HEALTH EFFECTS OF AMBIENT AND HOUSEHOLD AIR POLLUTION EXPOSURES IN INDIA

Abstract

Air pollution has emerged as the world's largest environmental health risk and is the leading cause of death and disability in India, according to the Global Burden of Disease 2010 study. The study revealed that combined exposure to PM2.5 from household cooking fuels and ambient air pollution contributes to a significant number of premature deaths and disability-adjusted life years (DALYs) in India, accounting for 9% of the national burden of disease. The use of solid cooking fuels such as wood and coal remains prevalent in India and exposes a large section of the population, especially women and children, to harmful by-products of incomplete combustion.

India also faces high levels of ambient air pollution, with 13 cities in the world's top 20 for annual PM2.5 levels. Weak emission control policies, along with industrial growth and increasing economic activity, pose a growing threat to air quality. Without intervention, PM2.5 levels from transport sources alone are projected to double by 2030.

This study aims to investigate the nature and extent of air pollution and household air pollution in India and associated health effects. Given the overlapping exposures across urban and rural areas, the study highlights the need for comprehensive interventions that address different pollution sources and income fractions. Through the evidence presented, the study will offer practical recommendations to reduce exposure and mitigate the resulting health burden. By

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taking proactive steps based on the study's findings, we can better understand the health impacts of air pollution and work toward effective prevention and mitigation strategies.

Keywords: Impact on health, ambient air quality, air pollution in households

I. INTRODUCTION

Exposure to air pollution in any form has long been recognized worldwide as an important risk factor for adverse health effects. However, this recognition has not yet translated into a coordinated multi-sectoral policy response that could reduce disease exposure and air pollution burden in India. More than 700 million people are still exposed to smoke from the use of biomass stoves nationwide, and India is home to 13 of the world's top 20 cities with the worst ambient air quality according to the World Health Organization (WHO).

The Global Burden of Disease study conducted in 2010 identified air pollution as the leading environmental risk factor worldwide and the leading cause of death and disability in India. A comparative risk assessment showed that approximately 1.6 million premature deaths and 59 million disability-adjusted life years (DALYs) in India are attributable to PM2.5 (fine particulate matter ≤ 2.5 μm in diameter) and other identified pollutants. in the field of household and ambient air pollution (HAP & AAP). Together, HAP and AAP account for 9% of the national burden of disease and are the single largest risk factor of the more than 60 risk factors examined in the study. GBD studies are evolving over time and specific numerical estimates can be expected to change, but it is clear that particulate air pollution will remain one of the largest causes of ill health in India until major efforts are made to reduce exposure in India population.

This is not surprising when we consider that the health effects associated with exposure to air pollution are pervasive. Our review shows that exposure to air pollution, whether indoor or outdoor, is associated with infectious diseases such as respiratory infections in infants, chronic respiratory diseases and cancer in adults, and cardiovascular disorders such as coronary heart disease and stroke. In addition, studies conducted around the world also show associations with many other health outcomes at much lower exposure levels than are common in India. Air pollution exposure also affects certain groups differently due to factors such as age, gender, pre-existing conditions, socioeconomic status, nutrition and access to health care, exacerbating existing vulnerabilities.

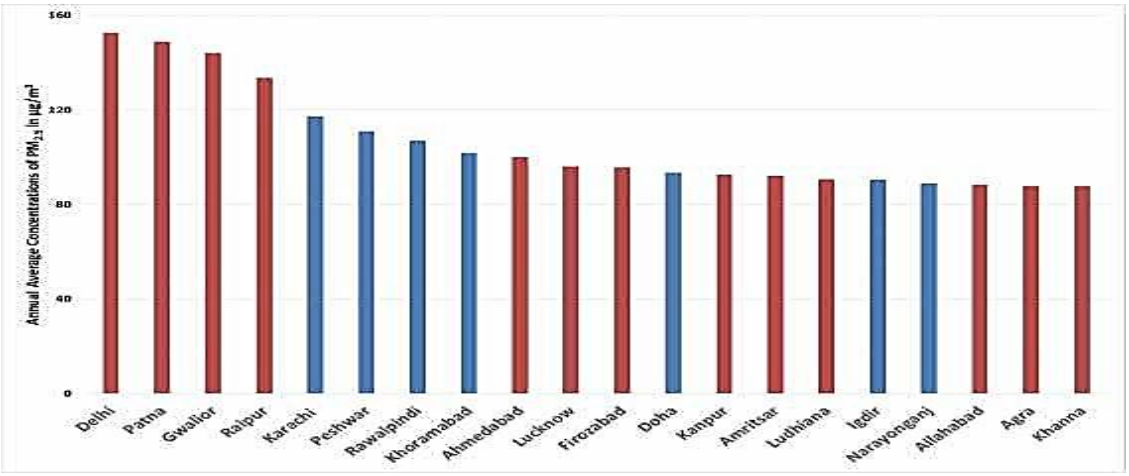

Figure 1: Top 20 Cities with Highest Annual Average $PM_{2.5}$ Levels (WHO, 2014)

Although both rural and urban populations face the risk of exposure to air pollution, current air quality monitoring practices primarily focus on large cities, making it challenging to understand the extent and distribution of population exposure. This limited monitoring hinders our ability to fully understand the nature of air pollution exposure in different regions.

Additionally, research has shown that emissions from biomass cooking are a significant contributor to PM2.5 air pollution in India. This finding underscores the interconnectedness of air and household air pollution and highlights the importance of adopting an integrated approach to mitigating and reducing the harmful effects of air pollution. By recognizing the continuum of exposure sources, we can develop comprehensive strategies that address both environmental and household pollution, leading to more effective solutions and better public health outcomes.

II. OBJECTIVE

The general objectives are listed below:

1. Focus on air pollution and household air pollution in India.
2. Focus on the health impacts of air and household air pollution in India.
3. Focus on recommendations to mitigate air pollution and health impacts.

III. LITERATURE REVIEW

Air pollution has gained global recognition as a major environmental health risk, with the Global Burden of Disease study highlighting its significant impact on mortality and disability in India. The study revealed that exposure to PM2.5 from both household and ambient sources is responsible for approximately 1.6 million premature deaths and 49 million disability-adjusted life years (DALYs) in the country. This combination of indoor air pollution (HAP) and ambient air pollution (AAP) represents the largest risk factor among the 60 factors assessed and contributes to 9% of the national burden of disease.

Despite a gradual decline in the percentage of the population using solid fuels for cooking, the absolute number remains significant, with 780 million people in India relying on wood, manure, crop residues and coal. Traditional biomass burning during cooking releases toxic by-products, including PM2.5, equivalent to the harmful effects of burning about 400 cigarettes per hour. As a result, a significant part of the population, especially women and children, who spend considerable time in the kitchen, are exposed to this source of pollution.

Worryingly, India is home to 13 of the top 20 cities worldwide with the highest annual PM2.5 levels, with Delhi taking the top spot. Inadequate policies to control emissions from industry, transportation and other sources, combined with escalating economic activity and industrialization, paint a bleak future. Without intervention, ambient levels of PM2.5 from transport alone are projected to double by 2030.

These findings highlight the urgent need for comprehensive measures to combat air pollution in India. Efforts should focus on household and ambient sources, with a focus on

reducing solid fuel consumption, strengthening emissions controls, and implementing effective policies to mitigate the growing air pollution crisis. By making improvements to air quality a priority, we can protect public health and create a cleaner, healthier environment for everyone.

IV. AIR POLLUTION: SOURCES, CONCENTRATION AND EXPOSURE

1. **Household Air Pollution:** Household air pollution (HAP) from the use of solid cooking fuels arises primarily from the challenges of achieving efficient combustion in traditional home stoves. This imperfect combustion process releases many chemicals in the form of gases and particles. While regulations in India primarily target outdoor pollutants such as particulate matter, carbon monoxide and nitrogen oxides, studies reveal that traditional chulhas (stoves) release a range of other harmful pollutants including formaldehyde, benzene, polyaromatic hydrocarbons and even dioxins.

   Unlike ambient air quality, which benefits from national monitoring programs providing routine data, HAP exposure assessments have relied heavily on single research studies since the 1980s. However, in recent decades there has been a significant increase in the depth of information on HAP exposures in India. Measurements of short-term and 24-hour concentrations and exposures in homes were conducted in a variety of home environments in multiple states, contributing to a more comprehensive understanding of the problem. Notably, the exposure estimate for solid fuel users used in the 2010 Global Burden of Disease assessment was based on an exposure model developed specifically for India.

   These advances in HAP research and exposure assessment have added to our knowledge and awareness of the significant health risks associated with the use of solid fuels in cooking. By recognizing the diverse spectrum of emitted pollutants and their potential health consequences, policymakers and stakeholders can develop targeted interventions and strategies to reduce exposure, improve indoor air quality, and ultimately protect the health of individuals and communities affected by indoor air pollution.

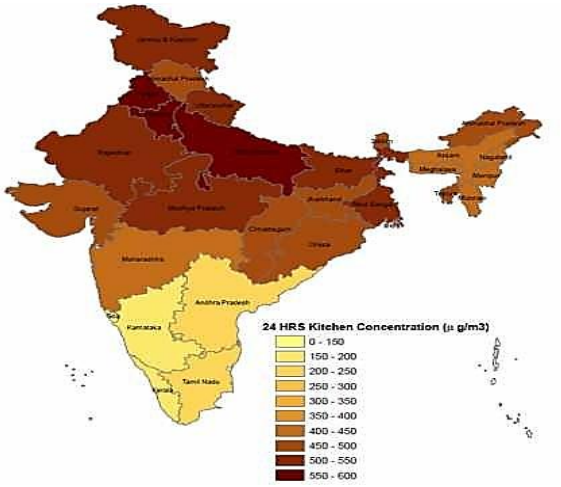

Figure 2: Distribution of 24-Hr Average Kitchen Area $PM_{2.5}$ Concentrations in Solid Fuel Using

Households Acrossstates (Source: Balakrishnan et al. 2013)

Although varying by state (Figure 2), national exposure models developed for solid fuels using household-level estimates have average PM2.5 exposures of 337 µg/m3, 204 µg/m3 and 285 µg/m3 for women, men and children. Exceeding the current interim targets of the WHO Air Quality Guidelines (WHO-AQG IT-1) of 35 µg/m3 or the Indian standard of 40 µg/m3.

Several recent studies (Chengappa et al. 2007, Dutta et al. 2007, Balakrishnan et al. 2014, Sambandam et al. 2014) have also shown that many technologies used in earlier or newer models of "improved" biomass stoves reduce emissions so significantly , to really protect health. This is partly because, as discussed in Chapter 4 of this report, detectable health risks for most disease endpoints begin at low levels of PM2.5 concentration. For example, reducing exposure from 350 to 175 µg/m3 is unlikely to result in much risk reduction, especially compared to reaching Indian standards of 40 µg/m3 or even lower.

2. **Air Pollution:** The rapid expansion of the industrial, energy and transport sectors along with urbanization in India has raised significant concerns about air pollution. City dwellers face increasing levels of particulate matter (PM10 and PM2.5), sulfur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO) and ozone. While SO2 levels have declined, all other pollutants consistently exceed National Air Quality Standards (NAAQS). More than half of the cities monitored by the National Air Quality Monitoring Program (NAMP) show critical levels of PM10, with more than two-thirds exceeding the safe limit of 60 µg/m3. NO2 levels are also on the rise in several cities, with Delhi frequently breaching ozone standards. Although SO2 levels have generally declined, many cities still struggle with unhealthy levels of multiple pollutants simultaneously.

However, assessment of the contribution of different sources to air pollution in India remains insufficient. Some studies have been conducted by various agencies in selected cities and the Central Pollution Control Board (CPCB) operates a limited number of air quality monitoring stations, mainly in larger cities. Thus, gaining a comprehensive national understanding of this issue relies heavily on satellite modelling. Satellite modeling of PM2.5 concentrations across the country, as shown in Figure 2, reveals the harsh reality of ambient air pollution in rural areas. While most of South India complies with NAAQ standards, the Indo-Gangetic Plain consistently shows critical PM2.5 levels due to the prevalence of brick kilns, outdated and inefficient combustion technologies, and the use of biomass and coal for domestic cooking and cooking. heating purposes.

These findings highlight the urgent need for comprehensive air pollution control measures that target specific pollution sources and geographic areas. Expanding the air quality monitoring network and implementing effective policies and regulations across sectors will be essential to address India's complex air pollution problem. By understanding specific sources and their impact, policymakers can develop targeted strategies and interventions to mitigate pollution and protect public health.

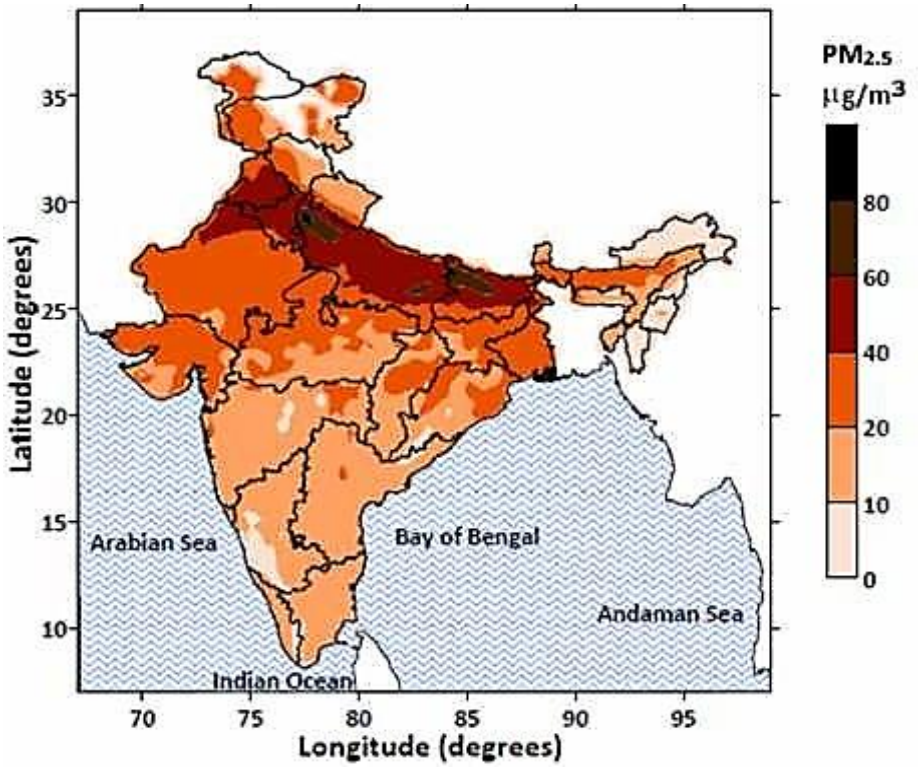

Figure 4: Ambient $PM_{2.5}$ Concentrations Derived from Satellite Observations (Van Donkelaar Et Al., 2012)

Studies have revealed a strong correlation between elevated PM10 and SO2 levels and proximity to coal-fired power plants. With the expected growth in coal-fired power generation and the absence of strict regulations on stack emissions, this problem is expected to worsen over time.

Recent research has focused on apportionment of exposure and identification of emission sources. However, these calculations primarily consider downwind exposure and do not account for near-field exposures, which can often be significantly higher. However, exposure partitioning estimates can play a key role in designing and implementing policies to mitigate specific sources of exposure and improve traditional control measures by more effectively targeting health-related exposures.

The revised 2009 ambient air quality standards now include six carcinogenic air toxics and heavy metals. However, data on their levels across the country is limited because cities have not yet established the capacity to continuously monitor toxic substances in the air.

Over the past three decades, substantial progress has been made in building a global evidence base that offers a comprehensive understanding of household air pollution (HAP). The evidence base for the health effects of ambient air pollution (AAP) is even more extensive and includes thousands of studies worldwide. Recently, HAP has been shown to be a significant contributor to AAP in many countries, including India. Therefore, it is essential to examine air pollution exposure and its impacts in an

integrated manner in order to develop comprehensive strategies to address this complex problem.

In India, many studies have been conducted in recent decades to investigate the health effects of air and household air pollution. These studies used established techniques to estimate health effects based on findings from research conducted elsewhere. Similar techniques using exposure-response analyzes are commonly used in policies that address various environmental health risks such as water pollution, toxic chemicals, and workplace pollutants.

Understanding the health burden of air and household air pollution in men, women, and children has evolved beyond respiratory outcomes. It is now widely accepted that air pollution also affects conditions such as coronary heart disease, stroke, cataracts, lung cancer, adverse pregnancy outcomes, tuberculosis, asthma exacerbations, other cancers and cognitive impairment. As with tobacco smoking, which has similar health effects, air pollution requires its integration into public health programs that address both non communicable and communicable diseases.

Estimating the burden of disease related to air pollution has been significantly enhanced by the development of integrated exposure-response (IER) relationships. These relationships draw on a vast body of health literature on outdoor air pollution (mostly from developed countries), active smoking and indoor air pollution. The IERs demonstrate a stepwise increase in disease risk in five major categories (lung cancer, heart disease, stroke, chronic obstructive pulmonary disease, and childhood pneumonia) spanning a wide range of exposures. Outdoor air pollution represents the lower limit of exposure, active smoking the highest, and passive smoking and indoor air pollution fall in between.

The consistency of effects observed across the spectrum of exposure through IER increases the reliability of risk estimates and allows for the comparison of attributable disease estimates across different combustion sources. This makes it possible to evaluate intervention options based on individual benefits as well as co-benefits. In particular, the use of IER in the 2010 Global Burden of Disease assessment attributed approximately 1.04 million premature deaths and 31.4 million DALYs to household air pollution from the use of solid cooking fuels and 627,000 deaths and 17.7 million DALYs to ambient air pollution in India.

Given the widespread prevalence of high exposure levels in rural and urban populations, the diverse range of associated health outcomes (including those with high base prevalence rates), and the wide range of populations at risk (encompassing all age groups, including infants and children). young children who do not smoke), the burden of disease caused by air pollution remains significant.

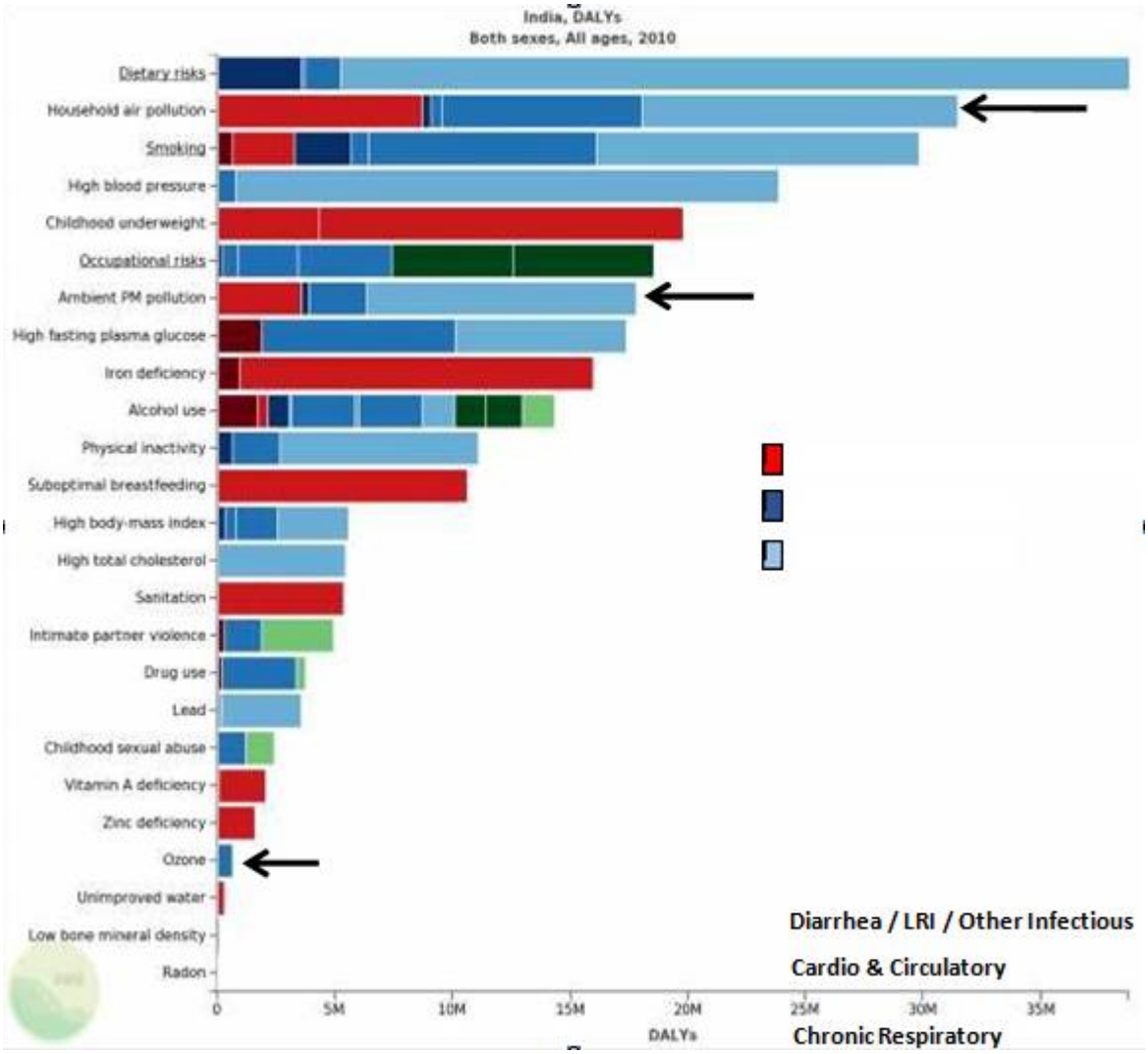

Figure 5: Ranking of Risk Factors based on DALY Contribution in India (GBD, 2010)

V. RECOMMENDATIONS

Given the complex nature of air pollution, which is characterized by multiple sources and impacts, it is clear that there is no single solution that can effectively address the problem. Addressing this issue requires a multidisciplinary approach guided by extensive environmental and health data, scientific research and evidence-based practices. Developing, strengthening, and implementing policies and programs to combat this significant risk factor in our national disease burden requires a unified and coordinated effort across various government entities. While the Ministry of Health and Family Welfare (MoHFW) can take certain steps listed below, many others will require the involvement of other ministries and agencies.

We recognize that reducing both emissions and exposure is critical to protecting public health. However, when prioritizing interventions, it is vital to base decisions primarily on exposure, as it directly affects health outcomes. Therefore, while we strongly advocate reducing emissions to minimize overall population exposure, the sources that

contribute the most significant levels of exposure and adverse health effects should have the highest immediate priority.

1. **Source-Wise Actions To Reduce Exposure:** We recommend focusing on key sources of air pollution that contribute to long-term and episodic exposures. Within each category, we list the following sources in order of priority based on exposure estimates to reduce the health effects of air pollution.

Long-Term Exposures

- **Air Pollution in Households:** Adopting the WHO-recommended PM2.5 and CO emission targets in ventilated and unventilated kitchens is essential to address indoor air pollution, which requires a shift to cleaner energy sources in the home. There are two primary options to consider: make clean energy sources readily available, such as electric cooking or gas, or focus on cleaner widely used biomass sources. In the first case, special attention should be paid to the implementation of fiscal policies and the development of distribution systems that ensure affordable and accessible clean energy options for the economically disadvantaged. In the second case, the existing norms for biomass stoves in India need to be revised to be in line with the emission targets set by the WHO, leading to the adoption of advanced stove technologies that reduce pollution. Additionally, community-level approaches should be emphasized for effective intervention strategies to address household air pollution.

  Achieving widespread adoption of clean energy in cooking and transitioning away from traditional sources and practices will require insights from the behavioral and social sciences. Drawing on successful health interventions such as improved sanitation, vaccine delivery, safer sex, and malaria control, these disciplines can provide valuable knowledge and strategies. It is essential to coordinate efforts between various ministries and leverage existing initiatives such as the National Biomass Stove Program of the Government of India to ensure greater access to clean energy for cooking within set time frames.

- **Vehicle pollution:** A number of control measures can be put in place to address the health impacts of vehicular pollution. We recommend adopting an avoid-change-improve framework for prioritizing actions and managing the health effects of vehicles.

  The 'avoidance' aspect involves minimizing the use of vehicles, especially in areas with high or dense population, through integrated land use planning that effectively manages transport demand. In the short term, targeted approaches can be implemented such as the implementation of financial disincentives such as higher fuel taxes, congestion charges and increased parking charges in densely populated areas. Regulatory measures can also be used, such as the creation of vehicle-free zones in areas of high population density or the introduction of wider restrictions on vehicle use.

The "shift" component emphasizes the shift to modes of transportation that reduce pollution and overall impact while still facilitating the movement of goods and people. This can be done by promoting the availability of mass transit options such as buses and subway rail systems, as well as promoting non-motorized modes of transportation such as bicycles. By increasing the use of these cleaner modes of transport, the health impacts per passenger kilometer traveled can be reduced.

The 'improve' element focuses on improving vehicle technology to minimize pollutant emissions per kilometer driven. This can be achieved through significantly stricter emission and fuel standards, which will reduce emissions per vehicle kilometer and prevent the spread of polluting technologies in the new fleet. Strict controls on road vehicles should also be introduced to ensure they do not exceed emission limits. Prioritizing health-based criteria can lead to the adoption of Euro VI emission standards by 2020, reducing the toxic risks associated with diesel emissions.

It is essential to understand that there is no single solution to reducing transport emissions and that a comprehensive range of measures is needed to mitigate these emissions. Therefore, it is essential to adopt an integrated approach to address the health impacts of vehicle pollution.

- **Waste Incineration:** The burning of garbage in highly populated areas such as residential areas contributes significantly to urban pollution. Strict enforcement of existing legislation banning waste burning along with improved infrastructure for waste collection, composting of plant waste and overall waste management is essential to control this practice.

- **Diesel Generator Sets:** Another major source of urban pollution is diesel generators located in residential and commercial areas. Discouraging their use and promoting more efficient and less polluting alternatives such as BEE rated diesel generators can help reduce emissions. In addition, stricter emission standards for generator sets would be beneficial.

- **Road and Construction Dust:** Dust from local sources, including areas with little green cover, construction sites and road dust resuspension, contribute to particulate matter levels in cities. Effective strategies for managing this form of pollution include adopting dust control regulations, implementing street design guidelines with vegetative barriers, limiting vehicle speeds, enforcing truck loading guidelines, using appropriate truck covers, and implementing gravel paving for haul routes. Enforcing good construction practices, safe disposal and recycling of construction waste, and stricter compliance with environmental impact guidelines can address construction dust pollution.

- **Brick Kilns and other Local Industries:** Brick kilns and other local industries located near cities contribute significantly to pollution due to the use of highly polluting fuel sources. Phasing out inefficient and polluting technologies, introducing emission standards, enforcing bans on inefficient furnaces and

promoting alternative building materials are key steps to address emissions from these sources.

- **Large Sources (such as industry and Power Plants):** Large sources such as industries and power plants require emission standards to encourage the adoption of clean technologies and reduce overall emissions nationwide. Strict particulate matter standards, as well as standards for nitrogen oxides, sulfur dioxide and mercury, should be introduced to reduce exposure to emissions from power plants. Siting policies should also be in place to ensure these sources are not located near densely populated areas, and strict compliance monitoring is essential.

- **Episodic Pollution:** Episodic sources of pollution, including biomass burning, vehicular pollution during rush hour and seasonal crop burning, lead to high pollution episodes. While the health effects of short-term high exposures are not as well studied as chronic exposures, they are known to be harmful, especially to vulnerable populations. Strategies to control episodic pollution should be put in place and health advisories or public warning systems developed to protect vulnerable groups. Reporting of air pollution-related hospitalizations during high episodic pollution events may contribute to a better understanding of the exposure–response relationship.

2. **Special Role of the Ministry of Health and Family:** The establishment of the Steering Committee by the Ministry of Health and Family Welfare (MoHFW) is a recognition of the significant impact of exposure to air pollution, both household and ambient, on public health in India. This recognition puts air pollution on par with or even surpassing various other risk factors such as poor nutrition, smoking, alcohol, high blood pressure and obesity in terms of its adverse health effects. Given the scale of this health problem, it is imperative that the Department improve and focus its critical health systems to effectively respond to the health consequences of air pollution. Strengthening and directing resources to solve this problem will allow the ministry to adequately address the multifaceted impact of air pollution on the well-being of the population. Actions MHFW can take include:

- **Better Integration of Air Pollution and Public Health Policies:** The existing legal framework falls short of an effective solution to the comprehensive reduction of overall exposure to air pollution and the achievement of clean air goals. To address this gap, explicit provisions such as the Air Act (1986) should be incorporated into the legal framework, which specifically targets the management of indoor air pollution. In addition, the integration of drivers aimed at addressing household air pollution within the mechanisms of the Ministry of New and Renewable Energy (MNRE) would contribute to a comprehensive solution to the problem.

  A thorough review of the current legal framework for addressing air pollution and public health is recommended to create a blueprint for a health-based decision-making process and an effective compliance system, with the main objective of reducing overall exposure to protect public health. The ongoing reforms of various environmental laws present a valuable opportunity to address this issue comprehensively. An important first step in this direction is, in particular, the recent

decision of the Ministry of the Environment to include an objective health indicator in the Comprehensive Environmental Pollution Index for critically polluted areas.

- **Integrate care modalities into existing national frameworks or programs:**The implementation of RSBY, the nation's leading health insurance scheme, along with similar state-led initiatives, has played a significant role in reducing the financial burden associated with health care expenditure. These programs primarily focused on providing coverage for inpatient services in both public and private healthcare facilities. However, data suggest that a substantial portion of the country's health care spending goes to outpatient services and drug costs.

  It is worth noting that the majority of disability-adjusted life years (DALYs) associated with air pollution exposure are attributed to non-communicable diseases (NCDs), namely respiratory and cardiovascular diseases that require long-term and continuous care. Ongoing discussions around the National Health Assurance Mission (NHAM) have highlighted the importance of improving access to essential medicines and integrating chronic disease management mechanisms. This includes expanding allopathic care and promoting the incorporation of indigenous medical practices such as AYUSH.

  In order to effectively address the significant burden of disease associated with exposure to air pollution, it is essential to develop and implement pathways of care within national programs such as NHAM. As exposure to air pollution disproportionately affects poor and vulnerable populations, integrating comprehensive care strategies through these initiatives becomes imperative.

- **Strengthen policy-making capabilities in air pollution and health:** To ensure sustained engagement with air pollution and health issues, the Ministry of Health and Welfare (MoHFW) should develop internal processes to enable the use of evidence derived from toxicological, epidemiological and other scientific research to inform policy-making and development. tightened regulations on air pollution. This would include the integration of scientific knowledge into the decision-making process, the promotion of evidence-based policies and the promotion of continuous improvement in air quality management.

  To facilitate this effort, MHFW could establish a permanent expert group dedicated to air pollution and health. This expert group would serve as a valuable resource providing input and advice to MHFW on various aspects, including monitoring and evaluation of existing programs and initiatives. In addition, an expert panel could review the ever-evolving state of the science in relation to air pollution and its implications for policy, allowing MHFW to remain current and responsive to emerging research findings.

  By establishing a permanent expert group, MHFW would strengthen its ability to effectively address the complex issues posed by air pollution and its impact on public health. This collaborative approach, which combines scientific expertise with policy-making, would support informed decision-making, strengthen regulatory

frameworks and contribute to the overall improvement of air quality and public health in the country.

- **Air Pollution Data Collection and Health Impact Research:** Establishing a strong monitoring network is essential to address the urgent need for comprehensive air pollution monitoring with a particular focus on key health pollutants. This network should include monitoring of both particulate matter (PM2.5) and other relevant pollutants to ensure a comprehensive understanding of air quality and mitigate potential trade-offs between pollutants. PM2.5 monitoring can be prioritized for immediate implementation while ensuring coverage in both urban and rural areas for accurate estimation of population exposure. The Ministry of Health and Family Welfare (MoHFW) should play a central role in managing the collection of this data, Recognizing its importance in shaping effective air pollution management strategies.

  Collaboration with institutions such as the National Family Health Survey and the National Sample Survey Organization is essential. MHFW should convene a group composed of relevant stakeholders to improve the existing standardized household survey questions. This improvement will enable a better assessment of the health risks associated with household air pollution and facilitate monitoring of changes over time. In addition, conducting risk assessments and economic analyzes of both air pollution health impacts and mitigation strategies would provide valuable insights for evidence-based policy making.

  By taking a proactive approach to improving data collection, refining survey questions, and conducting comprehensive risk assessments, MHFW can make a significant contribution to understanding and addressing the health risks posed by air pollution. This collaborative effort will strengthen the knowledge base, inform policy decisions, and support the development of effective mitigation strategies to protect public health.

- **Capacity Building for Public Health Professionals and Health Care Providers:** Healthcare providers play a key role as key stakeholders in addressing air pollution and its health impacts. They should receive training to effectively provide harm reduction strategies to their patients as part of their clinical practice. This training will enable healthcare professionals to provide relevant information and guidance to patients on mitigating the health risks associated with air pollution. In addition, incorporating modules on air pollution and health into the curricula of medical and nursing schools across the country will help raise awareness and ensure that future healthcare workers are well informed about this critical issue.

  Medical associations can serve as powerful partners in raising awareness and promoting interdisciplinary collaboration to address air pollution. These associations can play a vital role in disseminating information, organizing awareness campaigns and facilitating collaboration between health professionals, policy makers and the public. As independent and trusted sources, physicians can effectively translate scientific information into practical recommendations for policymakers and the general public.

Given the widespread and significant health impacts of air pollution in India, it is important to develop national clinical criteria to assess patient risks specifically related to air pollution. Dissemination of these criteria to healthcare professionals will improve their ability to identify symptoms related to air pollution and provide appropriate guidance to patients. This step will help ensure that health care providers are knowledgeable about the protective measures that can be recommended for at-risk individuals, thereby promoting proactive management of air pollution-related health problems.

- **Information Dissemination Strategies to reduce the Health Impacts of Air Pollution:** The Ministry of Health and Welfare (MoHFW) can use its existing infrastructure of services such as Accredited Social Health Activists (ASHAs), Public Health Clinics and Primary Health Centers to disseminate information related to air pollution and promote exposure reduction measures. These channels can be used to educate and raise awareness among vulnerable groups, especially pregnant women and young children, about the health risks associated with air pollution and provide advice on how to minimize their exposure.

  In order for the public to better understand pollution levels, information on air pollutant concentrations should be readily available to the public. This transparency can empower individuals and communities to make informed decisions and take the necessary actions to protect their health.

  Incorporating the Air Quality Index (AQI) and other early warning systems into public communication strategies can serve as effective risk communication tools. By contextualizing health messages based on real-time air quality data, individuals can better understand potential health risks and make informed decisions about how to reduce their exposure to air pollution.

  Taking inspiration from successful anti-smoking campaigns, MHFW could launch an anti-pollution campaign with a specific focus on indoor air pollution (HAP). This campaign could include initiatives such as "smoke-free village" awards, similar to the recognition given to villages for achieving open defecation-free status. In addition, a media campaign can be launched to promote the provision of clean cooking technologies as wedding gifts to encourage families to adopt cleaner cooking practices, as was done in Gujarat to support the construction of toilets.

  By leveraging existing platforms, disseminating information and launching targeted campaigns, MHFW can effectively raise awareness of air pollution and encourage communities to take action to reduce their exposure, thereby protecting the health of vulnerable populations.

- **Strong and Permanent Ties to other Actors/Programs:** In order to effectively address the health impacts of air pollution, a multi-sectoral framework involving multiple ministries and agencies is essential. The Ministry of Health and Family Welfare (MoHFW) should play a central role as the coordinator of this framework. To ensure comprehensive action, other relevant ministries such as environment, energy, new and renewable energy and rural/urban development should be involved

and involved in the health impact assessment of major projects that may have an impact on public health.

MHFW should work with state health authorities to raise awareness of the health effects of air pollution and provide guidance on the most effective strategies to address the problem. This collaboration can increase the capacity of state health agencies to address air pollution-related health problems and implement appropriate interventions.

Given the significant health consequences of air pollution and the existing focus on cleanliness and hygiene through the Swachh Bharat Abhiyan (Clean India Mission), it is essential to link air pollution control efforts with this initiative. By incorporating air pollution concerns into the Swachh Bharat Abhiyan, a comprehensive approach to improving public health can be achieved, addressing both indoor and outdoor sources of pollution.

Through a coordinated multisectoral framework, active engagement with state-level health agencies, and integration with existing initiatives, MHFW can lead efforts to address the health impacts of air pollution and promote a healthier, cleaner environment for all.

- **International ties and agenda setting:** Establishing international links, especially with organizations such as the World Health Organization (WHO), is essential for the Ministry of Health and Welfare (MoHFW) to stay abreast of the latest developments in addressing air pollution and explore potential collaborations with other countries. These linkages can promote knowledge exchange, create synergies with global programs and facilitate the sharing of success stories from Indian efforts. In addition, holding a global meeting to showcase the committee's approach and recommendations would strengthen MHFW's reputation as a leader in addressing air pollution both nationally and globally.

  Increased investment in health research is essential to strengthen the evidence base for policy making. By supporting research initiatives focused on the impact of air pollution on various health outcomes, MHFW can create evidence-based policies and risk-based assessments. These research efforts will provide valuable insights into the specific health risks associated with air pollution in India and enable targeted interventions and effective strategies to protect public health.

  Through international collaboration and increased investment in health research, MoHFW can leverage global expertise, share experiences and advance scientific knowledge to address the complex challenges posed by air pollution and ensure evidence-based policies to protect public health.

VI. CONCLUSION

Air pollution in India comes from various sources and has significant health implications. For a comprehensive solution to this problem, a number of recommendations and steps must be taken to understand the health effects of air pollution and to prevent and

mitigate its adverse effects. It is important to realize that there is no single solution or "silver bullet" to solve this complex problem.

Efforts to combat air pollution require a multidisciplinary approach that integrates environmental and health data, scientific research, and evidence-based practices. The formulation and implementation of policies and programs aimed at reducing this major risk factor in our national burden of disease requires a coordinated effort across various government entities.

While it is important to focus on both emission reductions and exposure reductions to protect public health, prioritizing interventions based on exposure levels is becoming a priority. Immediate attention should be given to identifying sources that contribute to high levels of exposure and adverse health effects.

In summary, addressing air pollution in India requires a comprehensive, collaborative approach that spans multiple sectors, uses science, and prioritizes action based on exposure and health outcomes. By reducing both emissions and exposure, we can work to protect public health from the harmful effects of air pollution.

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