Abstract

Ambient Air pollution is recognized as one of the major environmental health problems facing mankind. According to the World Health Organization (WHO) standard, more than 92% of the world's population is exposed to unsafe air and both short- and long-term exposure to air pollution can lead to various diseases including three of the leading causes of death globally: stroke ischemic heart disease (IHD) and primary cancer of the trachea, bronchus, and lung (TBL). Especially, exposure to ambient fine particulate matter less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$) is a leading health risk factor and approximately 4.9 million premature deaths were attributed to air pollution in 2017, mostly in developing countries. Air pollution is also documented as one of the leading risks to child health and among them, children under 5 years of age are more vulnerable to air pollution due to their smaller airways, immature respiratory and immune systems, faster breathing, and more inhalation than body weight.

Child mortality, also known as under-5 mortality, denotes the likelihood of a child experiencing death between birth and the age of 5. It serves as a pivotal indicator, shedding light on the broader landscape of child healthcare and socioeconomic advancement within a country. By 2019, there was a significant decrease in child mortality, dropping from 12.5 million in 1990 to 5.2 million, owing to global endeavors aimed at achieving the Sustainable Development Goals (SDGs) regarding child survival. Nonetheless, elevated child mortality rates persist in low- and middle-income countries (LMICs), notably in Sub-Saharan Africa and South Asia. In these regions, predominant causes of child mortality encompass lower respiratory diseases and neonatal preterm birth complications, both of which are related to ambient air pollution. According to the World Health Organization (WHO), air pollution is one of the leading risks to child health. In 2016, over 90% of the world's children, particularly the 630 million residing in LMICs, were exposed to levels of ambient PM2.5 exceeding WHO air quality standards.

For several years, South Asia has been designated as a $PM_{2.5}$ hotspot due to unplanned and extensive development efforts. Climate change, as a potential factor affecting $PM_{2.5}$ pollution, poses another major challenge for this region. The intricate interplay between air pollution and climate change can result in severe health repercussions. Notably, short-lived climate pollutants

(SLCPs) such as black carbon (BC), ozone, methane, and hydrofluorocarbons exert a warming influence on the climate. Recently, it has been acknowledged that reducing SLCP emissions can yield co-benefits by mitigating climate change and minimizing adverse health effects. Nevertheless, the current body of evidence about under-5 mortality directly attributed to $PM_{2.5}$ under the influence of climate change scenarios remains limited.

To address the existing research gap, the objective of this study is to project the under-5 mortality attributable to ambient $PM_{2.5}$ for the period 2010–2049 in South Asia and its eight constituent countries under seven distinct scenarios involving air pollution and climate change mitigation, each characterized by varying levels of air pollution emissions. The log-linear concentration-risk function was employed to estimate under-5 mortality attributed to ambient $PM_{2.5}$, derived from a comprehensive review conducted as part of this research endeavor. In that review, articles were searched using "PubMed" and "Web of Science," published between 1970 to the end of January 2022, which explicitly linked ambient $PM_{2.5}$ and under-5 mortality by considering study area, study design, exposure windows, and child age. Several pieces of information including study characteristics, exposure assessment and duration, outcomes, and effect estimates/ findings were extracted. Thirteen studies on infant and child mortality were selected for final analyses. Among these, only four studies specifically assessed the influence of post-birth exposure to $PM_{2.5}$ on under-5 mortality. The risk function was generated from the coefficient obtained from the single cohort study regarding the association between post-birth ambient $PM_{2.5}$ exposure and under-5 mortality within the context of South Asia.

The obtained risk function, featuring a theoretical minimum risk exposure threshold of 2.4 $\mu g/m^3$, was connected with gridded annual $PM_{2.5}$ concentrations derived from previous atmospheric modeling. This linkage aimed to project under-5 mortality between 2010 and 2049 under various climate change mitigation scenarios. The scenarios were developed from the Aim/Enduse global model based on end-of-pipe (removing the emission of air pollutants at the source, EoP) and 2°C target measures. Our findings indicate that during the period 2010–2014, approximately 306.8 thousand deaths of children under five in South Asia were linked to $PM_{2.5}$ pollution under the Reference scenario (representing business as usual). Projections suggest that by 2045–2049, this figure is expected to rise by 36.6% under the same scenario, and by 7.7% under a scenario where

EoP measures are partially implemented by developing countries (EoPmid). However, under other scenarios, such as the one where EoP measures are fully adopted by all countries alongside efforts to achieve the 2°C target (EoPmaxCCSBLD), a substantial decrease in mortality (81.2%) across South Asia is projected. Specific trends in under-five mortality vary among individual countries. Overall, these results underscore the inadequacy of current air pollution and greenhouse gas emission control strategies in reducing avoidable deaths in South Asia. Implementing robust policies for climate change mitigation and air pollution control is required.

For the specific analysis at the country level, we conducted an analysis utilizing real-time monitoring station data from eight distinct cities in Bangladesh. This analysis aimed to estimate the under-5 mortality attributable to ambient $PM_{2.5}$ for the period spanning 2012 to 2020. The outcomes revealed that both air pollution concentration and the under-5 mortality attributed to it were notably elevated in Dhaka, the capital of Bangladesh, characterized by a substantial population and dense vehicular traffic. However, the results exhibited a lack of consistency across the other cities considered during the study period. These variations in results among different cities highlight the need for more in-depth cohort studies. Conducting a greater number of such studies is crucial to gaining a comprehensive understanding of the relationship between exposure to ambient $PM_{2.5}$ and under-5 mortality in Bangladesh.