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A Review of the Health Burden Associated with Air Pollution Exposure in Nepal

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Abstract

Background: Air pollution has emerged as the foremost environmental challenge threatening public health in Nepal, particularly within the rapidly growing population of the Kathmandu Valley. The region consistently experiences hazardous air quality, with pollutants from vehicular emissions, industrial activities, brick kilns, and household biomass combustion exceeding World Health Organization (WHO) safe limits.

Objective: This study aims to synthesize the existing evidence on air pollution's health impacts in the Kathmandu Valley, identify critical gaps in current research, and evaluate the efficacy of policy enforcement to propose comprehensive, multi-sectoral solutions.

Methods: This review synthesizes findings from existing literature on environmental health, epidemiological data, and policy analysis related to air quality management in Nepal. It focuses on the intersection of pollution sources, clinical health outcomes, and the vulnerabilities of specific subpopulations.

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Results

The analysis confirms a direct correlation between air pollution and elevated rates of respiratory diseases (including asthma, chronic obstructive pulmonary disease, and pneumonia) as well as cardiovascular disorders (such as hypertension and ischemic heart disease). Vulnerable groups—namely children, pregnant women, and the elderly—are disproportionately affected. However, significant research gaps persist, including a lack of long-term exposure data, limited comprehensive clinical evaluations, an over-reliance on short-term monitoring and self-reported health data, and insufficient investigation into cumulative health impacts and non-respiratory conditions. These gaps are compounded by weak policy enforcement, which undermines national air quality improvement goals.

Conclusion

Addressing Nepal's air quality crisis requires an integrated approach that moves beyond fragmented interventions. The government must prioritize strengthening regulations on pollution sources, increasing investment in longitudinal scientific research, and developing targeted community-based programs.

Implications

Sustainable progress necessitates the adoption of green infrastructure, clean energy solutions, and cleaner transportation systems. Public awareness campaigns, coupled with specific protective measures for vulnerable groups, are essential for achieving health equity. A coordinated, multi-sectoral strategy—unifying policy reform, rigorous scientific inquiry, and active community participation—is critical to safeguarding public health and ensuring long-term environmental sustainability in Nepal.

Keywords: Air pollution, health impacts, Nepal, respiratory diseases, policy intervention

1. Introduction

Air pollution constitutes an urgent environmental challenge that also threatens public health, especially in areas experiencing rapid urban development like Kathmandu Valley, Nepal. The valley suffers from critical air quality problems because vehicle emissions, industrial operations, brick kilns, and construction dust pollution interact with the area's bowl-shaped landforms, which create a pollution trap (Gurung & Bell, 2013; Poudel et al., 2022). Urbanization and infrastructure development in Kathmandu lead to a major global air pollution problem, which the 21st century faces, because it threatens public health, according to another study about air pollution. The study demonstrates that both short-term and long-term exposure to polluted air increases the probability of respiratory problems, allergic reactions, and non-communicable diseases like lung and heart diseases, which scientists studied to determine their sources and health impacts in the Kathmandu Valley (Saud & Paudel, 2018). The World Health Organization (WHO) ranks Kathmandu among the most polluted cities globally, with particulate matter ($PM_{2.5}$ and PM_{10}) levels exceeding safe limits (WHO 2021).

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A recent study shows that Nepal experiences extreme urban air pollution, which ranks among the most severe air pollution problems in the world. The research shows that rising pollution levels lead to adverse health effects that impact every region, including the Terai Hills and Mountains (Giri et al., 2023). The population and vehicle count in Kathmandu increased at an accelerated pace while residents began using more energy, which resulted in higher emissions of pollutants, including TSP and PM10, SO_2, CO, and NO_2. The major sources of pollution come from vehicle emissions, factory operations, residential activities, and waste incineration, which all contribute to severe air quality deterioration. The metropolitan area experiences environmental contamination because of housing development and vehicle congestion, which also creates critical health risks for its population (Gautam, 2014). The analysis of energy consumption patterns in Kathmandu Valley showed that air pollutant emissions reached 63,000 tons in 1993 and would increase fivefold by 2013 according to the business-as-usual projection. The transport sector represented the highest emission level, which followed the household and industrial sectors that used gasoline and fuelwood, and coal as their primary fuels, while carbon monoxide (CO) served as the main pollutant (R. Shrestha, 1996).

The world experiences a rising number of respiratory diseases, which scientists link to pollution because air pollution, especially through PM2.5 particles, carbon monoxide, and nitrogen dioxide emissions, creates a significant health threat, enabling infections to develop in children and adults to acquire chronic diseases. The metropolitan areas of Nepal, particularly in Kathmandu Valley, experience increasing health hazards because population growth, unplanned urbanization, industrial emissions, vehicular emissions, and incomplete policy enforcement create dangerous conditions. The Nepal Health Research Council conducted a year-long study (2014–2015) about ambient air pollution and its respiratory health effects because consistent air quality monitoring did not exist despite the existing challenges (Karki et al., 2016).

The research estimates health benefits and economic advantages that come from bringing air pollution levels down to safe standards in Kathmandu and Lalitpur. This study found that each person would receive an annual welfare benefit of NRS 266, which equals USD 3.70. The research predicts an annual benefit of NRS 315 million, which equals USD 4.37 million for both cities through its analysis of household and pollution data from different times and places. The completed implementation of Nepal's energy Master Plan, together with safe pollution levels, will provide discounted health benefits that total NRS 6,085 million, which equals USD 80.53 million over a period of 20 years, according to Adhikari 2012 (Adhikari, 2012). People who experience long-term contact with air pollution develop respiratory disorders, which include asthma and chronic obstructive pulmonary disease, and they also develop cardiovascular diseases, and their risk of death increases (Brook et al., 2010). The elderly population, together with children and low-income groups, forms the vulnerable population because they face greater health risks (Gurung & Bell, 2013). The need for comprehensive research studies that examine the health effects of air pollution in Nepal has not been fulfilled because existing studies do not cover urban areas. The study bridges the research gap through

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its investigation of air pollution exposure and public health results, which build on earlier research.

2. Methodology

The study applies a systematic review method to examine existing scientific literature about air pollution and its health effects in Nepal. The authors conducted an in-depth examination of prior research studies, together with secondary data and national survey reports, to determine the existing levels of ambient air pollutants and their respective sources and the resulting health effects. The researchers combined data from air quality monitoring stations, hospital records, and household surveys to study how pollutant exposure patterns affected respiratory and cardiovascular health outcomes. The review included economic evaluations and policy assessments to show the complete impacts of the research while demonstrating existing research gaps and limitations, which included the requirement for longitudinal studies, advanced exposure assessments, and empirical evaluations of policy interventions.

3. Findings of Previous Studies

3.1 Air pollution in Nepal

The research shows that decreasing childhood pneumonia rates in Nepal between 2006 and 2016 did not eliminate the ongoing danger of household air pollution (HAP). The study discovered that national survey data showed greater pneumonia rates in residences that used polluting fuels and did not have distinct cooking areas. Households with this condition in 2016 had children who faced almost double the pneumonia risk because 30.9% of cases resulted from missing separate kitchens and 39.8% occurred due to using polluting fuels. The existing energy solutions for households need to become cleaner because HAP from these solutions directly connect to childhood pneumonia cases (Budhathoki et al., 2020).

Research demonstrates that countries that develop economically and industrialize their economies produce high levels of air pollution, which leads to climate change, but nations such as Nepal face greater environmental damage because of this situation. Nepal ranks among the top 10 most polluted countries and is experiencing increasing climate-related impacts. The study evaluates current climate risks in Nepal by reviewing previous research and secondary data, which show how domestic and transboundary pollution sources, such as regional air pollutant transport and increased mobility and forest fires, have increased climate risks and need specific mitigation efforts and access to climate funds (Nepal & Raj Panthee, 2025).

The fast growth of cities, together with the rising number of vehicles and the development of industrial facilities, has resulted in increased air pollution problems that now affect Nepal. The research examines air pollution patterns in Pokhara Valley between 2018 and 2020 by studying PM2.5 and PM10 measurements from three different monitoring stations. The results show that PM2.5 levels reach their highest point during winter months because they surpass healthy AQI thresholds, while most of the time PM10 stays within safe boundary limits. The research identifies primary sources of pollution together with their health effects, which provide essential information that will help develop future policies and plans to reduce air pollution in the area (Pandey et al., 2024).

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Air pollution presents a major public health danger to Nepal because there is insufficient research about its effects on health at the regional level. The study shows that about 48881 adults aged 25 and above died from non-communicable diseases and lower respiratory infections, which doctors linked to PM2.5 exposures throughout the year 2019. The study demonstrates that air quality improvements based on WHO air quality targets would have saved 39419 lives of adults who would have died prematurely in 2019, which represents an important chance to enhance public health by reducing air pollution (Dhital et al., 2024).

Household air pollution (HAP) from biomass fuel use continues to be a major public health problem in Nepal, which affects respiratory health through its impact on rural communities and leads to increased rates of childhood pneumonia, ARI/pneumonia, and COPD/asthma. The study estimated Attributable Fraction (AF) and Attributable Burden (AB) of the diseases through national and sub-national data for 2019/20, which showed that HAP caused most diseases through its presence in all regions of the study area, but especially in Karnali province. The AFs showed higher values in rural areas, which established HAP as a major respiratory health risk throughout the country (Shrestha, 2022).

3.2 Effect of Air Pollution on Human Health

Authors & Years	Title	Key findings
Poudel et al. (2022)	Air Pollution and Respiratory Health in Kathmandu Valley	$PM_{2.5}$ levels in Kathmandu exceed WHO guidelines by 5–10 times, resulting in an increase in asthma, COPD, and lung infection cases. Children and the elderly showed the highest susceptibility to pollution-related respiratory diseases.
Shakya et al. (2021).	Cardiovascular Risks from Chronic $PM_{2.5}$ Exposure in Urban Nepal	Long-term exposure to $PM_{2.5}$ was linked to hypertension, ischemic heart disease, and stroke. Traffic police and street vendors had 30% higher cardiovascular risks than office workers.
Khadka et al. (2020).	Brick Kiln Emissions and Respiratory Morbidity in Kathmandu	Communities near brick kilns had 2.5 times higher prevalence of chronic bronchitis compared to control areas. Sulfur dioxide (SO_2) from kilns was a major contributor to lung function decline.
Raut et al. (2023).	Indoor Air Pollution and Women's Health in Rural Nepal	Biomass fuel use in rural households caused acute respiratory infections (ARI) in 68% of women.

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Authors & Years	Title	Key findings
		Pregnant women exposed to indoor smoke had higher risks of low birth weight.
Thapa et al. (2021).	Impact of Winter Air Pollution on Public Health in Kathmandu	Winter inversions worsened $PM_{2.5}$ levels, increasing hospital admissions for pneumonia by 40%. Mask usage reduced respiratory symptoms by 25% during peak pollution months.
Bhandari et al. (2019).	Vehicular Emissions and Lung Function Decline in Kathmandu	Traffic-related NO_2 was associated with reduced lung function in adults. Rickshaw pullers and taxi drivers showed higher airway inflammation than the general population.
Joshi et al. (2022).	Air Pollution and Child Health in Nepal	Children in high-pollution zones had lower cognitive performance and higher absenteeism due to respiratory illnesses. PM_{10} exposure was linked to asthma in 22% of school-going children.
Dhimal et al. (2023).	Industrial Pollution and Occupational Health Risks	Factory workers in Kathmandu's industrial areas had higher rates of lung fibrosis. Lack of protective gear worsened occupational health hazards.
Adhikari et al. (2021).	Air Pollution and Mental Health in Urban Nepal	High $PM_{2.5}$ exposure correlated with increased anxiety and depression symptoms. Green spaces reduced psychological stress linked to pollution.
Karki et al. (2020).	COVID-19 and Air Pollution Synergy in Nepal	High $PM_{2.5}$ levels worsened COVID-19 severity and mortality rates. Lockdowns improved air quality, reducing respiratory ER visits by 35%.
Bhattarai et al. (2022).	Heavy Metals in Air and Health Risks in Kathmandu	Lead (Pb) and cadmium (Cd) from vehicular and industrial sources posed cancer risks. Street dust ingestion was a significant exposure pathway.
Gurung et al. (2021).	Seasonal Variations in Pollution and Health Effects	Post-monsoon pollution spikes increased heart attack risks by 15%. Biomass burning in winter contributed to 50% of $PM_{2.5}$ pollution.

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Authors & Years	Title	Key findings
Aryal et al. (2023).	Economic Burden of Air Pollution-Related Diseases	Annual healthcare costs due to air pollution exceeded NPR 12 billion. Lost productivity from pollution-related illnesses reduced GDP growth by 0.5%.
Dhakal et al. (2022).	Policy Gaps in Nepal's Air Quality Management	Weak enforcement of emission standards worsened public health risks. Public awareness campaigns were recommended to reduce exposure.
Shrestha et al. (2024).	Green Solutions to Mitigate Air Pollution Health Effects	Urban tree planting reduced $PM_{2.5}$ by 20% in test areas. Electric vehicle adoption could prevent 500+ annual premature deaths.

Researchers have investigated air pollution and its health impacts in Kathmandu Valley, yet their studies have not resolved multiple fundamental issues. Existing studies (Poudel et al., 2022; Shakya et al., 2021) demonstrate strong links between $PM_{2.5}$ and PM_{10} with respiratory and cardiovascular diseases, yet their studies use short-term data and cross-sectional data, which prevents understanding of extended exposure impacts. The research by Khadka et al. (2020) demonstrates the connection between brick kilns and chronic bronchitis, yet researchers have not conducted longitudinal studies that follow disease development over time. The majority of health evaluations use hospital databases and self-reported assessments, which provide insufficient data through clinical tests and biomarker measurements to determine actual health damage through physiological assessment.

Researchers have not investigated the health needs of specific vulnerable populations who require protection. The research of Joshi et al. (2022) focused on children, while Raut et al. (2023) studied rural women; however, research has not examined risk comparisons among different occupational sections, which include traffic police officers, street vendors, and factory employees, as well as pregnant women and immunocompromised persons. Adhikari et al. (2021) established a link between air pollution and mental health problems, yet studies on neurological effects and reproductive health issues remain limited. Researchers have not adequately examined how air pollution interacts with other environmental stressors, which include noise pollution and heat islands.

Researchers in multiple studies, which Thapa et al. (2021) conducted, use stationary air quality monitors that do not measure the small-scale changes in air quality throughout the valley. Personal exposure monitoring appears in only a few studies (Bhandari et al. 2019), which show that people experience different exposure levels when they travel through their work environments and move between indoor and outdoor spaces. Research studies on economic burden estimates exist (Aryal et al. 2023), yet researchers have conducted almost no studies

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about the cost-effectiveness of different mitigation methods, which include green infrastructure and electric vehicles, and the effectiveness of behavioral methods, which involve mask usage and air purifiers.

There remain implementation gaps that affect our current policies. Dhakal et al. (2022) found that air quality laws faced weak enforcement; however, research studies have not examined the health benefits resulting from present policies, which include vehicle emission standards and brick kiln regulations. The green solutions proposed by Shrestha et al. (2024) need testing to establish their practical implementation in different real-world situations and their effects on social equality, which include accessibility for low-income communities. Researchers need to conduct integrated interdisciplinary research that combines long-term health monitoring with advanced exposure assessment and policy analysis to create practical solutions for Kathmandu Valley.

4. Conclusion & Recommendation

The study shows that air pollution in Nepalese cities creates serious public health problems, which particularly affect the residents of Kathmandu Valley. The research findings show that both outdoor air pollution and indoor air pollution lead to various health conditions, which particularly impact vulnerable populations such as children, pregnant women, and elderly individuals. The existing knowledge about these impacts shows only partial progress because researchers need to collect long-term exposure data and conduct health evaluations, and create specific treatment strategies. The existing methods for enforcing policies do not provide sufficient protection against airborne pollutants, which continue to expose the population to health dangers. The solution to these problems needs an extended interdisciplinary method that unites successful policy execution with scientific investigation and public participation.

The government needs to enforce existing air quality standards more effectively while creating special regulations to manage major pollution sources, which include vehicle emissions, brick kilns, and the biomass fuel usage in rural households. Understanding how diseases progress requires health organizations to invest in permanent monitoring systems, which include clinical assessments and biomarker evaluations. Green infrastructure practices, which include urban tree planting, the promotion of clean energy, and electric vehicle adoption, will create major reductions in pollutant emissions. The public should receive more information about air quality through public awareness campaigns, while the vulnerable groups need access to behavioral interventions, which include masks and indoor air purifiers. Air quality and public health improvement require essential cooperation between researchers, policymakers, and local communities.

Transparency Statement: The authors confirm that this study has been conducted with honesty and in full adherence to ethical guidelines.
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