Outdoor air pollution impacts chronic obstructive pulmonary disease deaths in South Asia and China: a systematic review and meta-analysis [version 1; peer review: awaiting peer review]

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Abstract
Background: Chronic obstructive lung disease is among leading causes of death globally. Exposure to outdoor pollution is an important cause for increased mortality and morbidity.
Objective: To present a systemic synthesis evidence regarding impact of outdoor pollution on COPD mortality in south asia and china.
Methods: A systematic search on studies with statistical power has been conducted from 1990 - June 30th 2021, in English electronic databases following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines from MEDLINE and PUBMED databases with terms: Chronic Obstructive Pulmonary disease OR COPD OR Chronic Bronchitis OR Emphysema OR COPD Deaths OR Chronic Obstructive Lung Disease OR Airflow Obstruction OR Chronic Airflow Obstruction OR Airflow Obstruction, Chronic OR Bronchitis, Chronic AND Mortality OR Death OR Deceased AND Outdoor pollution, ambient pollution was conducted.
Results: Out of 1899 papers screened only 16 found eligible to be included in the study. Subjects with COPD exposed to higher levels of outdoor air pollution had a 49 % higher risk of death as compared to COPD subjects exposed to lower levels of outdoor air pollution. When taken individual pollutants into consideration, common air pollutants like PM10 had an OR of 1.06 at CI 95%, where as SO2 had OR of 0.66 at 95% CI , and NO2 with 1.01 OR at 95% CI. These values suggest that there is an effect of outdoor pollution on COPD but not to a significant level.
Conclusion: Despite heterogeneity across selected studies, exposure
to outdoor pollutants found to have risk of COPD mortality. Though it appears to have risk, COPD mortality was not significantly associated with outdoor pollutants. Controlling air pollution can substantially decrease the risk of COPD in South Asia and China. Further research including more prospective and longitudinal studies are urgently needed in COPD sub-groups.

**Keywords**
COPD, Chronic Obstructive Pulmonary disease, Death, Mortality, Outdoor Pollution, Air Pollution

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Introduction
Urban air pollution is one of the major issues affecting public health environment as well as rural population, and has caused 5 million deaths in South Asia till 2012. South Asia has shown significant economic growth over the last few decades particularly in the most populous countries such as India. In addition to the increase in population, there is an increase in industrialization leading to severe urban air pollution, which has resulted in South Asian countries being among the most polluted in the world. Chronic obstructive pulmonary disease (COPD) is one of the leading causes of death in the present day due to increase in exposure to varied air pollutants. These pollutants were also related to the cause of other conditions like asthma, interstitial pulmonary fibrosis, cystic fibrosis, and lung cancers. Increase in mortality and morbidity rates have been associated with short term exposure to outdoor pollution. In total, 90% of COPD accounted deaths occurred mostly in low- and middle-income countries as reported by the World Health Organization (WHO). Epidemiological studies show that health problems associated with aged populations affect a wide and expanding proportion of the world population; one of the major epidemiological trends of this century is the rise of chronic diseases. The main outcomes of respiratory illness, such as COPD, include a progressive decrease in lung function and dyspnea, leading to an increase in hospitalizations and death.

Strong evidence has shown a link between air pollution and non-infectious respiratory diseases, such as COPD. An earlier study observed chronic bronchitis was caused by changes in air pollution levels. Risk factors for chronic respiratory diseases are mainly indoor and outdoor pollutants, for example biomass fuel use has affected at least 2 billion people, 1 billion are exposed to outdoor air pollution, and 1 billion are smokers. Around 4 million people die prematurely every year from chronic respiratory diseases. Along with emissions from burning low-quality (sulphurous) coal domestically and industrially, even photochemical smog from automobiles consisting of hydrocarbons and nitrogen dioxides (NO2) have become the source of outdoor pollution in the south Asian countries. Smog such as ozone and respirable particles PM2.5 emitted from urban industries can travel long distances and can even affect population residing in distant areas from the source of outdoor pollution. Since the use of automobiles and coal occur simultaneously, there would be an overlap of photochemical and sulphurous smog in South Asian countries.

The effect of outdoor pollution and COPD has always been a source of research, but there is a lack of systematic synthesis of evidence from studies of South Asia and China regarding outdoor air pollution and its impact on mortality associated with COPD. Therefore, this systematic review and meta-analysis is aimed to highlight the current evidence on the relationship between outdoor air pollution and COPD mortality in South Asia and China.

Methods
Search strategy
Systematic searches were performed to identify studies on the associations between outdoor pollution and COPD deaths from 1985 to June, 2021. Online electronic databases included PubMed, Cochrane database and Google Scholar (Advanced Google search). We conducted a literature search for combined key terms such as [exposure AND Outcome AND Population] (Table 1)

Selection of the studies
The search was restricted to English language. No limitation was set for participants’ age. To better fulfill our objectives, studies which recruited patients who had COPD and had or were having exposure to outdoor pollution and death due to COPD were included in the study. Studies belonging to south Asian countries like Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, Sri Lanka were particularly searched. China and Asia pacific regions were focused in our study due to limited availability of research publications on outdoor pollution. Studies that were prospective controlled or non-controlled trials and retrospective studies conducted in South Asia, China and Asia Pacific region were included.

Studies excluded were those that recruited patients without COPD, patients without data on outdoor air pollution, and patients who lived outside South Asia. Studies where primary data was not collected and duplicate publications were also excluded. All references from the identified papers were screened to check for any additional articles that had not been identified in the original search. No unpublished or ongoing studies were selected for this systematic review.

One reviewer (SP) checked all the titles and abstracts and other reviewer (MP) checked the articles; therefore, both the investigators evaluated the full text of potential studies independently (SP and MP). Duplicate studies were removed and any conflicts between the two reviews were discussed with the third reviewer (GD) before extracting the data. The details of the studies were extracted as per our inclusion criteria (Box 1)

Box 1. Data extraction and quality assessment checklists.
The numbers beside the quality assessment criteria are used to indicate the 8 points

<table>
<thead>
<tr>
<th>Data extracted</th>
<th>Quality assessment check list</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study dates or Publication dates</td>
<td>1. Type of report</td>
</tr>
<tr>
<td>Study design</td>
<td>2. Clear aims and objectives</td>
</tr>
<tr>
<td>Type of report</td>
<td>3. Clear and appropriate methods, including sampling and recruitment</td>
</tr>
<tr>
<td>Number of participants (enrolled, excluded and lost to follow up)</td>
<td>4. Appropriate and rigorous analysis</td>
</tr>
<tr>
<td>Participants characteristics (age, sex, exposure to indoor pollution)</td>
<td>5. Out comes not reported/ additional outcomes reported</td>
</tr>
<tr>
<td>Study setting (place/ urban/ rural)</td>
<td>6. Risk of bias in selection</td>
</tr>
<tr>
<td>Definition of diagnosis used</td>
<td>7. Risk of bias in measurement and outcomes</td>
</tr>
<tr>
<td>Measurement / assessment tool</td>
<td>8. Limitations discussed</td>
</tr>
<tr>
<td>Out Comes (Fuel exposure / Odd's ratio)</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. PICOS identifiers from research questions (‘key terms’) used to generate database searches.

<table>
<thead>
<tr>
<th></th>
<th>P</th>
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<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All population</td>
<td>Prevalence, COPD</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td>residents in</td>
<td>deaths, outdoor</td>
<td></td>
<td>(Chronic Obstructive Pulmonary disease (COPD)) OR (Chronic Obstructive Pulmonary disease) OR (COPD) OR (Chronic Bronchitis (CB)) OR (Chronic Bronchitis (CB)) OR (Chronic Bronchitis (CB)) OR (Emphysema) OR (COPD Deaths) OR (Chronic Obstructive Airway Disease (COAD)) OR (Chronic Obstructive Airway Disease) OR (COAD) OR (Chronic Obstructive Lung Disease) OR (Airflow Obstruction) OR (Chronic Airflow Obstruction) OR (Airflow Obstruction, Chronic) OR (Bronchitis, Chronic) OR (Mortality) OR (Fatality) OR (Demise) OR (1Death) OR (Deceased) AND (Outdoor Air Pollution) OR (PM2.5) OR (PM10) OR (NO2) OR (SO2) OR (Nano particles) OR (Ozone) (South Asia) (China)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asia</td>
<td>pollution, ASIA</td>
<td></td>
<td>All</td>
</tr>
</tbody>
</table>

Quality assessment
All included studies were subjected to a quality assessment to estimate potential bias that could result from combining studies of varying methodological quality, which might lead to misleading conclusions. Each study was assessed for clear aims, randomization techniques, blinding of interventions and participants, eligibility for intervention assessed, description of intervention provided to allow replication, effect size, details of long term follow up and sustained change, analysis of confounding variables, power analysis, the definition of all outcomes, reliable measurement tools, results provided for measurement, and appropriate statistical analysis. The values of odds ratios (ORs) and confidence intervals (CIs) collected were subjected to statistical conversion by applying Log to ORs and 95% CIs into their respective Risk Ratio values and their CIs. These were considered as effect size values. A standard error (SE) has been estimated based on the calculated log values of 95% CIs. A funnel plot was generated by obtaining standard error values and the effect size values, whereas the Forest plots were populated based on the collected values of ORs and the estimated 95% CIs based on overall effect size from their respective finalized studies. Two independent reviewers (SP and MP) graded the extracted data quality of each data point as ‘Good’, ‘Poor’ and ‘Not-Assessable’. Disagreements were resolved through discussion and consensus decision with third reviewer (GD). The quality check list has been presented in Box 1.

Data analysis
ORs and CIs were entered into an Excel sheet. STATA Software version 16.0 was used to perform further analysis. ORs and CIs were log converted to risk ratios and corresponding confidence limits, which are considered as effect size. By assuming a linear relationship between air pollution and COPD, the relative risks (RRs) with 95% CI for a standardized increment of pollutants’ concentrations were pooled as follows: 10 μg/m³ for PM₁₀, PM₂.₅, NO₂, SO₂, and O₃ and 100 μg/m³ for CO. These values were frequently used in the previous air-pollution-related studies. If percentage change with 95% CI were reported, then it could be transformed to RR with 95% CI. SE is also estimated based on the log 95% CI values and the resultant values were plotted as forest plots and funnel plots.

STATA was used to assess pooled mean deviation (MD) and standard deviation (SD) for continuous outcomes. 95% CI was regarded as effective size in the combined analysis. Chi-square and I² tests were performed to assess the heterogeneity. The fixed-effect model was applied when P>0.1 or I²<50% considered as homogeneous, and the random-effect model was more eligible when I²>50%. Statistical significance was defined as P<0.05.

Results
Characteristics of the articles
Our search identified 1899 articles up to June 30th 2021. After title review and duplicates removed, 274 abstracts were reviewed and 100 full-text articles were identified for inclusion in the study. After reviewing the full text articles, 14 were excluded for not meeting the inclusion criteria and not having odd ratios (ORs) with insufficient data for extraction. Finally, 16 papers were eligible to be included in this systematic review. The detailed selection process is shown in Figure 1.

Statistical analysis
Table 2 summarizes the 16 articles, which all had an acceptable study design, risk levels and data available for extraction and had information on the effect sizes and were done in Nepal, India and Pakistan, Bangladesh, other South Asian countries and China. In total, 12 citations focused on association between short term exposure of outdoor pollutants and COPD effects (deaths). The meta-analysis included 6 articles, which focused on the association between outcomes of COPD and did not focus on deaths and outdoor pollution.

Several outdoor pollution-causing particulate matter were studied: PM₂.₅, PM₁₀, NO₂, SO₂, Nano particles and ozone (Figure 2). Lin et al. had OR of 2.01, respectively[13]. Other studies like Zhang et al.[14] and Yang et al.[17] have ORs of 1.01,1.10 and 1.08 respectively. PM₁₀ exposure was studied in most of the studies. Short term exposure of PM₁₀ was
Table 2. Odds ratios of studies showing COPD mortality.

<table>
<thead>
<tr>
<th>First author, year, reference</th>
<th>Study design</th>
<th>Country</th>
<th>Mortality among recruited (n)</th>
<th>Exposure measured</th>
<th>Study population</th>
<th>OR, 95% CI (COPD mortality)</th>
<th>Quality†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhang et al. 2014[^16]</td>
<td>Case cross over</td>
<td>China</td>
<td>332 (short term exposure)</td>
<td>SO2 NO2</td>
<td>Age matched adults</td>
<td>1.01(1.00, 1.02)</td>
<td>G =6 P=3 N</td>
</tr>
<tr>
<td>Yang et al. 2007[^17]</td>
<td>Case cross over</td>
<td>Taiwan</td>
<td>99 (short term exposure)</td>
<td>PM10</td>
<td>&gt;50-70 years</td>
<td>1.08 (0.99,1.18)</td>
<td>G =7 P=2 N</td>
</tr>
<tr>
<td>Chen et al. 2004[^18]</td>
<td>Time series</td>
<td>Taiwan</td>
<td>154 (short term exposure)</td>
<td>PM10</td>
<td>&gt;30 years</td>
<td>1.05 (1.01,1.09)</td>
<td>G =7 P=2 N</td>
</tr>
<tr>
<td>Pande et al. 2002[^19]</td>
<td>Time series</td>
<td>India</td>
<td>12</td>
<td>PM10</td>
<td>&gt;20 years</td>
<td>1.28 (0.49, 3.33)</td>
<td>G =8 P=3 N</td>
</tr>
<tr>
<td>Qian et al. 2010[^20]</td>
<td>Case cross over</td>
<td>China</td>
<td>76 (short term exposure)</td>
<td>NO2</td>
<td>&gt;40 years</td>
<td>1.01 (0.98,1.21)</td>
<td>G =6 P=3 N</td>
</tr>
<tr>
<td>Tan et al. 2009[^21]</td>
<td>Cross sectional</td>
<td>China</td>
<td>213 (short term exposure)</td>
<td>PM10</td>
<td>&gt;50 years</td>
<td>1.10 (0.99,1.23)</td>
<td>G = 7 P=2 N=1</td>
</tr>
<tr>
<td>Lin et al. 2018[^15]</td>
<td>Prospective</td>
<td>China</td>
<td>211</td>
<td>PM2.5</td>
<td>&gt;60 years</td>
<td>2.10 (0.19,2.13)</td>
<td>G =8 P=2 N</td>
</tr>
<tr>
<td>Xu et al. 2000[^22]</td>
<td>Prospective</td>
<td>China</td>
<td>45.5 (per day)</td>
<td>SO2</td>
<td>Age matched</td>
<td>0.66 (95% CI: 0.35-1.38)</td>
<td>N=2 G=3</td>
</tr>
<tr>
<td>Colbeck et al. 2010[^23]</td>
<td>Data analysis</td>
<td>Pakistan</td>
<td>79 (short term exposure)</td>
<td>PM(10), PM(2.5), and PM(1)</td>
<td>All age groups</td>
<td>1.74, 2.49, and 3.01 respectively</td>
<td>N=6 G=4</td>
</tr>
<tr>
<td>Lu et al. 2015[^24]</td>
<td>Systematic review and meta analysis</td>
<td>127 major cities in Mainland China, Hong Kong, and Taiwan</td>
<td>-</td>
<td>PM10 and PM2.5</td>
<td>Meta analysis</td>
<td>0.40 (95%CI: 0.22-0.59)</td>
<td>G=6 N=7</td>
</tr>
</tbody>
</table>

[^16]: Zhang et al. 2014[^16]
[^17]: Yang et al. 2007[^17]
[^18]: Chen et al. 2004[^18]
[^19]: Pande et al. 2002[^19]
[^20]: Qian et al. 2010[^20]
[^21]: Tan et al. 2009[^21]
[^22]: Lin et al. 2018[^15]
[^23]: Xu et al. 2000[^22]
[^24]: Colbeck et al. 2010[^23]
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<th>First author, year, reference</th>
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<th>Country</th>
<th>Mortality among recruited (n)</th>
<th>Exposure measured</th>
<th>Study population</th>
<th>OR, 95% CI (COPD mortality)</th>
<th>Quality†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atkinson et al. 2012</td>
<td>Data analysis</td>
<td>Asia</td>
<td>-</td>
<td>PM10</td>
<td>16034 participants</td>
<td>OR = 1.07 (95% CI 1.03 to 1.11) per 2.2 µg/m3</td>
<td>G=7 N=2</td>
</tr>
<tr>
<td>Meng et al. 2013</td>
<td>Data analysis</td>
<td>Asia</td>
<td>-</td>
<td>PM2.5</td>
<td>9292 participants</td>
<td>OR = 1.13 (0.02-2.14)</td>
<td>G=4 N=1</td>
</tr>
<tr>
<td>Jin et al. 2017</td>
<td>Data analysis</td>
<td>China</td>
<td>-</td>
<td>SO2</td>
<td>667,553</td>
<td>24% (95% CI of OR = 1.08–1.41)</td>
<td>G=1 N=0</td>
</tr>
<tr>
<td>Sirithunga et al. 2006</td>
<td>Data analysis</td>
<td>Sri lanka</td>
<td>-</td>
<td>SO2, NO2</td>
<td>578 participants</td>
<td>1.48 (95% CI = 1.31-1.67)</td>
<td>G=3 N=3</td>
</tr>
<tr>
<td>Cai et al. 2019</td>
<td>Time-series study</td>
<td>China (2013 e2015)</td>
<td>-</td>
<td>PM2.5</td>
<td>41,815 participants</td>
<td>8.24 (95% CI: 3.53-13.17) for per 10 mg/m3 increase in PM 2.5</td>
<td>G=7 N=4</td>
</tr>
<tr>
<td>Xu et al. 2016</td>
<td>Exposure study</td>
<td>Beijing, China</td>
<td>327</td>
<td>PM2.5</td>
<td>Age matched</td>
<td>0.96% (95% CI: 0.35-1.57)</td>
<td>N=2 G=5</td>
</tr>
</tbody>
</table>

†Quality assessment grading as G= Good, P= Poor and N=Not Assessable

Figure 2. Effect sizes for pollutants (in combination or alone) showing impact of outdoor air pollution on COPD mortality.
studied by Yang et al. which had odds ratio between 0.99, 1.18 and short term exposure of SO2 was studied by Srithunga et al. which showed an odds ratio of 1.48.

Publication bias
Publication bias was tested using funnel plots for COPD and its risk factors (Figure 3). The funnel plot shows that the studies related to most risk estimates were distributed symmetrically along the midline which is the pooled estimate. Two studies done by Yang et al. and Chen et al. related to COPD exceeded the 95% CI. The combined data showed no evidence of publication bias.

Discussion
To the authors knowledge, this was the first study to report the association between outdoor pollution and COPD risk factors and deaths. The present systematic review and meta-analysis reexamines existing research findings about the association between outdoor pollution and COPD deaths in south Asian countries and China. A total of 16 individual studies were analyzed based on the specific inclusion and exclusion criteria from PubMed, Google Scholar and CDSR from 1985 to June 30th 2021. In total, 9 studies were conducted in China and the rest in India, Sri Lanka, Taiwan and South Asia, which gave a conclusive result of effect of outdoor pollution on COPD. This systematic review provided a confirmation that exposure to outdoor pollution is related to COPD deaths. The systematic review, which was published in 2016 by Lin et al. included 12 studies from South Asia and China. Our systematic review analyzes additional six studies in the last four years from countries of South Asia and China. The studies conducted in various regions of Asia evidence that industrialization and high usage of automobiles were one of the main reason for COPD. There were studies comparing asthma and outdoor pollution but not COPD. A study done by Pande et al. concluded that outdoor pollution, like industrial pollution and pollution from automobiles, had significant impact on COPD deaths with an odds ratio of 1.28. Risk was higher in urban areas than rural areas (OR = 0.329).

Fusco et al. found only weak associations for CO (2.8% increase per interquartile range (IQR) only, 1.5 mg/m3) and no effects were identified for SO2. NO2 and CO seemed to be strongly associated with seasonality, especially in warmer seasons, whereas O3 played important roles in acute respiratory attack. Particulate pollutants are considered to be responsible for the adverse cardiovascular and respiratory diseases, and some adverse impacts induced by PM2.5 might be aggravated by PM10.

Our results were unaffected by adjustment for additional smoking variables and supported several studies that found inverse associations with asthma.

In an Asian time-series study, per 10 μg/m3 increase in PM10 indicated an 0.36% increase in respiratory mortality and COPD. In one meta-analysis, a meta-regression analysis was performed on the daily mean PM10 concentrations and estimated rate of mortality in different studies. This method effectively demonstrated the relationship between PM and its health effects. The heterogeneities of the air pollutants CO, NO2, and O3 were more significant than that of SO2 and for particulate

Figure 3. Funnel plot for COPD mortality.
pollutants, the heterogeneity of PM2.5 was greater than that of PM10\textsuperscript{12}.

A study in New Zealand reported an 3.37% increase for NO, CO2 14.8 mcg/m\textsuperscript{3} increase in PM10, and an Australian study also showed a 4% increase in hospital admissions for every 10 μg/m\textsuperscript{3} increase of PM10. These studies included a population who were smokers and both studies found significant impact of outdoor pollution on COPD\textsuperscript{13,14}.

Though the ORs in the included studies of South Asia in this systematic review were less than the previous systematic review and meta-analysis, the findings are unique and cannot be directly compared. power of this research seems to be acceptable for publication\textsuperscript{15}.

This paper gathers 16 papers with different results. The publication research period ranged from 1985 to 2020, representing almost 35 years. In comparison with other previous meta-analysis and systematic reviews, this review had seven additional papers and results, including Chen \textit{et al.}\textsuperscript{16} Yang \textit{et al.}\textsuperscript{17}, Zang \textit{et al.}\textsuperscript{18}, Tan \textit{et al.}\textsuperscript{19}, Sirithunga \textit{et al.}\textsuperscript{20}, Cai \textit{et al.}\textsuperscript{21} and Xu \textit{et al.}\textsuperscript{22}. These studies provided a broad risk level analysis about the relation between outdoor pollution and COPD. The systematic review on indoor pollution and COPD was 2016 by Lin \textit{et al.} which included all countries\textsuperscript{15}. The individual risk of PM 2.5 is 1.60, SO2 and NO2 combined is 1.24, PM 10 is 1.06, PM 10 and PM 2.5 combined is 0.40, SO2 is 0.66 and NO2 was 1.01 according to this study. The risk has been increased by 1.04 in our study with the addition of the six additional studies. Evaluation of the results was also broad and diversified in this review taking more pollutants into evaluation and finding the individual risk. Taking the average risk of all the studies into consideration in this systematic review, the OR is 1.04 being slightly risky.

This study confirms that outdoor pollution has been always a risk factor for COPD. A large population in India and China was also one of the reasons for more COPD cases in South Asian countries and China. Additional designs with specific particulate matter effecting COPD with well-designed morphological and histological assessment of the lung should be done in order to confirm this research and systematic review.

Interpretation of findings in relation to previously Published work

Although a systematic review of COPD prevalence and mortality in southern Asia has not, to our knowledge, been carried out previously, Fusco and Pitard in 2010 and 1997 suggested a median COPD prevalence with outdoor pollution of 6% in males and 1.7% in females\textsuperscript{23,24}. In an Asian time-series study, every 10 μg/m\textsuperscript{3} increase in PM10 indicated an 0.36% increase in respiratory mortality\textsuperscript{25}. Because of a disproportional burden of COPD exacerbation in these middle- and lower-income counties, more studies on PM10 are required to explore the combined effects of particulate pollutants\textsuperscript{26}. A systematic review showed that a 10 μg/m\textsuperscript{3} increase in PM2.5 was associated with a 0.40% (95% CI: 0.22%, 0.59%) increase in total non-accidental mortality\textsuperscript{27}.

Practical implications

The present study’s findings have provided evidence of an association between short-term outdoor air pollution exposure and the risk of COPD exacerbation’s. These findings can help improve and implement regulations on air quality that will provide measurable benefits to public health. Our results also provide a basis for future research studies on the relationship between outdoor air pollutants and risk estimation.

Limitations of the study

There are a few limitations to this study. First, the heterogeneity of the included methodologies did not permit quantifying the risk of death due to COPD on air pollutant exposure. Secondly, the values of pollutants causing COPD should have been standardized. The air pollutants thus studied as co-pollutant models, and none of the studies assessed discussed the effect of individual air pollutants on deaths due to COPD. A single air pollutant method would be preferable for more strength. Also, efficient and discreet methods to assess each air pollutants would facilitate controlled studies.

Conclusion

This study confirms that outdoor air pollution is associated with deaths due to COPD deaths. Though there is no statistically significant risk for pollutants, COPD mortality was found to be associated with outdoor pollutants. Many low-income, middle-income countries face an important issue on the effect of outdoor pollution on COPD deaths due to industrialization and automobile usage which can be controlled by controlling the outdoor pollutants. The draw backs of the present study were the inclusion of five studies that had confidence intervals >95%. Another drawback is that outdoor pollutants included in the study were limited to particulate matter and NO2. Additional data is needed to further explore the effect of outdoor pollution and particulate matter in causing COPD deaths. The study provides quantitative evidence for government, especially for India, to set up an air quality plan to achieve an acceptable goal in COPD control.

Data availability

Underlying data

All data underlying the results are available as part of the article and no additional source data are required.

Reporting guidelines


Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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References


