both psychological and physiological [1, 2]. Although strategies and inter-ventions have been proposed and implemented to purify ambient air, such as the introduction of cleaner tech-nology and fuels and the use of greener urban greener, waste-related air pollution remains the second largest environmental factor that contributes to health comor-bidities and deaths [3]. These air pollutants originate from both households and

manufacturing industries. With 8.3 million deaths worldwide reported per year, 89% of those deaths occurred in low and middle-income countries, with South Asia and the western Pacific region containing the highest number of deaths. While air quality has steadily improved in high-income countries, it continues to deteriorate in low- and middle-income countries [4, 5].

In Africa alone in 2019, waste-related air pollution was associated with approximately 1.1 million mortalities. Household air pollution accounted for approximately 63% of mortality, and ambient air pollution for approximately 37% [6]. Africa is known for its mineral richness. It produces minerals such as gold, diamond, copper, bauxite, iron ore, platinum, cobalt, and others. The latest mineral production rate was approximately 912 million tons. The impact of mineral mining on air quality is a significant concern, as it contributes to ambient air pollution and adversely affects surrounding communities [7-9]. While it is important to highlight the richness of the African continent and the innovations aimed at mitigating waste-related air pollution, the socio-economic disparities among its populations present significant challenges to the successful implementation of these interventions. For these reasons, many populations cannot afford cleaner technological interventions and must instead rely on more accessible, simpler methods [10]. According to the World Health Organization, approximately 2.4 billion people rely on open fires or basic stoves fueled by polluting agents, which significantly impact air quality [11]. These people are then frequently exposed to dangerous levels of air pollution that consequently impact their health. This makes it difficult to achieve the Sustainable Development Goals (SDGs) 7 and 3, achieving synergy between climate change and health through ensuring access to affordable, reliable, sustainable and modern energy for all, and achieving good health and well-being for all ages [11]. The burden of non-communicable diseases secondary to air pollution has grown exponentially. This comprises a range of diseases affecting the respiratory, cardiovascular, neurological and other organ systems [5]. Current evidence indicates that air pollution triggers acute exacerbations of chronic obstructive pulmonary disease (COPD) and asthma and contributes to increased respiratory morbidity and mortality. Several scholars alluded that exposure to air pollution progresses one from being a healthy individual to being sick. A study conducted in the United Kingdom indicated that 5.2% of 265 506 individuals exposed to air pollution progressed from being healthy to developing at least one chronic lung disease. Additionally, 0.4% developed lung multimorbidity and 4.8% died from the exposure [12, 13]. In addition to respiratory disease development, other studies have shown that long-term exposure to air pollution is strongly associated with a higher risk of mental disorders, including schizophrenia, depression and anxiety [14].

Nonetheless, South Africa is one of the leading mineral-producing countries in Africa, known especially for its large-scale production of gold, iron, coal, and other minerals [15]. It is clear from the evidence that there is a limited existing body of evidence exploring the impact of air pollution on public health in Africa. Therefore, this study delves into dissembling the question *"What are the public health impacts of waste-related air pollution in Africa?"* with the sole purpose of exploring and describing the effects of waste-related air pollution on public health in Africa.

2. METHODOLOGY

We adhered to the 2018 PRISMA guidelines for Scoping Reviews (PRISMA-ScR) [16]. To facilitate knowledge synthesis through the identification of important research concepts, gaps, and evidence to support research in health practice and policymaking, a scoping review methodology was selected for this study [17-19]. Furthermore, scoping reviews employ rigorous techniques to find and evaluate pertinent research [20]. One benefit of scoping reviews is that they incorporate material that is methodologically diverse and heterogeneous. The following five stages were followed: identifying the research question, identifying relevant studies, study selection, charting the data, and collating, summarizing, and reporting the results.

2.1. Identifying the Research Question

Globally, there is literature on the impact of air pollution on public health. However, few studies have been conducted in South Africa, especially looking at our socio-economic and health challenges. The main review question was, "What are the public health impacts of waste-related air pollution in Africa?

2.2. Identifying Relevant Literature and Study Selection

The literature search was conducted between May 2024 to July 2024. Our search method was created to locate all publications on the impact of air pollution on public health in Africa. Databases such as PubMed, Scopus, and Google Scholar were searched using keywords like "waste management," "air pollution," "public health," and "Africa." The search method adopted ensures a comprehensive search of the studies. The search was broadened by the use of combinations of the concepts mentioned above, along with Boolean operators and quotation marks, to narrow the search to the phenomenon of inquiry. The literature search was further widened by the use of synonyms. More research was identified by means of manual searching of literature. The literature search was limited between the studies from 2000 to 2024. The eligibility criteria are detailed in Table **1** using the elements of Population, Intervention, Context and Outcomes (PICO).

2.3. Data Extraction and Analysis

The literature search yielded a total of 950 studies and 5 Gray literature. Following the abstract screening of the yielded literature, studies not relevant to the phenomenon of inquiry and duplicates were removed. Moreover, studies written in native languages were not part of the review; only English-written studies and those accessible formed

part of the study. Following the full-text review of the studies, only 23 publications were included in this review. The identification process is depicted in Fig. (**1**). The research team designed a data extraction form, which entailed the author's name, date of publication, research design, and key outcomes of the study. Using the designed data extraction form, the research team independently extracted data from the eligible studies. Thereafter, the extracted data were compared for similarities. Upon reaching a consensus on the data extracted, the data with similar meanings were then grouped together to create themes and subthemes of the study.

Table 1. Eligibility criteria.

Element	Inclusion Criteria	Exclusion Criteria
Population (P)	• These include the general population, including vulnerable groups (Children, elderly and pregnant women)	• Studies not specifically focused on the human health effects of waste air pollution.
Intervention (I)	• Studies on exposure to air waste air pollution among the general pollution • Only primary data and secondary studies (Reviews, qualitative and quantitative studies)	• Studies not focused on exposure to waste air pollution • Study protocols, editorials and comments were not part of the study
Context (C)	• Studies conducted in Africa • Studies published between 2014-2024 • English written studies • Full-text studies that were accessible on the databases	• Studies conducted outside Africa • Studies published before 2014 • Non-English studies, written in native languages • Full-text studies that were not accessible
Outcomes (O)	• Public health impacts (These include respiratory diseases, healthcare burden, and health effects)	• Studies not public health impacts

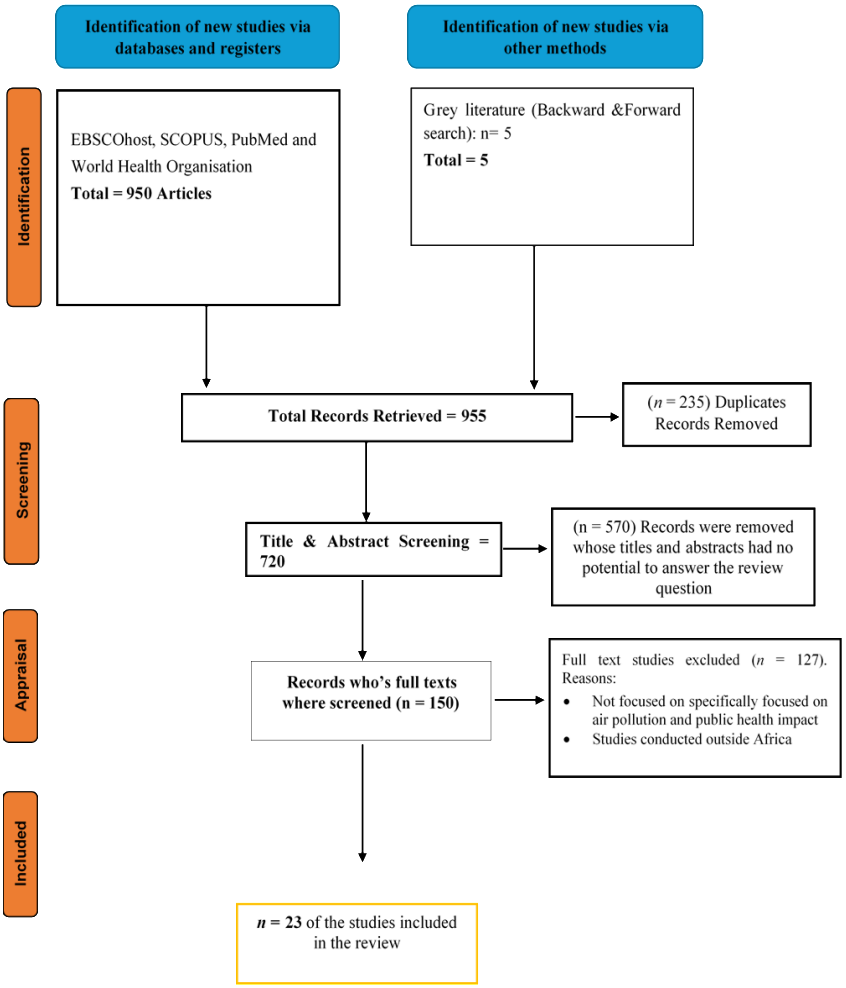

Fig. (1). Flowchart of study selection.

3. RESULTS

The review included 23 studies meeting the inclusion criteria. The key findings are categorized into sources of pollution, pollutants of pollution, health impacts among vulnerable populations, factors impending mitigation of air pollution and mitigation measures. Mainstream of the studies were quantitative in nature with an interest in measuring the impact of air pollution on human health, and the rest were reviews (*i.e.*, systematic, narrative, *etc.*). None of the studies reviewed were qualitative. Table **2** shows the data extracted from the studies.

Table 2. Data extraction processes.

Authors Name/Refs	Publication's Date	Research Design	Key Outcomes
Fisher *et al.* [6]	2021	Quantitative	Exposure to air pollution among children of less than 10 years impacts their cognitive functions and decreases their intelligence quotients.
Kadir *et al.* [21]	2010	Quantitative, cross-sectional	Populations use solid fuels as a key source of energy in their households.
Santos [22]	2024	Narrative review	In South Africa, as a result of a lack of resources, they rely on burning solid waste in their backyard. Among the lack of accessibility to optimal healthcare in isolated rural areas and poor sanitation in the health facilities.
Shirinde *et al.* [23]	2014	Quantitative, cross-sectional	Common sources of air pollution include dusty roads, trucks passing near homes and environmental tobacco.
Abera *et al.* [24]	2020	Review	Poor waste management and diesel powder vehicles contribute to air pollution. Socio-economic factors and political instability exacerbate the air pollution.
Airquoon [25]	2024	Perspective	19 African countries lack air quality monitoring systems.
Katoto *et al.* [26]	2019	Systematic review	Generally, the air pollutants in Sub-Saharan Africa are 10 or 20 times higher than the WHO standards. Worsened by rapid urbanization.
Thabethe *et al.* [27]	2021	Quantitative, epidemiological study design	Some South African cities exceed the WHO set limit for air pollutants; however remain within the South African air quality standards. Air pollution is associated with respiratory diseases. Reports more mortalities in winter than in warm weather.
Millar *et al.* [28]	2022	Quantitative, cross-sectional	Respiratory diseases such as cough, wheeze, and doctor diagnosed hay fever are associated with air pollutants among adolescents. Most of the exposure time has an impact.
Bagula *et al.* [29]	2021	Quantitative, cross-sectional	The study reported that air pollutants like $PM_{2.5,}$ even at their lowest levels, can cause chest pains among adults.
Johnson [30]	2024	Report	Estimates of cancer to multiply in Africa due to air pollution and elderly vulnerability. The estimate mortality was that of 2.8 million by 2050.
Wichmann *et al.* [31]	2012	Quantitative, case-crossover design	Air pollution is associated with cerebrovascular, cardiovascular and respiratory disease mortalities.
Coker *et al.* [32]	2018	Narrative review	Reports lack of epidemiological studies in Africa and lack air quality monitoring systems. Air pollution has a dire impact on human health.
Glenn *et al.* [33]	2022	Systematic review	Schoolchildren are diagnosed with respiratory diseases such as shortness of breath, tightness of chest and wheezing. This is because of air pollution. The exposure could be during their journey to school.
Naidoo *et al.* [34]	2013	Quantitative	Schoolchildren from industrially exposed communities of Durban experience persistent asthma.
Desouza *et al.* [35]	2022	Quantitative	Upon evaluation of the impact of air pollution in utero and early childhood, the study reported that exposure to air pollutants is associated with stunting among children.
Nkosi *et al.* [36]	2015	Quantitative, cross-sectional	The elderly population exposed to air pollution had a higher prevalence of chronic respiratory diseases and symptoms. Residing in the mine dumps was associated with asthma, pneumonia, chronic cough and emphysema.
Shezi *et al.* [37]	2022	Quantitative	Exposure to air pollutants like $PM_{2.5}$ in pregnancy is associated with adverse outcomes such as low birth weight and preterm labour.
Mitku *et al.* [38]	2023	Quantitative	Exposure to air pollutants has been linked to various adverse pregnancy outcomes, including small for gestational age and low birth weight.
Weber *et al.* [39]	2020	Quantitative, cohort study	iIndoor air pollutionamong pregnant women was reported to be associated with perinatal mortality and low Apgar score.
Thabethe *et al.* [40]	2014	Quantitative	The study reported exposure of air pollutants to PM_{10} among all four stages of life, which consequently impacts their health and well-being.
Esong *et al.* [41]	2021	Quantitative, cross-sectional study	The study reported an exclusive exposure to air pollution in rural as a means of burning solid waste for cooking. In rural areas, they exclusively used firewood.

3.1. Sources of Pollution

The review revealed that there are a variety of sources of air pollution, particularly in Africa. The rapid urbanization and population growth signifies the expansion of sources of pollution within the African Continent. The study of Kadir *et al*. affirmed that roughly three billion of the population rely on the use of solid fuels such as wood, charcoal, dung, crop residuals and coal as the key source of household energy. Some of these solid fuels, like charcoal, wood and coal, are often used for cooking and heating [21]. The combustion of some of these solid fuels is burned over an open fire, causing a release of toxins that has a significant impact on human health. Santos affirmed that, particularly in rural areas of South Africa, the communities still rely on the burning of solid fuels in the backyards as a result of a lack of garbage transportation [22].

Several studies argue that the sources of air pollution are beyond the household sources of air pollution. In addition to the use of solid fuels for cooking, the study by Shirinde *et al*. highlights other common sources of air pollution exposure [23]. These include sources such as environmental tobacco smoke, frequent passing trucks near homes and living near dusty and unpaved roads. Abera *et al*. [24] concurred with Shirinde *et al*. [23] and Santos [22] that poor household waste management, diesel-powered vehicles and burning are the contributors to air pollution. This is supported by genuine observations that South Africa relies on the use of trains and diesel-powered trucks that release toxins for the transportation of their minerals such as coal. These sources emit pollutants such as particular matter ($PM_{2.5}$ and PM_{10}), Nitrous Oxide (NO_2), and sulphuric oxide. Uncontrolled landfills release methane, volatile organic compounds (VOCs), and other hazardous substances.

3.2. Pollutants of air Pollution in Africa

Africa is increasingly the vulnerable continent when it comes to air pollution, and it is quite far from solving its air pollution crisis, inadequate healthcare systems and poor equal distribution of cleaner energy across the continent [25]. Out of 54 countries, only 19 countries have the ability and required quality systems to measure the air quality. Apart from that, the African continent is the largest continent in the provision of mineral resources and is also known for socio-economic status injustice. Therefore, many pollutants are being released from those industrial areas into the ambient air and polluting the air quality. It releases toxic pollutants such as Particular Matter (PM), Volatile Organic Compounds (VOCs) and dioxins and furans [24, 25].

3.2.1. Particulate Matter (PM_{10} and $PM_{2.5}$)

PM is an end product of the combustion of solid fuel and biomasses. It can be released from household and industrial air pollution. It is a fine particle known to impact human health. The WHO has set a certain limit for an average PM concentration. However, some of the African countries surpass the threshold of the recommendations of the PM. For instance, a study conducted in South Africa has noted exceeding levels of PM and ozone. Meanwhile, others lack such systems to measure air quality [22, 24, 26, 27]. Fig. (**2**) displays the level of $P.M_{2.5}$ in African countries. Seemingly, exceeding the WHO recommended PM levels has no legal implications; this could be associated with non-compliance to the above threshold levels of PM. Therefore, legislation is needed in place to combat adverse health effects as a result of air pollution [26]. However, high levels of PM have been noted to impact the health of human health, causing harm to multiple organ systems. PM, like $PM_{2.5}$, has been quantitatively linked to fatal diseases such as pneumonia, stroke, heart disease, lung diseases and cancer. It is a small particle that can easily deeply penetrate the lungs when inhaled and can pass into the bloodstream, posing danger to human health [22, 28]. The study by Bagula *et al*. [29] affirmed that air pollutants like $PM_{2.5}$, even at lower level, cause chest pains among adults.

3.3. Understanding the Health Impacts of air Pollution Amongst the Vulnerable Populations

In the pursuit of achieving Sustainable Development Goal 3 (SDG 3), it is important to note that chronic diseases are on the rise, with some cases linked to waste-related air pollution. The burden of diseases in Africa has triplicated as the result of air pollution, lifestyle choices and other contributing factors [24]. Air pollution releases pollutants that affect the respiratory, cardiovascular, and neurological systems. It has enhanced the burden of diseases such as respiratory tract infections and chronic obstructive pulmonary disease (COPD) [5]. The WHO projects that, in the absence of appropriate measures to enhance air quality in Africa, the number of cancer cases in the continent will increase from 1.2 million in 2022 to around 2.8 million by 2050. This is attributed to the elderly population's vulnerability, greater exposure to air pollution, and inequities in healthcare resources [30]. Other than that, a study by Wichmann *et al*. noted an association of cerebrovascular disease mortalities with air pollutants such as PM_{10}, NO_2 and SO_2 [31].

3.3.1. Health Impact Among Children

A recent quantitative study has linked exposure to air pollutants such as PM2.5 to an estimated loss of approximately 1.96 billion IQ points among African children under the age of 10 [6]. Clearly depicting that air pollution has a certain impact on human intelligence. Studies have noted that exposure of the developing brain to air pollution during pregnancy or childhood can adversely cause brain injury, impacting the cognitive function of children [6].

Several South African studies have reported that in children, air pollution pollutants such as $PM_{2.5}$, NO_2 and SO_2 are significantly associated with respiratory illnesses and symptoms like cough, wheezing, shortness of breath and tightness of the chest. The studies signify that exposure to air pollution among children is related to the

notion that children spend most of their time indoors with their mothers. In some instances, they are mostly exposed during the journey to school which exposes them to the pollutants in ambient air [23, 32, 33]. The impact of respiratory illness among children and adolescents is dependent on the length of stay in that significant area. The study of Millar *et al*. [28] affirmed that the presence of respiratory illness is statistically significantly associated with the number of years that particular adolescent has lived in that place. The study by Millar *et al*. [28] reports findings similar to those of other studies, indicating that the most commonly reported respiratory illnesses among adolescents exposed to air pollution include cough, wheezing, and doctor-diagnosed hay fever. Moreover, exposure to industrial pollution is very strongly connected to these detrimental health consequences on the respiratory system. According to the study of Naidoo *et al*. [37] conducted in South Africa, compared to schoolchildren from non-exposed regions, those from industrially exposed neighbourhoods had higher rates of chronic asthma and noticeable airway hyperactivity. Other than respiratory diseases, the quantitative analysis of Desouza *et al*. revealed that exposure to air pollutants is statistically significantly associated with stunting among children [35].

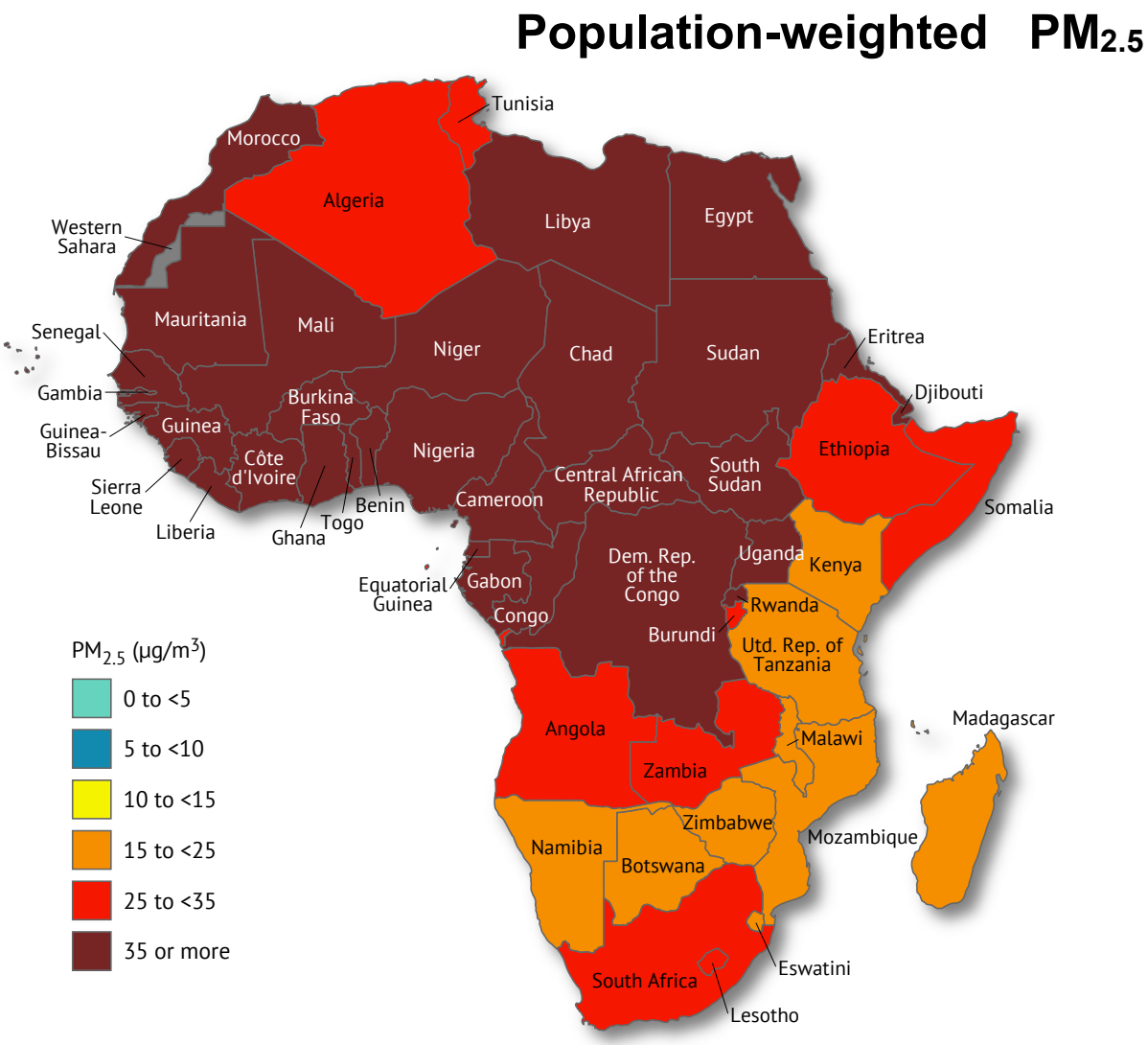

Fig. (2). Africa and level of $PM_{2.5}$ exposure [25].

3.3.2. Health Impact Among Elderly

Only two studies from South Africa were found in the extensive literature search on the health effects of air pollution on the elderly in Africa. According to the study of Nkosi *et al.* [36], there is a substantial correlation between elderly people's exposure to mine dump air pollution and conditions like asthma, emphysema, chronic bronchitis, wheeze, pneumonia, and chronic cough, despite the fact that some research contends that these illnesses are most likely related to ageing and changes to the respiratory system that come with it. On the other hand, the results of the other study showed that air pollution was linked to respiratory and cardiovascular fatalities among the elderly in all three South African cities: Johannesburg, Cape Town, and Durban. There have been more reported deaths in winter seasons than in the warmer ones. The elevated levels of air pollutants in the cities, which were beyond the WHO standard, contributed to these deaths [27]. Moreover, several studies conclude that overpopulation in some places and the increased use of local resources for cooking and space heating, especially during the winter, maybe the cause of air pollution levels surpassing the WHO threshold [23, 27].

3.3.3. Health Impact Among Pregnant Women

There's a paucity of studies delving into the health implications of air pollution among pregnant women in Africa and only a few studies delved deep into the pregnancy outcomes following exposure to air pollution in Africa. Nonetheless, in efforts to understand the impact of pollution on public health in Africa, studies have shown that in utero exposure to waste-related air pollution is associated with adverse pregnancy outcomes. For instance, a study conducted in South Africa reported that maternal exposure to waste-related air pollution such as $PM_{2.5}$ is significantly associated with preterm birth, low birth weight and gestational age [37, 38]. This was consistent with the Ghanaian cohort study that reported that exposure waste waste-related air pollution has adverse pregnancy outcomes, among which are low Apgar scores and perinatal mortality [39]. Seemingly, such negative outcomes were associated with high exposure to waste-related air pollution.

Pregnant women in African countries were reported to use diverse sources of air pollution for cooking. Among those sources are wood, petroleum gas, charcoal *etc* [21]. Due to these exposures, negative maternal and perinatal outcomes prevailed. Studies ascertain that the rationale behind such outcomes is that women and children are more exposed to indoor pollution than men. Some studies identified that the level of $PM_{2.5}$ was seven times higher in women than men [24]. This could be because Africa still remains a cultural continent; in some aspects of the continent, women still remain at home and be housewives; and cook for the family and care for children. As a result of that, they are exposed to higher indoor pollution that further impacts their health.

3.4. Factors Impeding the Mitigation of Air Pollution in Africa

3.4.1. Socio-economic Injustice and Poverty

According to the majority of African constitutions on the human rights section, it is stipulated that everyone has a right to a safe environment, not harmful to their well-being and health. Moreover, everyone has a right to access optimal healthcare, clean water and sanitation. However, socio-economic injustice is still a contributing factor to premature mortalities related to environmental factors such as air pollution, poor water and sanitation. For instance, a study by Santos [22] conducted in the Kruger biosphere regions of South Africa and Amazonas, Brazil, revealed that some isolated regions of South Africa burn solid waste in the backyard due to a lack of garbage transportation; some live near unpaved roads and some of the clinical facilities lack functional toilets. This shows that the socio-economic injustices in South Africa predispose the populations to polluted environments, further causing premature deaths. Asseverating that this current review is in Africa, the study of Santos could not have been disregarded, noting it investigated the South African regions and contained worthwhile data relevant to the study.

On the other hand, this was consistent with other studies conducted in Africa that stated that the populations are exposed more to air population as a result of using wood and other biomasses. The assumed rationale behind this was the lack of electricity in certain areas, where most people rely on wood for cooking and heating during the winter months [6, 24, 40]. Abera *et al.* [24] further supported this by stating that poverty also enhances a person's susceptibility to air pollution as a result of poor healthcare, unaffordability of nutritious food, and as well as the enhanced likelihood of living in proximity to industrial areas, unpaved roads and biomass burning. Some of the reasons behind the excessive use of firewood among African countries were cultural factors, affordability and also local availability of solid fuels [41]. Nonetheless, the majority of the studies used questionnaires to measure exposure to air pollution and there is a paucity of studies that were interested in delving into the qualitative reasoning behind the use of wood for cooking and space heating rather than using electricity itself. However, it was only assumed to be associated with socio-economic injustices.

3.4.2. Political and Corruption Issues

However, during the course of the review, it was observed that research in Africa explored the factors impeding the mitigation of air pollution. The study by Abera *et al.* [24] highlighted the impact of political issues and corruption in improving air quality. Most of the African countries still struggle with access to healthcare services, access to clean water and sanitation, and informal unemployment. For example, from genuine observation, South Africa struggled with the issue of load-shedding for two to four years. This clearly depicts that

the issue of political solidity and admiration of human rights still remain a concern. This may be attributed to the disregard for the rule of law, widespread corruption, and weak governance. In many cases, governments are still unable to allocate adequate funding for the monitoring, regulation, and control of air pollution [21, 24]. This was evident by the lack of proper materials and equipment needed to measure the air quality in some African countries. Several studies have stated that Africa still struggles with prioritizing measuring air quality and roughly 19 African countries have air quality monitoring systems [24, 25]. It is clear from the evidence that due to a lack of prioritization of mitigating air pollution and air quality monitoring, premature deaths attributed to environmental risk will gradually rise yearly. For this effect, it may prove to be a challenge for African countries to achieve the SDGs 7 and 3 targets by 2030; looking at that, the continent still scuffles with poverty reduction, poor access to healthcare, load-shedding, political issues, corruption and access to clean water and sanitation. As a result, the public health impacts of air pollution will persist [6]. The study by Santos [21] recommends that authorities should take it upon themselves to establish an air quality monitoring strategy and enforce compliance with air quality regulations to protect public health.

4. DISCUSSION

The analysis highlights the significant public health risks posed by waste-related air pollution in Africa. The most impacted groups are low-income neighborhoods and children. To add to the matter of waste-related air pollution, climate change is also a concern exacerbating the effects of air pollution. Dealing with climate change is a complex and challenging issue. One of the significant ways it impacts our environment is by altering the distribution and concentration of air pollutants. As global temperatures rise due to climate change, there is a notable increase in the emissions of harmful pollutants such as particulate matter (PM) and ozone. Higher ambient temperatures exacerbate the formation of ozone in the atmosphere and increase the levels of PM that are emitted from various sources [42, 43]. This increase in air pollution is not just a minor environmental concern; it has serious implications for human health. Elevated concentrations of PM can lead to a range of health problems. Furthermore, the effects of climate change on air pollution are not uniform across the globe; different regions experience varying levels of impact based on local environmental and climatic conditions. Therefore, as the climate continues to change, it is essential to understand these shifting patterns of air pollution in order to develop effective strategies for managing and mitigating its adverse health effects [42, 43]. Addressing this challenge requires a comprehensive approach that considers both the causes of climate change and the health risks associated with increased air pollution. There are, however, significant data gaps, especially in longitudinal research looking at long-term health effects. Hence, the SDGs aim to ensure comprehensive health and well-being for all by preventing premature mortalities due to non-communicable diseases. Achieving the target of SDG 7—which aims to ensure access to affordable, reliable, sustainable, and modern energy for all—is essential to realizing SDG 3, as it would help reduce air pollution and its adverse effects on human health, ultimately decreasing premature mortality [44].

Drawing from the evidence, it is clear that the impact of air pollution and its implications on human health is definitely understudied in Africa. There has been minimal focus on the sources of air pollution and the toxins they emit. The vast majority of the studies conducted in Africa focused mostly on $PM_{2.5}$ rather than on other pollutants such as volatile organic compounds, microplastics, and hazardous electronic waste emissions. Therefore, this indicates that a substantial gap remains on the health impacts of other pollutants such as volatile organic compounds, hazardous electronic waste emissions and microplastics. To reduce air pollution-related mortalities in Africa, it is crucial to thoroughly identify these sources and develop alternative strategies for mitigation. Nonetheless, the review revealed the respiratory health impacts of air pollution were similar throughout the African studies; this could be that the majority of the studies adopted the use of questionnaires to explore the exposure to air pollution using predetermined variables such as cough, wheeze, emphysema, pneumonia and asthma. Some of these conditions were common among children [23, 28, 32, 35, 36]. This raises the question, “which diseases, other than respiratory diseases, impact human health?” The WHO clearly states that air pollution affects multiple systems, including cardiovascular, neurology, and respiratory systems [5]. However, this review revealed that none of the other systems were investigated in-depth in Africa, looking at how they were impacted by air pollution. These could be attributed to a lack of resources and funding for environmental health and air pollution, as suggested by Abera *et al.* [24].

On the other hand, the review revealed that most of the South African cities exceeded the WHO set standard of air pollutants. Not only that, it also revealed that most of the African countries lack air quality monitoring systems. This could be because there is a lack of global legal implications surrounding the exceeding of the set standards as recommended by WHO [26, 27]. One could argue that socioeconomic injustices have an impact on exceeding the WHO-set standards, looking at the variations in developed and developing countries. For instance, countries like Germany, Italy, Belgium and Denmark have relied on varied mitigation strategies. Noting that they are more developed countries than most African countries, they rely on the use of modern solar energy technologies to reduce air pollution. Meanwhile, some countries in Africa still face power failures, corruption and economic imbalances. Modern energy is essential for these nations, especially Africa, to increase production and income generation, social advancement, and the mitigation of the major health risks associated with the usage of fuelwood, charcoal, animal manure, and agricultural waste [24, 45]. Nonetheless, currently, as a

result of rapid growth in populations and poverty, most of the African countries end up relying on the burning of solid waste for cooking and saving electricity [40]. Despite the availability and establishment of policies such National Environmental Management Air Quality Act 39 of 2004, National Environmental Standards and Regulation Enforcement Agency Act 2007, and National Environmental policy aimed to ensure compliance with the standards and regulations of air quality and that the air pollutants are within the level not harmful to the health and well-being of the humans in South Africa, Nigeria and Ghana, respectively. The burning of solid wastes persists [45-48].

In the same wavelength, studies conducted in South Africa highlighted that some provinces exceed the set limits recommended by WHO. However, do not exceed the standards set by the National environmental management air quality act 39 of 2004. The exceeding of the limits is credited to the burning of biomasses in the country, particularly in winter [27, 28, 31]. The study rationale was similar to the other studies conducted in African countries like the study of Esong *et al*. conducted in Cameroon affirmed that air pollution was worsened by the exclusive use of wood, particularly in rural areas and sawdust as well as kerosene in peri-urban areas [41]. In South Africa, load-shedding also has a negative influence on the air quality. Load-shedding dates back to 2007, however, now it has amplified twofold [49]. The study by Pretorius *et al*. argues that emissions of air pollutants from South Africa were a result of poor maintenance and deterioration of the power stations [50]. Nonetheless, in the load-shedding era, companies, supermarkets and some households have relied on generators to keep their business running. This releases more emissions as the generators rely on petrol and diesel for running. Moreover, the communities relied on the use of paraffin, gas stoves and burning of solid waste to meet their basic needs within households, further impacting air quality and consequently impacting human health [49].

The problem is exacerbated in Africa by poor waste management in rural regions with limited resources, where people burn some of their waste in their backyards. The study by Godfrey *et al*. concluded that poor waste management is linked to weak organizational structures, a shortage of skilled personnel, inadequate resources, ineffective legislation and enforcement, low public awareness, political instability, conflict, corruption, and a lack of political will [51]. The air pollution crisis and impact is beyond only the field of energy resources; its impact extends to the environment, healthcare and finance divisions. All this makes it difficult for South Africa to achieve the SDG 3 and 7 targets. The study recommends the development of community-based interventions to strengthen compliance with South African Air quality standards involving multiple South African ministries working together towards achieving a precise goal: a safe and healthy environment for all. Public education campaigns, stronger enforcement of environmental laws, and better waste management techniques are all desperately needed. The report suggests that African laws and policies pertaining to fines and punishments for breaching predetermined thresholds be strengthened. Nevertheless, penalties and other consequences are imposed for exceeding established air pollution limits. However, monitoring systems are in place, along with other strategies aimed at ensuring compliance with established limits.

5. LIMITATIONS OF THE STUDY

The strength of this study lies in its use of a scoping review, which enables a comprehensive synthesis and critique of existing evidence to identify knowledge gaps regarding the public health impact of air pollution in Africa. This methodology facilitates an extensive search of the literature of studies ranging from qualitative, quantitative and review studies. However, the methodology also had some limitations, including the inclusion criteria. This may have led to the oversight of significant literature published before 2014. Therefore, future studies should consider conducting a comprehensive literature search beyond 2014 to determine and identify patterns and trends of the public health impact of air pollution. Furthermore, although some findings align with previous studies, the results of this review cannot be generalized to other contexts. Future research could focus on conducting comparative studies that examine the impact of air pollution in both the Global North and South. Such efforts could contribute to the development of unified, context-sensitive strategies for mitigating air pollution.

CONCLUSION

Waste-related air pollution poses a serious public health challenge in Africa. The review revealed the diverse sources and the health effects of air pollution. Among the health effects were respiratory conditions and symptoms such as asthma, chronic pulmonary obstructive diseases, sneezing, coughing and wheezing. The review indicated that the exposure to sources of air pollution was exacerbated by socio-economic injustices, corruption, and political issues, particularly in rural areas. This increases the risk of exposure to air pollution, thus increasing the risk of premature mortality among vulnerable populations. In addition, the review further highlighted little attention has been paid to other emerging pollutants that impact human health. These include pollutants such as volatile organic compounds, hazardous electronic waste emissions and microplastics. Therefore, addressing these issues requires a multifaceted approach involving policy changes, infrastructure improvements, and community engagement. Further longitudinal research studies are needed to understand the long-term health impacts fully and to develop effective mitigation strategies.

FUTURE RESEARCH DIRECTIONS

1. **Longitudinal Studies**: To assess the long-term health impacts of exposure to waste-related air pollution.

2. **Intervention Studies**: Evaluating the effectiveness of various waste management interventions in reducing air pollution and improving public health.

3. **Geospatial Analysis**: Mapping the distribution of waste-related air pollution and its correlation with health outcomes across different regions.

4. **Policy Impact Studies**: Assessing the impact of existing policies and regulations on air quality and public health.

By addressing these areas, we can better understand and mitigate the public health impacts of waste-related air pollution in Africa.

AUTHORS' CONTRIBUTIONS

The authors of this paper contributed to the study in various ways. The conception and design of the study were primarily carried out by MN and LM. JS was responsible for drafting the manuscript. All authors thoroughly reviewed the results and collectively approved the final version of the manuscript.

LIST OF ABBREVIATIONS

COPD = Chronic obstructive pulmonary disease

PICO = Population, Intervention, Context and Outcomes

NO_2 = Nitrous Oxide

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA guidelines were followed.

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CONFLICT OF INTEREST

The author(s) declare no conflict of interest, financial or otherwise.

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SUPPLEMENTARY MATERIAL

Supplementary material is available on the publisher's website along with the published article.

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