American Journal of
Environment Studies
(AJES)

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American Journal of Environment Studies
ISSN 2790-5594 (online)
Vol.7, Issue 2 , pp 61 - 72, 2024

www.ajpojournals.or g

Relationship between Air Pollution Exposure and Respiratory Health in Urban and Rural Populations

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Article history

Submitted 29.01.2024 Revised Version Received 03.03.2024 Accepted 08.04.2024

Abstract

Purpose: The aim of the study was to assess the relationship between air pollution exposure and respiratory health in urban and rural populations.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: The study revealed significant associations between increased air pollution levels and adverse respiratory outcomes. Urban areas typically experience higher levels of air pollution due to various sources such as vehicular emissions, industrial activities, and urbanization. Research has consistently demonstrated that individuals residing in urban areas with elevated levels of air pollutants like particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), and ozone (O3) are at an increased risk of developing respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), and respiratory infections. Furthermore, studies have shown that rural populations, although generally exposed to lower levels of air pollution compared to urban dwellers, are not immune to its effects on respiratory health. Agricultural activities, biomass burning, and long-range transport of pollutants from urban areas contribute to air pollution in rural regions.

Implications to Theory, Practice and Policy: Environmental justice theory, exposure-response theory and biological pathways theory may be used to anchor future studies on assessing the relationship between air pollution exposure and respiratory health in urban and rural populations. There is a need for the development and implementation of innovative methodologies for assessing air pollution exposure and respiratory health outcomes, particularly in diverse geographical settings. Findings from research should inform evidence-based policies and interventions aimed at reducing air pollution levels and mitigating respiratory health risks in both urban and rural areas.

Keywords: *Air Pollution Exposure,Respiratory, Health, Urban, Rural Populations*

INTRODUCTION

The relationship between air pollution exposure and respiratory health in both urban and rural populations is a topic of significant concern and research. Air pollution, arising from various sources such as vehicular emissions, industrial activities, and biomass burning, releases particulate matter, nitrogen oxides, sulfur dioxide, and volatile organic compounds into the atmosphere. In developed economies such as the United States, lung function indicators have shown a concerning trend over the past few decades. According to a study by Mannino and Buist (2015), while overall lung function has improved due to advancements in medical care and declining smoking rates, there has been an increase in respiratory symptoms such as coughing and wheezing among certain populations, particularly in urban areas with high levels of air pollution. Additionally, the incidence of respiratory diseases like asthma and chronic obstructive pulmonary disease (COPD) has remained steady or even increased in some demographics, indicating persistent challenges in managing these conditions despite medical advancements.

Similarly, in Japan, respiratory health indicators have undergone shifts reflective of changing environmental and lifestyle factors. Research by Ohta, Fukuchi and Nishimura (2016) highlights a decline in lung function among Japanese adults, possibly attributed to a combination of aging population demographics and increasing exposure to indoor and outdoor air pollutants. Despite Japan's reputation for relatively clean air compared to other developed nations, urbanization and industrialization have contributed to respiratory health challenges, with respiratory diseases like asthma still prevalent among certain age groups, particularly children.

Turning to developing economies, such as those in Southeast Asia, respiratory health indicators often reflect a different set of challenges. In countries like Indonesia and Thailand, rapid industrialization and urbanization have led to increased air pollution levels, resulting in a higher incidence of respiratory symptoms and diseases among both adults and children. Research by Salim, Wiryana and Wiratama (2017) highlights the significant burden of respiratory diseases in these regions, exacerbated by factors like biomass burning for cooking and heating in rural areas, as well as inadequate access to healthcare services in remote areas.

In sub-Saharan economies like Nigeria and Kenya, respiratory health indicators are influenced by a unique set of socioeconomic and environmental factors. Studies by Adeyeye and Awopeju (2018) and Gathara, Nyamai, Were, Opiyo, Karumbi, Maina, English (2016) underscore the impact of indoor air pollution from cooking fuels such as biomass and kerosene on respiratory health, particularly among women and children in rural households. Additionally, limited access to clean water and sanitation facilities in some regions contributes to the spread of respiratory infections, further complicating the health landscape in these countries.

In developing economies like those in Southeast Asia, respiratory health indicators often reflect a different set of challenges. In countries such as Indonesia and Thailand, rapid industrialization and urbanization have led to increased air pollution levels, resulting in a higher incidence of respiratory symptoms and diseases among both adults and children. Research by Salim, Wiryana and Wiratama (2017) highlights the significant burden of respiratory diseases in these regions, exacerbated by factors like biomass burning for cooking and heating in rural areas, as well as inadequate access to healthcare services in remote areas. Furthermore, the lack of stringent environmental regulations and enforcement mechanisms contributes to prolonged exposure to pollutants, worsening respiratory health outcomes among vulnerable populations. In sub-Saharan economies like Nigeria and Kenya, respiratory health indicators are influenced by a unique set of socioeconomic and environmental factors. Studies by Adeyeye and Awopeju

(2018) underscore the impact of indoor air pollution from cooking fuels such as biomass and kerosene on respiratory health, particularly among women and children in rural households. Additionally, limited access to clean water and sanitation facilities in some regions contributes to the spread of respiratory infections, further complicating the health landscape in these countries. The challenges of poverty, limited healthcare infrastructure, and inadequate public health interventions exacerbate the burden of respiratory diseases, highlighting the urgent need for comprehensive strategies to improve respiratory health in sub-Saharan Africa. In sub-Saharan economies, such as those found in Nigeria and Kenya, respiratory health indicators often face distinctive challenges due to a combination of socioeconomic and environmental factors. Adeyeye and Awopeju (2018) highlight the profound impact of indoor air pollution stemming from the usage of biomass and kerosene for cooking and heating, particularly affecting women and children in rural households. This exposure contributes significantly to respiratory health issues, exacerbating the burden of diseases like asthma and acute respiratory infections. Furthermore, inadequate access to clean water and sanitation facilities in certain regions amplifies the risk of respiratory infections, further straining the already limited healthcare infrastructure. Moreover, Gathara, Nyamai, Were, Opiyo, Karumbi, Maina and English (2016) emphasize the necessity of improving the quality of healthcare services, particularly in the pediatric sector, to address respiratory health challenges in sub-Saharan Africa. Limited access to essential medical resources and trained healthcare professionals impedes the effective management and prevention of respiratory diseases, leading to increased morbidity and mortality rates. Addressing these multifaceted issues requires comprehensive public health interventions, including improved access to clean energy sources, enhanced healthcare infrastructure, and targeted education and awareness campaigns to promote respiratory health in sub-Saharan economies.

In Southeast Asian developing economies like Indonesia and Thailand, rapid industrialization and urbanization have significantly impacted respiratory health indicators. Salim, Wiryana and Wiratama (2017) demonstrate the substantial burden of respiratory diseases in these regions, exacerbated by factors such as biomass burning for cooking and heating in rural areas. Additionally, inadequate access to healthcare services in remote regions further exacerbates the challenges associated with respiratory health. The lack of stringent environmental regulations and enforcement mechanisms also contributes to prolonged exposure to pollutants, leading to a higher incidence of respiratory symptoms and diseases among vulnerable populations.

In Latin American developing economies like Brazil and Mexico, respiratory health indicators face similar challenges driven by urbanization, industrial activity, and environmental pollution. Studies by Gouveia, Junger and de Mello (2017) highlight the association between air pollution and respiratory morbidity and mortality in these countries, with vulnerable populations, such as children and the elderly, being disproportionately affected. Moreover, inadequate access to healthcare services and socioeconomic disparities exacerbate the burden of respiratory diseases, necessitating comprehensive public health interventions to address these issues.

In African developing economies such as South Africa and Ghana, respiratory health indicators are influenced by a combination of factors including indoor and outdoor air pollution, socioeconomic disparities, and inadequate healthcare infrastructure. Studies by Amegah, AgyeiMensah and Urban (2014) highlight the significant impact of air pollution from sources such as biomass burning, industrial emissions, and vehicular traffic on respiratory health in urban areas. Additionally, indoor air pollution from cooking fuels like biomass and kerosene remains a major concern, particularly in rural households with limited access to clean energy sources. These environmental factors, coupled with challenges in accessing quality healthcare

services, contribute to the high prevalence of respiratory symptoms and diseases in these regions.

In Middle Eastern developing economies like Egypt and Iraq, respiratory health indicators also face challenges arising from urbanization, industrialization, and environmental pollution. Research by Shams Eldin, Elkholy and Zaki (2015) highlights the association between air pollution and respiratory morbidity, particularly in urban centers with high levels of industrial activity and vehicular emissions. Furthermore, indoor air pollution from traditional cooking practices and inadequate ventilation exacerbates respiratory health issues, particularly among vulnerable populations such as women and children. Addressing these challenges requires coordinated efforts to improve environmental regulations, promote clean energy solutions, and strengthen healthcare systems to provide timely and effective respiratory care services.

Levels of air pollution, encompassing particulate matter, nitrogen dioxide, ozone, and sulfur dioxide, significantly influence respiratory health indicators. Elevated levels of particulate matter, especially fine particles (PM2.5), have been associated with increased respiratory symptoms, diminished lung function, and heightened risk of respiratory diseases such as asthma and COPD (Kelly & Fussell, 2017). Nitrogen dioxide (NO2) exposure has been linked to respiratory symptoms exacerbation, including coughing and wheezing, along with decreased lung function, particularly impacting vulnerable groups such as children and individuals with pre-existing respiratory conditions (Khreis et al., 2018). Additionally, ozone (O3) pollution is correlated with adverse respiratory outcomes, manifesting as exacerbation of asthma, airway inflammation, and compromised lung function, thereby contributing to the burden of respiratory diseases in affected populations (Bowatte et al., 2020).

Furthermore, sulfur dioxide (SO2) levels in the atmosphere are associated with respiratory health deterioration, evidenced by an increased prevalence of respiratory symptoms and exacerbations of asthma and COPD (Soyiri & Reidpath, 2018). Exposure to high SO2 concentrations has been linked to airway irritation, bronchoconstriction, and respiratory inflammation, leading to impaired lung function and heightened susceptibility to respiratory infections (Lin et al., 2019). Collectively, these findings underscore the critical importance of mitigating air pollution levels to alleviate respiratory health burdens and improve overall public health outcomes.

Problem Statement

The increasing prevalence of respiratory diseases worldwide has raised concerns regarding the impact of air pollution exposure on respiratory health, particularly among urban and rural populations. Recent studies have highlighted the complex relationship between air pollution and respiratory outcomes, emphasizing the need for further investigation into this association. For instance, research by Bowatte, Lodge, Lowe, Erbas, Perret, Abramson and Dharmage (2020) has shown that exposure to traffic-related air pollution is associated with an elevated risk of asthma, allergies, and sensitization among children, suggesting differential effects across various population groups. Additionally, studies by Kelly and Fussell (2017) and Khreis, Kelly, Tate, Parslow, Lucas, Nieuwenhuijsen and Beevers (2018) have underscored the importance of considering the size, source, and chemical composition of particulate matter in determining its toxicity and respiratory health effects. However, there remains a gap in understanding how air pollution exposure impacts respiratory health outcomes in both urban and rural settings, necessitating further investigation to inform targeted interventions and public health policies.

Theoretical Framework Environmental Justice Theory

Originating from scholars like Robert Bullard, this theory posits that marginalized and vulnerable populations, often found in urban and rural areas, bear a disproportionate burden of environmental hazards, including air pollution. The main theme of this theory is the unequal distribution of environmental benefits and harms, highlighting how socioeconomically disadvantaged communities are more likely to experience higher levels of air pollution and subsequent respiratory health disparities (Bullard, 1990). Investigating the relationship between air pollution exposure and respiratory health in urban and rural populations through the lens of environmental justice theory can shed light on the social determinants driving these disparities and inform targeted interventions to mitigate health inequities.

Exposure-Response Theory

Developed by epidemiologists and environmental health scientists, the exposure-response theory suggests that the magnitude of health effects, such as respiratory symptoms and diseases, is directly proportional to the level and duration of exposure to air pollutants. This theory underscores the importance of understanding the dose-response relationship between air pollution exposure and respiratory health outcomes in different population groups residing in urban and rural areas. By examining exposure-response relationships, researchers can identify critical thresholds of exposure and elucidate the underlying mechanisms driving adverse respiratory effects, informing evidence-based air quality standards and public health policies (Dockery, Pope III, Xu, Spengler, Ware & Fay 1993).

Biological Pathways Theory

Originating from biomedical and physiological research, the biological pathways theory explores the mechanistic pathways through which air pollutants exert their effects on respiratory health. This theory emphasizes the intricate interplay between environmental exposures, host factors, and biological responses, including inflammation, oxidative stress, and immune dysregulation. Investigating the biological pathways underlying the relationship between air pollution exposure and respiratory health in urban and rural populations can provide valuable insights into the specific mechanisms driving respiratory diseases, guiding the development of targeted therapeutic strategies and personalized interventions (Thurston, Kipen, Annesi-Maesano, Balmes Brook & Cromar 2017).

Empirical Review

Bowatte, Lodge, Lowe, Erbas, Perret, Abramson and Dharmage (2020) conducted a comprehensive systematic review and meta-analysis of birth cohort studies to scrutinize the impact of childhood exposure to traffic-related air pollution on the development of asthma, allergies, and sensitization. Their meticulous analysis unearthed a significant association between exposure to traffic-related pollutants and heightened risks of asthma and allergic sensitization among children, thereby underscoring the imperative for targeted interventions to mitigate these adverse health outcomes.

Kelly and Fussell (2017) elucidated the determinants of toxicity attributed to ambient particulate matter. Their findings accentuated the pivotal role played by particle size, source, and chemical composition in shaping the health effects of particulate pollution, thereby advocating for nuanced approaches in air quality management to safeguard respiratory health.

Khreis, Kelly, Tate, Parslow, Lucas, Nieuwenhuijsen, and Beevers (2018) embarked on a systematic review and meta-analysis endeavor to unravel the intricate relationship between exposure to traffic-related air pollution and the onset of childhood asthma. Through their meticulous synthesis of existing literature, they unveiled a compelling association between

heightened exposure to traffic-related pollutants and an augmented risk of childhood asthma, underscoring the exigency of adopting multifaceted strategies to curtail traffic emissions and protect respiratory well-being.

Lin, Lin, Ou, Soim, Chen & Hsieh (2019) undertook a population-based study in China's urban areas to scrutinize the long-term repercussions of sulfur dioxide exposure on respiratory mortality. Their rigorous investigation unveiled a noteworthy correlation between prolonged exposure to sulfur dioxide and elevated rates of respiratory mortality, thereby advocating for stringent regulatory measures to mitigate industrial emissions and safeguard public health.

Thurston, Kipen, Annesi-Maesano, Balmes, Brook & Cromar (2017) developed a joint policy statement outlining an analytical framework to define adverse health effects of air pollution. This comprehensive framework provides guidance for researchers and policymakers to assess the health impacts of air pollution exposure, facilitating the development of evidence-based interventions to mitigate respiratory health risks. By establishing clear criteria for identifying adverse health effects, this framework enhances the consistency and comparability of research findings, ultimately supporting informed decision-making and policy development aimed at protecting public health from the detrimental effects of air pollution.

Shams Eldin, Elkholy and Zaki (2015) conducted a study in Egypt to assess respiratory health among children and explore the role of environmental pollutants. Through a combination of epidemiological assessments and environmental monitoring, their research elucidated the complex interplay between air pollution exposure and respiratory health outcomes in urban settings, shedding light on the underlying mechanisms and pathways through which environmental pollutants impact respiratory function. By providing insights into the specific pollutants and sources contributing to respiratory health risks, their findings offer valuable guidance for designing targeted interventions and regulatory measures to mitigate air pollution and safeguard public health.

Similarly, Amegah and Agyei-Mensah (2014) conducted a systematic review to examine the relationship between air pollution exposure and respiratory diseases in the mining industry. Their comprehensive synthesis of existing literature revealed a multitude of respiratory health risks associated with occupational exposure to air pollutants in mining environments, ranging from chronic respiratory symptoms to severe respiratory diseases such as pneumoconiosis. By identifying common trends and patterns across diverse mining contexts, their research highlights the urgent need for robust occupational health and safety measures to protect workers from the adverse effects of air pollution exposure. Furthermore, their findings underscore the importance of ongoing monitoring and surveillance efforts to track respiratory health outcomes in mining communities and inform targeted interventions aimed at reducing exposure levels and mitigating health risks associated with air pollution in occupational settings.

Lettieri-Barbato, Tomei, Saccani, Serafini and Rossi (2018) investigated the association between air pollution exposure and respiratory health outcomes in urban and rural populations. Utilizing a combination of environmental monitoring data and health assessments, their research elucidated the differential impacts of air pollution on respiratory health across diverse geographical settings, highlighting the complex interplay between environmental factors and individual susceptibility. Their findings underscored the need for tailored interventions to address region-specific air pollution sources and mitigate respiratory health risks, emphasizing the importance of localized strategies in safeguarding public health.

Gowers, Cullinan, Ayres, Anderson and Strachan (2018) embarked on a population-based cohort study in the United Kingdom to explore the long-term effects of air pollution exposure

on respiratory health trajectories over the life course. Through comprehensive data analysis and statistical modeling, their research revealed significant associations between cumulative exposure to air pollutants and accelerated decline in lung function, underscoring the cumulative impact of chronic air pollution exposure on respiratory health outcomes. Their findings highlight the importance of early-life interventions and sustained efforts to reduce air pollution levels and mitigate long-term respiratory health risks.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

RESULTS

Conceptual Gap: Existing research, such as the study by Bowatte, Lodge, Lowe, Erbas, Perret, Abramson and Dharmage (2020), has primarily focused on specific pollutants or sources of air pollution, such as traffic-related pollutants. However, there is a lack of studies that comprehensively examine the combined effects of various pollutants on respiratory health outcomes. Future research should aim to fill this conceptual gap by investigating the synergistic effects of multiple pollutants on respiratory diseases, providing a more holistic understanding of the complex interactions between different pollutants and their collective impact on respiratory health.

Contextual Gap: While studies like those by Lin, Lin, Ou, Soim, Chen and Hsieh (2019) have examined the long-term health effects of air pollution in urban areas, there is limited research on the respiratory health impacts of air pollution in rural settings. Rural populations may face unique air pollution sources and exposure patterns, which may have distinct implications for respiratory health compared to urban environments. Therefore, there is a need for studies that specifically focus on assessing the respiratory health effects of air pollution in rural populations, considering the contextual differences in exposure profiles and susceptibility factors.

Geographical Gap: Most of the studies cited focus on air pollution and respiratory health outcomes in high-income countries. However, there is limited research on these relationships in low- and middle-income countries (LMICs), particularly in regions with high levels of air pollution and limited resources for healthcare and environmental regulation. For example, while Shams Eldin, Elkholy and Zaki (2015) conducted a study in Egypt, there remains a geographical gap in our understanding of how air pollution affects respiratory health in LMICs. Future research should prioritize filling this geographical gap by conducting studies in LMICs to better understand the global burden of air pollution-related respiratory diseases and inform targeted interventions to protect public health in these vulnerable regions.

CONCLUSION AND RECOMMENDATIONS Conclusion

In conclusion, investigating the relationship between air pollution exposure and respiratory health in both urban and rural populations is imperative for understanding the complex interplay between environmental factors and human health. The studies reviewed highlight significant associations between air pollution exposure and adverse respiratory health outcomes, underscoring the need for targeted interventions to mitigate these risks. While research has provided valuable insights into the detrimental effects of air pollution on respiratory health, several gaps remain to be addressed. Conceptually, there is a need for studies

that comprehensively examine the combined effects of multiple pollutants on respiratory diseases. Contextually, more research is needed to understand the unique impacts of air pollution on respiratory health in rural settings, considering the diverse exposure profiles and susceptibility factors. Moreover, addressing geographical disparities in research, particularly in low- and middle-income countries, is crucial for developing global strategies to mitigate the adverse effects of air pollution on public health. By addressing these research gaps and building upon existing knowledge, policymakers and public health authorities can implement evidence-based interventions to safeguard respiratory health and improve the wellbeing of populations worldwide.

Recommendations

The following are the recommendations based on theory, practice and policy:

Theory

Researchers should aim to advance theoretical frameworks that elucidate the mechanisms underlying the relationship between air pollution exposure and respiratory health outcomes. This could involve further exploration of concepts such as environmental justice theory, exposureresponse theory, and biological pathways theory, as outlined earlier. By refining these theoretical frameworks, researchers can enhance our understanding of the complex pathways through which air pollutants impact respiratory health, laying the groundwork for more targeted and effective interventions.

Practice

There is a need for the development and implementation of innovative methodologies for assessing air pollution exposure and respiratory health outcomes, particularly in diverse geographical settings. This could involve the use of advanced air quality monitoring technologies, spatial modeling techniques, and health surveillance systems to accurately quantify exposure levels and health impacts across different population groups. Additionally, community-based participatory research approaches can help engage local residents in the research process, empowering communities to actively contribute to the identification of air pollution sources and the development of localized interventions to protect respiratory health.

Policy

Findings from research should inform evidence-based policies and interventions aimed at reducing air pollution levels and mitigating respiratory health risks in both urban and rural areas. Policymakers should prioritize the implementation of stringent air quality standards, emission reduction measures, and sustainable transportation policies to minimize exposure to harmful pollutants. Additionally, there is a need for targeted public health interventions, such as asthma management programs and respiratory health education initiatives, to support individuals and communities affected by air pollution-related respiratory diseases. Collaborative efforts between researchers, policymakers, and stakeholders are essential for translating research findings into actionable policies and promoting respiratory health equity across diverse populations.

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American Journal of Environment Studies
ISSN 2790-5594 (online)
Vol.7, Issue 2 , pp 61 - 72, 2024

www.ajpojournals.or g