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The health burden and economic costs averted by ambient $PM_{2.5}$ pollution reductions in Nagpur, India

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ABSTRACT

National estimates of the health and economic burdens of exposure to ambient fine particulate matter ($PM_{2.5}$) in India reveal substantial impacts. This information, often lacking at the local level, can justify and drive mitigation interventions. Here, we assess the health and economic gains resulting from attainment of WHO guidelines for $PM_{2.5}$ concentrations – including interim target 2 (IT-2), interim target 3 (IT-3), and the WHO air quality guideline (AQG) – in Nagpur district to inform policy decision making for mitigation. We conducted a detailed assessment of concentrations of $PM_{2.5}$ in 9 areas, covering urban, peri-urban and rural environments, from February 2013 to June 2014. We used a combination of hazard and survival analyses based on the life table method to calculate attributed annual number of premature deaths and disability-adjusted life years (DALYs) for five health outcomes linked to $PM_{2.5}$ exposure: acute lower respiratory infection for children <5 years, ischemic heart disease, chronic obstructive pulmonary disease, stroke and lung cancer in adults ≥25 years. We used GBD 2013 data on deaths and DALYs for these diseases. We calculated averted deaths, DALYs and economic loss resulting from planned reductions in average $PM_{2.5}$ concentration from current level to IT-2, IT-3 and AQG by the years 2023, 2033 and 2043, respectively. The economic cost for premature mortality was estimated as the product of attributed deaths and value of statistical life for India, while morbidity was assumed to be 10% of the mortality cost. The annual average $PM_{2.5}$ concentration in Nagpur district is 34 ± 17 μg m^{-3} and results in 3.3 (95% confidence interval [CI]: 2.6, 4.2) thousand premature deaths and 91 (95% CI: 68, 116) thousand DALYs in 2013 with economic loss of USD 2.2 (95% CI: 1.7, 2.8) billion in that year. It is estimated that interventions that achieve IT-2, IT-3 and AQG by 2023, 2033 and 2043, would avert, respectively, 15, 30 and 36%, of the attributed health and economic loss in those years, translating into an impressively large health and economic gain. To achieve this, we recommend an exposure-integrated source reduction approach.

1. Introduction

Ambient fine particulate matter ($PM_{2.5}$), which constitutes emissions from diverse combustion sources including transportation, power plants, industries and household use of solid fuels contributes substantially to increased risk of disease and death (Chafe et al., 2014; Lelieveld et al., 2015; Lim et al., 2012; Smith et al., 2014). Specific health outcomes linked with exposure to $PM_{2.5}$ include mortality and morbidity from acute lower respiratory infection (ALRI) in children <5 years; chronic obstructive pulmonary disease (COPD), ischemic heart disease (IHD), lung cancer (LC) and stroke in adults ≥25 years (Burnett et al., 2014). A growing body of evidence also indicates increased risk of mortality from diabetes mellitus and preterm and underweight births (Coker et al., 2016; Dõâaz et al., 2016; Feng et al., 2016; Li et al., 2016; Meo et al., 2015; Nachman et al., 2016; Weinmayr et al., 2015), especially in developing countries where both exposure to $PM_{2.5}$ and baseline mortality rates from these health outcomes are higher (IHME, Institute for Health Metric and Evaluation, 2015; WHO, 2015). The Global Burden of Disease (GBD) 2013 study estimates that the number of premature deaths and disability-adjusted life years (DALYs) attributable to ambient $PM_{2.5}$ is approximately 3.0 and 70 million, respectively, per year (Forouzanfar et al., 2015; WHO, 2016a). The burden is borne disproportionally across the globe, with India having the second largest

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