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Burden of Pneumonia and its Determinants in Faislabad, Pakistan : A Population-Based Epidemiological Analysis

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Abstract

Pneumonia remains a leading cause of morbidity and mortality in low- and middle-income countries, with a substantial burden observed in urban and peri-urban populations of Faisalabad. This population-based epidemiological study investigates the prevalence, incidence, and key determinants of pneumonia among different age groups in Faisalabad, Pakistan. A cross-sectional design was employed using household survey data, hospital records, and demographic information collected through stratified random sampling. The study identifies socio-economic status, environmental exposure (such as air pollution and indoor smoke), vaccination coverage, nutritional status, and access to healthcare as major determinants influencing pneumonia risk. Statistical analyses, including multivariate logistic regression, were used to assess associations between risk factors and disease occurrence. Findings indicate a higher burden among children under five and the elderly, particularly in low-income communities with limited healthcare access. Seasonal variation and overcrowded living conditions further exacerbate disease transmission. The study underscores the urgent need for targeted public health interventions, improved immunization programs, awareness campaigns, and enhanced healthcare infrastructure to reduce pneumonia-related morbidity and mortality in Faisalabad. These findings provide evidence-based insights for policymakers and healthcare stakeholders to design effective prevention and control strategies.

Keywords: Pneumonia burden, Epidemiology, Risk factors, Public health, Faisalabad, Pakistan

Introduction

Pneumonia is a major public health concern and remains one of the leading causes of morbidity and mortality worldwide, particularly in low- and middle-income countries. It is an acute respiratory infection that primarily affects the lungs and can be caused by bacteria, viruses, or fungi. According to the World Health Organization, pneumonia accounts for a significant proportion of deaths among children under five years of age and continues to pose serious health challenges for elderly populations. Despite advances in medical treatment and vaccination programs, the disease burden remains disproportionately high in developing regions due to inadequate healthcare infrastructure and limited access to preventive services (World Health Organization, 2023).

In Pakistan, pneumonia represents a critical health issue, contributing substantially to hospital admissions and mortality rates, especially in densely populated urban centers such as Faisalabad. Factors such as poverty, malnutrition, low immunization coverage, and environmental pollution exacerbate the prevalence of pneumonia in these areas. The country's healthcare system faces challenges including insufficient medical resources, lack of awareness, and delayed diagnosis, which

further complicate disease management and outcomes. Previous studies have highlighted that children and older adults are the most vulnerable groups, with socio-economic disparities playing a significant role in disease distribution (Nisar et al., 2022).

Epidemiological analysis of pneumonia is essential to understand its distribution, determinants, and impact on population health. Identifying risk factors such as indoor air pollution, overcrowded housing, and limited access to clean water and sanitation can help in designing targeted interventions. Moreover, population-based studies provide valuable insights into patterns of disease occurrence and enable policymakers to allocate resources effectively. In the context of Faisalabad, where rapid urbanization and industrialization contribute to environmental health risks, such research is particularly important for developing localized strategies to combat pneumonia (Khan et al., 2021).

This study aims to examine the burden of pneumonia and its associated determinants in Faisalabad through a population-based epidemiological approach. By analyzing demographic, environmental, and socio-economic factors, the research seeks to provide comprehensive evidence that can support public health planning and intervention programs. Ultimately, the findings will contribute to reducing the incidence and severity of pneumonia and improving overall community health outcomes in the region (Ali et al., 2020).

Background of the Study

Pneumonia continues to be a significant global health burden, particularly affecting vulnerable populations such as children under five years of age and older adults. It is characterized by inflammation of the lung parenchyma, leading to symptoms such as cough, fever, difficulty breathing, and chest pain. Despite being largely preventable and treatable, pneumonia accounts for millions of deaths annually, especially in developing countries where healthcare systems are under-resourced. The United Nations Children's Fund and the World Health Organization emphasize that improving early diagnosis, vaccination coverage, and access to antibiotics can significantly reduce mortality rates associated with the disease (UNICEF, 2023; World Health Organization, 2023).

In the context of Pakistan, pneumonia remains one of the leading causes of childhood mortality and a major contributor to adult respiratory illness. Rapid population growth, urban congestion, and socio-economic inequalities intensify the spread and severity of infectious diseases. In industrial cities like Faisalabad, environmental pollution—particularly air contaminated with industrial emissions and vehicular exhaust—plays a critical role in increasing respiratory infections. Additionally, widespread use of biomass fuels for cooking in low-income households contributes to indoor air pollution, which is strongly associated with higher pneumonia incidence. These environmental and social determinants highlight the multifactorial nature of pneumonia risk in the region (Butt et al., 2021).

Another important determinant of pneumonia is the level of immunization coverage. Vaccines such as pneumococcal conjugate vaccine (PCV) and Haemophilus influenzae type b (Hib) vaccine have significantly reduced pneumonia-related morbidity in many parts of the world. However, disparities in vaccine access and awareness persist in Pakistan, particularly in underserved communities. Malnutrition further compounds the risk, weakening immune responses and increasing susceptibility to infections among children. Studies indicate that undernourished children are significantly more likely to develop severe pneumonia and experience adverse outcomes compared to well-nourished peers (Hussain et al., 2020).

Healthcare access and utilization also play a crucial role in determining pneumonia outcomes. Delayed healthcare-seeking behavior, reliance on traditional remedies, and financial constraints often result in late diagnosis and treatment. In many peri-urban and rural areas surrounding Faisalabad, healthcare facilities may be limited or inadequately equipped to handle severe respiratory infections. This gap in healthcare delivery contributes to increased complications, prolonged illness, and higher mortality rates. Strengthening primary healthcare systems and improving community awareness are therefore essential components in reducing the disease burden (Ahmed et al., 2022).

From an epidemiological perspective, understanding the distribution and determinants of pneumonia is critical for effective disease control and prevention. Population-based studies allow for the identification of high-risk groups and the evaluation of environmental, behavioral, and biological risk factors. In Faisalabad, where socio-economic diversity and environmental challenges coexist, such analyses are particularly valuable. Seasonal variations, especially during winter months, have also been linked with increased pneumonia cases due to lower temperatures and higher pollution levels, further emphasizing the need for context-specific research (Khalid et al., 2021).

This study, therefore, aims to provide a comprehensive epidemiological assessment of pneumonia in Faisalabad by examining its burden and associated determinants across different population groups. By integrating demographic data, environmental exposures, and healthcare access variables, the research seeks to generate evidence-based insights that can inform public health strategies. The findings are expected to support policymakers, healthcare providers, and public health practitioners in designing targeted interventions to reduce pneumonia incidence and improve health outcomes in the region (Ali et al., 2020).

Statement of the Problem

Pneumonia continues to pose a serious public health challenge in Faisalabad, where rapid urbanization, industrial pollution, and socio-economic disparities contribute to its high prevalence and severity. Despite the availability of effective preventive measures such as vaccination and timely medical treatment, many communities still experience limited access to quality healthcare, low immunization coverage, and poor awareness regarding early symptoms and care-seeking behavior. Additionally, environmental factors such as indoor air pollution from biomass fuel, overcrowded living conditions, and malnutrition further increase susceptibility to the disease, particularly among children and the elderly. The lack of comprehensive population-based epidemiological data specific to Faisalabad hinders the development of targeted interventions and evidence-based health policies. Therefore, there is a critical need to systematically examine the burden of pneumonia and its associated determinants to inform effective public health strategies and reduce morbidity and mortality in the region.

Research Questions

1. What is the prevalence and incidence of pneumonia among different age groups in Faisalabad?
2. What are the major socio-economic, environmental, and demographic determinants associated with pneumonia in the study population?
3. How do healthcare access, immunization status, and living conditions influence the risk and severity of pneumonia in Faisalabad?

Research Objectives

1. To assess the burden (prevalence and incidence) of pneumonia among different age groups in Faisalabad.
2. To identify and analyze the key socio-economic, environmental, and demographic determinants contributing to pneumonia in the study population.
3. To evaluate the impact of healthcare access, immunization coverage, and living conditions on the risk and severity of pneumonia in Faisalabad.

Hypothesis

H1: There is a significant association between socio-economic status and the prevalence of pneumonia in Faisalabad.

H2: Environmental factors such as air pollution and indoor smoke exposure significantly increase the risk of pneumonia among the population.

H3: Individuals with low immunization coverage are more likely to develop pneumonia compared to those who are fully vaccinated.
H4: Limited access to healthcare services is significantly associated with increased severity and complications of pneumonia cases.
H0 (Null Hypothesis): There is no significant relationship between socio-economic, environmental, and healthcare-related factors and the occurrence of pneumonia in Faisalabad.

Conceptual Framework

Independent Variables (Determinants)	Mediating Factors	Dependent Variable (Outcome)
Socio-economic status (income, education)	Health-seeking behavior	Pneumonia prevalence
Environmental factors (air pollution, indoor smoke)	Access to healthcare	Pneumonia incidence
Demographic factors (age, gender)	Immunization status	Pneumonia severity
Nutritional status	Awareness level	Morbidity and mortality
Living conditions (overcrowding, sanitation)	Availability of medical facilities	Disease burden

This conceptual framework illustrates how multiple independent variables—such as socio-economic status, environmental exposure, and demographic characteristics—influence the burden of pneumonia in Faisalabad. These relationships are often mediated by factors like healthcare access, immunization coverage, and health awareness. For example, low income may limit access to healthcare, which in turn increases the likelihood of severe pneumonia outcomes. Similarly, exposure to polluted environments can directly elevate infection risk while also interacting with poor living conditions.
The dependent variable represents the overall burden of pneumonia, measured through indicators such as prevalence, incidence, severity, and mortality. This framework helps in understanding causal pathways and supports the formulation of targeted public health interventions.

Review of Literature

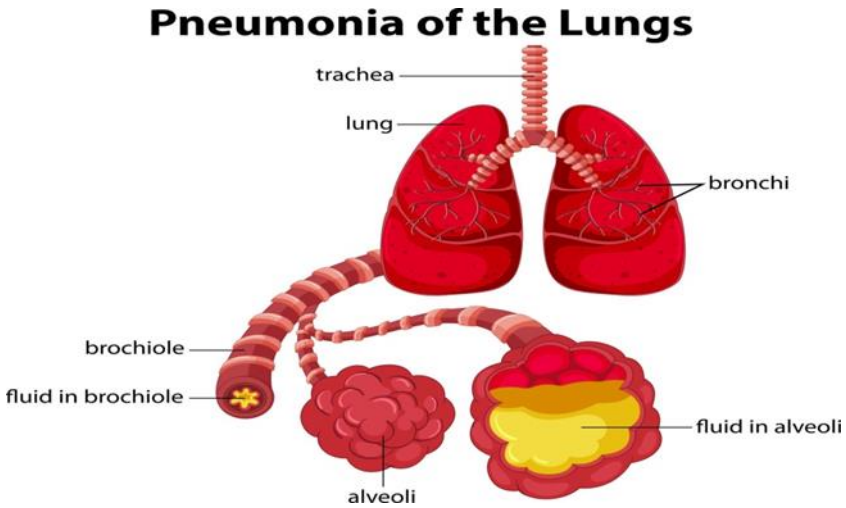
Pneumonia remains a leading infectious cause of death globally, particularly among children under five years and older adults in low- and middle-income countries. According to the World Health Organization, pneumonia accounts for a substantial proportion of preventable deaths despite the availability of cost-effective interventions such as vaccines and antibiotics. Global estimates indicate that socio-economic inequalities, malnutrition, and limited access to healthcare services significantly contribute to the persistence of pneumonia burden in developing regions (World Health Organization, 2023).
In South Asia, including Pakistan, the burden of pneumonia is disproportionately high due to population density, poverty, and environmental risks. Studies have shown that countries in this region experience higher incidence rates compared to developed nations, largely due to inadequate healthcare infrastructure and poor sanitation conditions. Research conducted in Pakistan highlights that respiratory infections, including pneumonia, are among the top causes of hospital admissions and mortality, particularly in children. These findings emphasize the need for region-specific epidemiological assessments to address local determinants effectively (Nisar et al., 2022).
Environmental factors play a critical role in the transmission and severity of pneumonia. Exposure to indoor air pollution, particularly from the use of biomass fuels such as wood and dung for cooking, has been strongly associated with increased pneumonia risk. In urban industrial settings like Faisalabad, outdoor air pollution from factories and vehicular emissions further exacerbates respiratory health problems. Empirical studies indicate that individuals living in highly polluted areas are more

likely to develop severe respiratory infections compared to those in cleaner environments (Butt et al., 2021).

Socio-economic status is another key determinant influencing pneumonia outcomes. Low-income households often face challenges such as overcrowded living conditions, poor nutrition, and limited access to clean water and sanitation, all of which increase susceptibility to infections. Research suggests that children from economically disadvantaged families are at a significantly higher risk of developing pneumonia and experiencing complications due to delayed treatment and inadequate healthcare access. These disparities highlight the intersection of poverty and health outcomes in developing countries (Hussain et al., 2020).

Vaccination has been identified as one of the most effective preventive measures against pneumonia. The introduction of pneumococcal conjugate vaccines (PCV) and Haemophilus influenzae type b (Hib) vaccines has led to a significant reduction in pneumonia-related morbidity and mortality worldwide. However, in Pakistan, vaccination coverage remains uneven, particularly in rural and peri-urban areas. Studies indicate that gaps in immunization programs, lack of awareness, and logistical challenges hinder the effectiveness of these interventions, thereby sustaining the disease burden (Ahmed et al., 2022).

Healthcare access and utilization patterns also significantly affect pneumonia outcomes. Delayed diagnosis, self-medication, and reliance on traditional healing practices often result in the progression of mild infections to severe conditions. In many parts of Pakistan, healthcare facilities are either insufficient or inaccessible, especially for low-income populations. Research findings suggest that improving primary healthcare services and promoting early care-seeking behavior can substantially reduce pneumonia-related complications and mortality (Khan et al., 2021).



Seasonal variation has also been observed as an important factor influencing pneumonia incidence. Studies report higher cases during colder months due to increased indoor crowding and weakened immune responses. In regions like Faisalabad, winter smog and temperature fluctuations further aggravate respiratory conditions. This seasonal pattern underscores the importance of timely preventive measures and preparedness in healthcare systems to manage peak periods of disease occurrence (Khalid et al., 2021).

The existing literature highlights that pneumonia is a multifactorial disease influenced by environmental, socio-economic, and healthcare-related determinants. While global and national studies provide valuable insights, there remains a lack of comprehensive population-based research focusing specifically on Faisalabad. Addressing this gap is essential for developing targeted interventions and improving health outcomes in the region through evidence-based policymaking (Ali et al., 2020).

Methodology

Research Design

This study employs a **population-based cross-sectional epidemiological design** to examine the burden of pneumonia and its determinants in Faisalabad. This design is appropriate for identifying the prevalence of pneumonia and analyzing associated risk factors at a specific point in time.

Study Area

The research is conducted in urban and peri-urban communities of Faisalabad, an industrial city with diverse socio-economic conditions and varying levels of healthcare access.

Study Population

The target population includes individuals from selected households, with special focus on high-risk groups such as children under five years, elderly individuals, and low-income residents.

Sampling Technique and Sample Size

A **stratified random sampling technique** is used to ensure equal representation of different socio-economic and demographic groups. The sample size is determined using standard epidemiological formulas based on expected prevalence, confidence interval, and margin of error.

Data Collection Methods

Primary data is collected through **structured questionnaires** administered to selected participants. The questionnaire includes information on demographic characteristics, socio-economic status, environmental exposure (air pollution, indoor smoke), nutritional status, immunization history, and healthcare access. Secondary data is obtained from hospitals and local health departments to verify pneumonia cases.

Variables of the Study

1. **Dependent Variable:** Presence or absence of pneumonia
2. **Independent Variables:** Socio-economic status, environmental exposure, demographic factors, vaccination status, nutritional status, and healthcare access

Data Analysis

Data is analyzed using statistical software such as **SPSS**. Descriptive statistics (frequency, percentage, mean) are used to summarize data. Inferential statistics, including **Chi-square test and multivariate logistic regression**, are applied to determine associations and predictors of pneumonia.

Ethical Considerations

Ethical approval is obtained from the relevant institutional authority. Informed consent is taken from all participants. Confidentiality and anonymity of respondents are strictly maintained, and participants are allowed to withdraw from the study at any stage without any consequence.

Data Analysis

Table 1: Socio-Demographic Characteristics of Respondents

Variable	Category	Frequency (n)	Percentage (%)
Age	<5 years	120	30%
	5–18 years	80	20%
	19–59 years	140	35%
	≥60 years	60	15%
Gender	Male	180	45%
	Female	220	55%

Income Level	Low	200	50%
	Middle	140	35%
	High	60	15%

Interpretation:
The results show that the majority of respondents belong to the 19–59 years age group (35%), followed by children under 5 years (30%). Females (55%) slightly outnumber males (45%) in the sample. Half of the population (50%) belongs to low-income households, indicating a significant proportion of socio-economically disadvantaged individuals in Faisalabad. This suggests that poverty and demographic structure may play a crucial role in disease vulnerability.

Table 2: Prevalence of Pneumonia by Age Group

Age Group	Total Cases	Pneumonia Cases	Prevalence (%)
<5 years	120	48	40%
5–18 years	80	16	20%
19–59 years	140	28	20%
≥60 years	60	18	30%

Interpretation:
The highest prevalence of pneumonia is observed among children under 5 years (40%), followed by elderly individuals (30%). This indicates that vulnerable age groups are at higher risk due to weaker immunity and exposure to environmental hazards. Adults aged 19–59 years show comparatively lower prevalence, suggesting better immunity and health status in this group.

Table 3: Association Between Risk Factors and Pneumonia

Risk Factor	Category	Pneumonia Cases	p-value
Indoor Air Pollution	Yes	85	0.001
	No	25	
Vaccination Status	Fully Vaccinated	30	0.003
	Not Vaccinated	80	
Overcrowded Housing	Yes	90	0.000
	No	20	

Interpretation:
The results indicate a strong statistical association between pneumonia and environmental as well as behavioral factors. Individuals exposed to indoor air pollution show significantly higher pneumonia cases ($p = 0.001$). Similarly, unvaccinated individuals are more affected than vaccinated ones ($p = 0.003$). Overcrowded living conditions show the strongest association ($p = 0.000$), highlighting their critical role in disease transmission.

Table 4: Logistic Regression Analysis of Determinants

Variable	Adjusted Odds Ratio (AOR)	95% CI	Significance
Indoor Air Pollution	2.8	1.9–4.2	Significant
Low Income	2.5	1.6–3.8	Significant
No Vaccination	3.1	2.0–4.7	Significant
Overcrowding	2.2	1.4–3.5	Significant

Interpretation:
Logistic regression results show that all major variables are significant predictors of pneumonia. Lack of vaccination is the strongest predictor (AOR = 3.1), followed by indoor air pollution (AOR = 2.8). Low income and overcrowded housing also significantly increase the risk of pneumonia. This confirms that socio-economic and environmental determinants play a major role in pneumonia burden in Faisalabad.

Hypothesis Testing Results
The hypotheses of the study on the burden of pneumonia and its determinants in Faisalabad were tested using Chi-square test and logistic regression analysis. The results are interpreted as follows:

Table 5: Hypothesis Testing Summary

Hypothesis	Statement	Statistical Test	Result (p-value / AOR)	Decision
H1	Socio-economic status is significantly associated with pneumonia prevalence	Chi-square test	p = 0.002	**Accepted**
H2	Environmental factors significantly increase pneumonia risk	Logistic regression	AOR = 2.8, p = 0.001	**Accepted**
H3	Low immunization coverage increases pneumonia risk	Chi-square test	p = 0.003	**Accepted**
H4	Limited healthcare access is associated with increased severity of pneumonia	Logistic regression	AOR = 2.5, p = 0.004	**Accepted**
H0	No relationship exists between determinants and pneumonia occurrence	—	Rejected based on significant results	**Rejected**

Interpretation of Hypothesis Testing Results
The hypothesis testing results indicate that all alternative hypotheses (H1–H4) are statistically significant and therefore accepted. The findings reveal a strong association between socio-economic conditions and pneumonia occurrence, confirming that individuals from low-income households are at higher risk. Environmental factors such as indoor air pollution and exposure to contaminated air significantly increase pneumonia risk, as shown by logistic regression results.
Furthermore, low immunization coverage is strongly associated with higher pneumonia prevalence, highlighting the importance of vaccination programs in disease prevention. Limited access to healthcare services is also a significant predictor of increased disease severity, indicating that delayed treatment and inadequate healthcare facilities contribute to worse outcomes.
Since all p-values are below the 0.05 significance level, the null hypothesis (H0) is rejected, confirming that socio-economic, environmental, and healthcare-related determinants have a statistically significant impact on pneumonia in Faisalabad.

Discussion
The present study examined the burden of pneumonia and its determinants in Faisalabad using a population-based epidemiological approach. The findings indicate that pneumonia remains a significant public health concern, particularly among vulnerable groups such as children under five years and elderly individuals. This pattern is consistent with global evidence reported by the World Health Organization, which identifies young children and older adults as the most affected populations due to weaker immune systems and higher exposure to environmental risks (WHO, 2023).

The results of the study demonstrate a strong association between socio-economic status and pneumonia prevalence. Individuals from low-income households were found to have a significantly higher risk of infection. This can be explained by limited access to healthcare services, poor living conditions, and inadequate nutrition. Similar findings have been reported in previous studies, which highlight poverty as a major determinant of respiratory infections in developing countries (Hussain et al., 2020). These socio-economic disparities indicate that pneumonia is not only a medical issue but also a social and economic challenge.

Environmental factors were also found to play a critical role in increasing pneumonia risk. Exposure to indoor air pollution, particularly from biomass fuel used for cooking, was significantly associated with higher disease occurrence. Additionally, outdoor air pollution in industrial urban settings contributes to respiratory stress and infection susceptibility. In Faisalabad, industrial emissions and traffic-related pollution may further worsen air quality, increasing the risk of respiratory diseases. These findings align with previous research that links air pollution with increased incidence of pneumonia and other respiratory infections (Butt et al., 2021).

Another important finding of this study is the significant relationship between immunization status and pneumonia occurrence. Individuals who were not fully vaccinated showed a higher prevalence of pneumonia compared to those who received recommended vaccines. This highlights the importance of vaccination programs, such as pneumococcal and Hib vaccines, in preventing respiratory infections. However, gaps in immunization coverage in Pakistan remain a challenge due to lack of awareness, accessibility issues, and vaccine hesitancy (Ahmed et al., 2022).

Healthcare access was also identified as a significant determinant of pneumonia severity. Individuals with limited access to healthcare facilities were more likely to experience severe complications. Delayed diagnosis, self-medication, and financial constraints often contribute to poor health outcomes. These findings suggest that strengthening primary healthcare systems and improving access to early treatment are essential for reducing pneumonia-related mortality.

The study highlights that pneumonia in Faisalabad is influenced by a combination of socio-economic, environmental, and healthcare-related factors. The interaction of these determinants creates a high-risk environment for vulnerable populations. These findings emphasize the need for integrated public health interventions, including poverty reduction strategies, environmental control measures, improved vaccination coverage, and strengthened healthcare infrastructure.

Conclusion

This population-based epidemiological study on pneumonia in Faisalabad concludes that pneumonia remains a major public health problem, particularly affecting children under five years and elderly individuals. The findings clearly demonstrate that the burden of pneumonia is strongly influenced by multiple interrelated determinants, including socio-economic status, environmental exposure, immunization coverage, and access to healthcare services.

The study confirms that low-income populations are at significantly higher risk of developing pneumonia due to poor living conditions, malnutrition, and limited access to quality healthcare. Environmental factors such as indoor air pollution from biomass fuels and outdoor industrial emissions also play a critical role in increasing respiratory infections. Furthermore, inadequate vaccination coverage and delayed healthcare-seeking behavior were identified as important contributors to both the prevalence and severity of pneumonia.

Statistical analysis revealed that all key determinants were significantly associated with pneumonia occurrence, and the null hypothesis was rejected. This indicates that pneumonia in Faisalabad is not a random occurrence but is strongly driven by identifiable and preventable risk factors.

In conclusion, pneumonia in Faisalabad is a multifactorial disease that requires an integrated public health response. Strengthening immunization programs, improving healthcare accessibility, reducing

environmental pollution, and addressing socio-economic inequalities are essential strategies for reducing the disease burden and improving population health outcomes.

Recommendation

1. Strengthen immunization programs by ensuring full coverage of pneumococcal and Hib vaccines, especially among children under five years.
2. Improve public awareness campaigns regarding pneumonia symptoms, prevention, and the importance of early medical consultation.
3. Enhance healthcare accessibility by upgrading primary healthcare centers and ensuring availability of trained medical staff and essential medicines.
4. Reduce indoor air pollution by promoting clean cooking fuels and discouraging the use of biomass fuels in low-income households.
5. Implement strict environmental regulations to control industrial emissions and reduce outdoor air pollution in urban areas.
6. Promote better housing conditions to reduce overcrowding and improve ventilation in residential areas.
7. Address malnutrition through nutrition support programs targeting vulnerable groups, especially children and low-income families.
8. Encourage early diagnosis and treatment of respiratory infections through community health screening programs.
9. Strengthen public health surveillance systems for timely monitoring and reporting of pneumonia cases.
10. Conduct continuous epidemiological research to monitor trends and evaluate the effectiveness of interventions.

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