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Research article

A systematic review and meta-analysis of the association between air pollutants and the incidence of tuberculosis

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A R T I C L E I N F O

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Air pollution
Tuberculosis
Systematic review
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A B S T R A C T

Objective: To investigate the association between air pollutants and the incidence of tuberculosis (TB) through a systematic review and meta-analysis, and to provide directions for future research and prevention of TB.

Methods: A search was conducted for all literature related to the incidence of TB and air pollution in the database. We screened the retrieved articles and proceeded statistical analyses using random effects models to investigate the relationships between five air pollutants ($PM_{2.5}$, PM_{10}, SO_2, NO_2 and O_3) and the incidence of TB.

Results: The initial search identified 100 pieces of literature and 9 studies met the screening criteria after the screening. The single-day lagged risk ratio (RR) and 95% Confidence Intervals (CIs) for the combined effects estimates are as follows: $PM_{2.5}$: 1.059 (0.966, 1.160); PM_{10}: 1.000 (0.996, 1.004); SO_2: 0.980 (0.954, 1.007); NO_2: 1.011 (0.994, 1.027); O_3: 0.994 (0.980,1.008). The cumulative lagged results for these five pollutants are listed like this: $PM_{2.5}$: 1.095 (0.983, 1.219); PM_{10}: 1.035 (1.006, 1.066); SO_2: 0.964 (0.830, 1.121); NO_2: 1.037 (1.010, 1.065); O_3: 0.982 (0.954, 1.010).

Conclusion: The single-day lag effects of $PM_{2.5}$, PM_{10}, SO_2, NO_2, and O_3 are not statistically significantly relevant for the occurrence of TB. However, the cumulative lag results show that both PM_{10} and NO_2 contribute to the prevalence of TB, while the statistical relationship between the cumulative lag effects of $PM_{2.5}$, SO_2, and O_3 and the onset of TB remains unknown.

1. Introduction

Tuberculosis (TB) is a globally infectious disease caused by the Mycobacterium TB. Transmitted mainly by the respiratory tract and invades the pulmonary tissues and can cause necrosis, exudation, and hyperplasia, making it become a leading threat among infectious

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diseases. Since the application of antibiotic treatment in the 1950s, the morbidity and mortality of TB have been significantly reduced. However, in the last 20 years, there has been a resurgence in the morbidity of TB, which has re-emerged as one of the leading causes of death worldwide. Before the advent of COVID-19, TB was the deadliest disease from a single pathogen, more than AIDS. In 2018, about 10 million new cases of TB and 1.24 million deaths from TB were reported globally, with an average TB incidence of 130/100,000 and a mortality of 16/100,000 [1,2]. China ranks the second in terms of TB infection, with 2018 data showing an approximate incidence as 59/per 100,000 and a fatality rate as 0.2257 per 100,000 [2]. Among all the infectious diseases in China, TB has the highest morbidity and mortality rates. The pandemic of TB, especially drug-resistant TB, causes threats and challenges to the health of the Chinese people [3]. Except from the high incidence rate and the death rate, TB can also harm the social life of patients and their fundamental health indicators. For example, Kibrisli et al. claimed that patients with TB exhibited varying degrees of weight loss, lack of appetite, social difficulties, low self-esteem, and fears that can affect personal health [4]. As for the economic influence of TB, it shows that TB not only puts a heavy financial burden on the families of those affected but also takes a heavy socio-economic toll. It is undoubtedly slowing down socioeconomic growth [5,6].

In recent years, the Chinese ecological environment has been facing critical challenges, especially air pollution, because of the sloppy economic development and some backward development concepts, such as "pollution first and treatment later" [7]. As a developing country, China is facing significant challenges in controlling air pollution. Data shows that in 2018, China ranked 177th among more than 180 countries and regions worldwide in the air quality assessment and there was only 121 out of 338 cities in the country met the air quality standards in 2018, with an urban air quality meeting rate at 35.8% [8]. The condition of air pollution in China is evident. In the meantime, people have realized for a long time that air pollution is closely related to the development of several diseases. Air pollution can increase the likelihood of the aggravation of respiratory diseases, such as pulmonary TB [9]. There are studies focused on the relationship between air pollution factors and TB. For example, a systematic review written by Popovic et al. summarizes the relationship between ambient air pollutants, chronobiology, and TB [10]. Also, the studies proposed by Lai et al. aimed at oxidizing pollutants have demonstrated that exposure to oxidizing pollutants, such as nitrogen dioxide and sulfur dioxide, can have a differential effect on the risk of developing TB [11]. Moreover, a study conducted in Korea shows that men with TB are more vulnerable to increased concentrations of SO_2 [12]. Another study in North Carolina also suggests a potential correlation between particulate matter exposure and TB risk [13]. Finally, scientists also observed that air pollutants will increase the death risk for people with TB [14]. Similar studies related to air pollution and TB are also carried out by Chinese researchers. A study carried out by Li et al. revealed the potential link between the exposure of $PM_{2.5}$, PM_{10}, SO_2 and NO_2 [15]. Zhu et al.'s study shows that the exposure of PM_{10} increase the risk of TB and the exposure of SO_2 increase the TB incidence among female people [16]. However the results of those studies are not the same, and because of this a comprehensive study of the relationship between air pollutants and TB incidence is necessary. And the results of such studies could also be used in formulating effective TB prevention measures.

2. Methods and techniques

The process of systematic review, as well as meta-analysis, was conducted under the PRISMA standard recommendations.

2.1. Search strategy

First of all, we searched the articles relevant to our research, after comparing all of the searching results and the search terms used, "Environmental", "pulmonary tuberculosis" and "Distributed Lag Non-linear Model" were used as the search term to collect the literature in the databases online, including the Chinese academic journals (CNKI), Wanfang database, VIP database, PubMed, Cochrane library, and Web of Science. We have no restrictions on the type of literature during the searching. A manual search was also used in the electronic databases, according to the reference lists in review articles, so that we could detect articles about the association between air pollution and TB up to May 2022. Due to the possibility of invalid data, we didn't accept the grey article. Two researchers carried out this process independently and a third researcher arbitrated if the results were different from the other.

2.2. Inclusion and exclusion criteria

Due to the limitation of the number of publications, we did not set the range of the pulication date for the search, but most of the literature included should be from the last five years. The literature included were all studies in the TB incidence and air pollution field, with a defined and precise population selection, using RR, and cumulative risk ratio(cRR) values as outcome measures. We filtered out all the search results without full text or no RR values and excluded low-quality and duplicate publications. We also weeded out articles with multi-contaminant exposure because of the common exposure issues. Meanwhile, systematic reviews, as well as Meta-analyses, were excluded from this study.

2.3. Literature screening and information extraction

After screening titles, abstracts, and full texts, we removed the articles that did not meet the inclusion criteria or duplicates and only left nine documents. Then, two researchers extracted data from these nine articles. There is the information we extracted from these nine articles: 1) study authors, 2) year of publication, 3) geographical region (country), 4) relevant studies, 5) participants, 6) research type, 7) sample size, 8) exposure factors, 9) assessment of all outcomes, 10) effect size estimates and its 95% CIs. Also, as for the studies that separated their observation groups, we extracted the data from all grouped pollutants both for each group and for the sum data.

Where multiple RR values were available for an article, the largest one was taken. Where single pollutant and multi-pollutant exposures were both presented, the results for single pollutant exposures were selected. Threshold function results would be included in their entirety. The process of searching and screening is shown in Fig. 1.

2.4. Statistical analysis

Two researchers assessed the quality of each study independently and resolved the discrepancies via discussion. The 9 papers included by us are all ecological studies in observational studies, so we used The Newcastle-Ottawa scale (NOS) for non-randomized studies to evaluate the quality of the research included. After analyzing the pollutants concerned in all nine papers, we removed the pollutant categories that were less frequently covered and only chose five pollutant categories $PM_{2.5}$, PM_{10}, SO_2, NO_2, and O_3. Then we did all cumulative lagged effects for these five pollutant categories in the included papers.

We used STATA 11 to carry out our analysis. We analyzed the heterogeneity of the included studies by using I^2 statistic in combination with the Q-test. A value of I^2 statistic that was greater than 50% or a Q-test with the *P*-value less than 0.1 indicated statistically significant heterogeneity and the random effects model would be used to pool the effect size in this case. Otherwise, the fixed effects model would be applied. Also, to evaluate the origin of the heterogeneity, we conducted a subgroup analysis using the selected region, the time unit of exposure, and the selected model as a classification standard to look for sources of heterogeneity.

Random effects models are used to carry out the analysis. We pooled the relative risks (RR and cRR) for these five pollutant categories across all included literature, and finally calculated the RR values and 95% CIs for each pollutant at single-day lags and cumulative effects. After this step, we made forest plots to visualize the results. To avoid the effect of a single study on the overall results, we carried out sensitivity analyses for each pollutant group.

The publication bias was visualized using funnel plots and was confirmed using Egger's regression test. It is carried out by one researcher. When publication bias was recognized, a Trim and Fill analysis was performed.

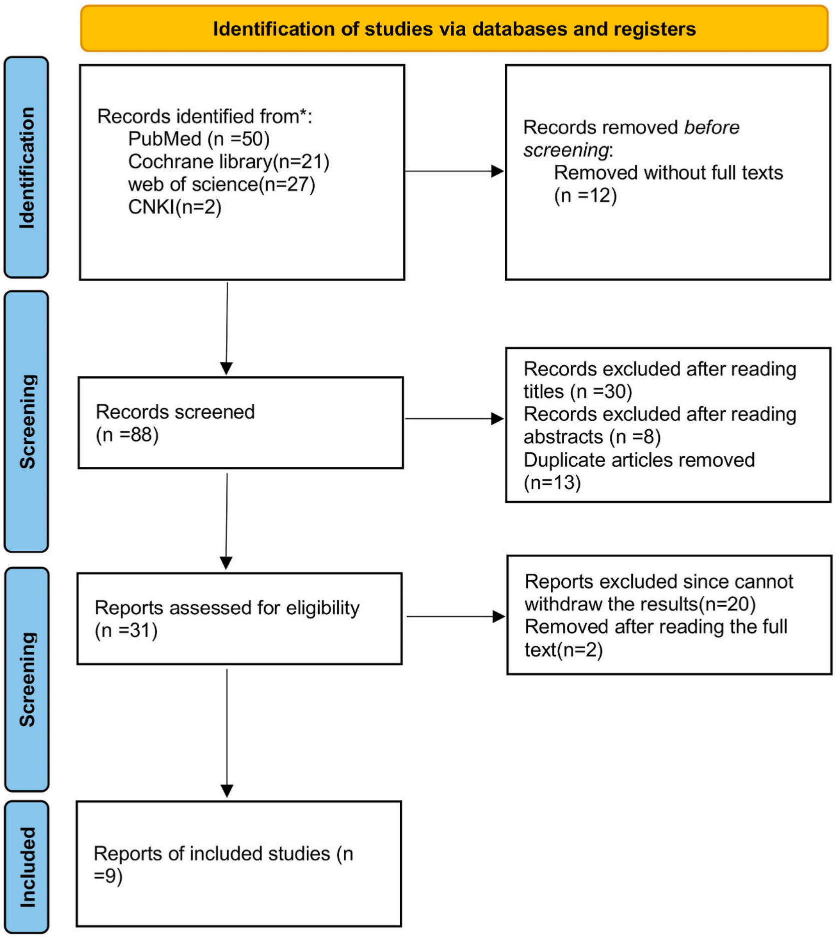

Fig. 1. Our process of searching and screening the documents.

3. Results

3.1. Basic information on the included literature

By searching the databases described in the retrieval strategy, we initially found 100 articles. 82 were left after removing duplicates, and then 27 were left after filtering by title. Finally, we accepted 9 articles as the included articles for our research after filtering for the full text and checking references [9,15,17–23].

The included literature all belonged to time series ecology studies, with five studies utilizing distributed lag nonlinear model (DLNM), one study using Bayesian models, three and two articles utilizing generalized additive and generalized linear models

Table 1
Characteristics of included articles evaluating the association between air pollution and TB.

Author. (Year)	Region	Sample size	Exposure (s)	Data sources	Statical model	RR (95%CI)	NOS score
Wang et al. (2021)	Shijiazhuang, Hebei	21052	PM_{10} SO_2	the National Infectious Diseases Network of Shijiazhuang	generalized linear model and generalized additive model	1.00209 (1.00076,1.00641) Cum1.02239 (1.00623,1.03882) 1.00015 (0.99491,1.00542) Cum0.96030 (0.90102,1.02348)	6
Huang et al. (2020)	Hefei, Anhui	22749	PM2.5 NO_2 SO_2 O_3	Hefei CDC	distributed lag nonlinear model (DLNM)	1.057(1.002,1.115) cum1.559(1.002,1.115) 1.026(1.008,1.044) Cum1.042(1.02,1.064) 0.987(0.978,0.996) Cum0.852(0.793,0.916) 0.986(0.936,0.984) Cum0.96(0.936,0.984)	7
Wang et al. (2022)	Fuyang, Anhui	21591	SO_2	Fuyang CDC	distributed lag nonlinear model (DLNM)	0.903(0.873,0.934)	7
Wang et al. (2022)	Anhui	186623	PM2.5 PM_{10} CO O_3 NO_2 SO_2	Municipal CDC in cities of Anhui province	random-effects model and distributed lag nonlinear model (DLNM)	1.0028(1.0015,1.004) Cum1.0291 (1.0082,1.0504) 1.0013(1.0002,1.0024) Cum1.0137 (1.0006,1.027) 1.0037(1.0005,1.0068) Cum1.0337 (1.0036,1.0647) 1.0049(1.0012,1.0086) Cum1.0119 (1.0038,1.0202) 1.0242(1.0059,1.0428) Cum1.018 (0.9988,1.0375) 0.9549(0.9389,0.9712) Cum0.8212 (0.7351,0.9173)	8
Li et al. (2019)	Lianyungang, Jiangsu	7282	$PM_{2.5}$ PM_{10} NO_2 SO_2	Lianyungang CDC	distributed lag nonlinear model (DLNM)	Cum1.12(1.03,1.22) Cum1.11(1.06,1.17) Cum1.29(1.11,1.49) Cum1.37(1.16,1.62)	7
Xu et al. (2022)	Hong Kong, China	28544	$PM_{2.5}$ PM_{10} CO	Centre for Health Protection, Department of Health, Hong Kong	distributed lag nonlinear model (DLNM)	1.8881(1.2609,2.7683) 1.7693(1.1308,2.7683) 1.8449(0.7734,4.4007)	8
Ge et al. (2017)	Ningbo, Zhejiang	18316	SO_2 NO_2 PM_{10}	Zhejiang CDC	generalized additive Poisson regression models	0.977(0.964,0.991) 0.985(0.968,0.993) 0.986(0.975,0.997)	7
Liu et al. (2020) 6	Hubei	–	SO_2 NO_2 PM_{10}	Hubei CDC	Bayesian models	1.046(1.038,1.054) 1.008(0.986,1.028) 1.002(0.988,1.019)	6
Sun et al. (2023)	Beijing	47666	NO_2 O_3 CO	Beijing CDC	distributed lag nonlinear model (DLNM)	1.013(1.004,1.023) Cum1.03(1.009,1.052) 0.988(0.982,0.995) Cum0.975(0.96,0.99) 0.995(0.992,0.998) Cum1.007(0.993,1.022)	7

respectively, and one study utilizing both generalized additive and generalized linear models [20].

The study covered a geographical area of more than 20 municipal administrative units in five provinces. One case was studied in Hebei Province, one in Beijing, three in Anhui, one in Hubei, one in Zhejiang, one in Jiangsu, and one in Hong Kong. The key information about all the documents can be found in Table 1.

3.2. Quality of included literature

Of the articles we included, two had a final scoring result of 8, while two were also scored as 6. A total of five articles received a score of 7. The final results of the scoring are listed in Table 1.

3.3. p.m.$_{2.5}$ exposure and TB

Two of the studies we included concerned the effect of $PM_{2.5}$ on the incidence of TB in people of different genders. The statistical analysis for $PM_{2.5}$ showed an $I^2 = 85.4\%$, $P = 0.001$ (the cumulative effect was $I^2 = 74.7\%$, $P = 0.019$) Therefore, the statistical analysis for $PM_{2.5}$ should be carried out in a random effect model no matter the cumulative effect is considered or not. The final relative risk for $PM_{2.5}$ was 1.059 with 95% CIs of 0.966–1.060, which meant there was no significant statistical association (Fig. 2/a). When considering a cumulative effect, the result is 1.095 (0.983, 1.219), with no statistically significant association between them (Fig. 2/b).

3.4. p.m.$_{10}$ exposure and TB

In total, there were five documents involving PM_{10} and three of them focused on its cumulative effect. The heterogeneity test for PM_{10} showed an $I^2 = 71.1\%$, $P = 0.008$ (the cumulative effect was $I^2 = 83.6\%$, $P = 0.002$), and the statistical analysis for both groups used a random effects model. The final relative risk for PM_{10} was 1.000 with a 95%CI of (0.996, 1.004) and the association between the two was not statistically significant (Fig. 2/c). When considering the cumulative effect, the result was 1.035 (1.006, 1.066), thus indicating a contribution of PM_{10} to the development of TB (Fig. 2/d).

3.5. SO_2 exposure and TB

In total, six papers focused on SO_2, and three were about cumulative effects. Similar to the $PM_{2.5}$ group, here we only analyzed SO_2 and its cumulative effects. The heterogeneity test for SO_2 showed an $I^2 = 97.6\%$, $P < 0.001$ (the cumulative effect was $I^2 = 90.6\%$, $P <$ 0.001), and the statistical analysis for both subgroups used a random effects model. The final relative risk for SO_2 was 0.980 with a 95%

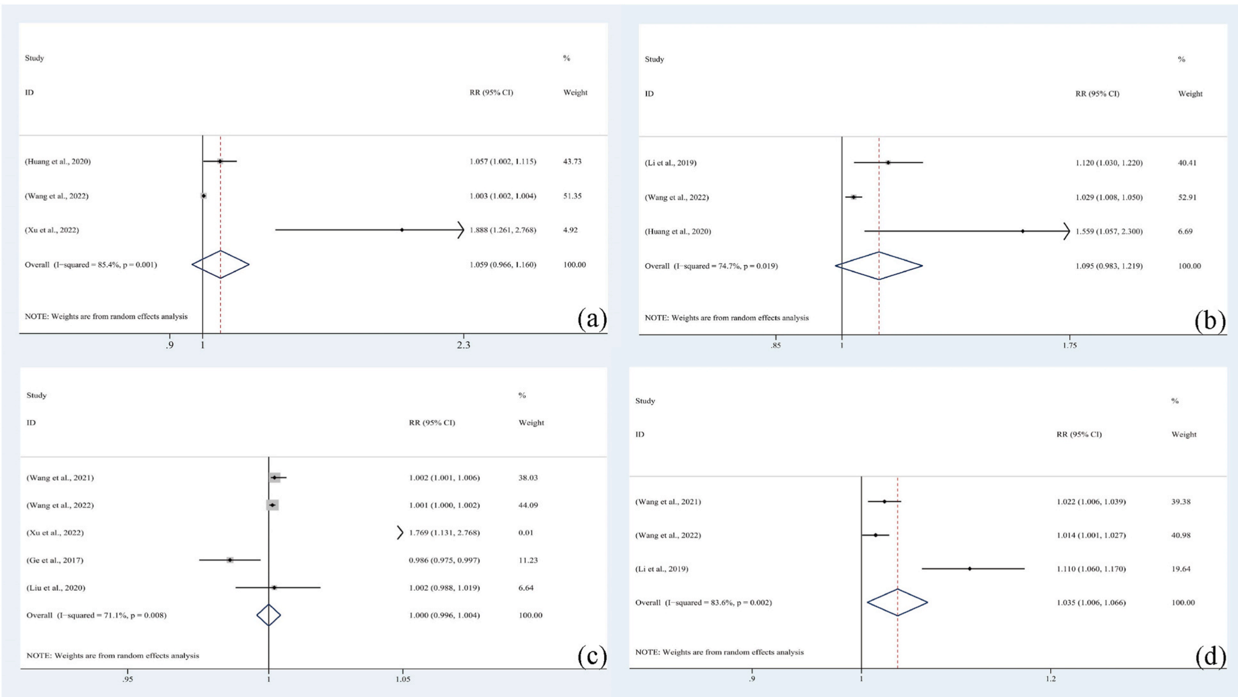

Fig. 2. Results of the $PM_{2.5}$ and PM_{10} groups, both include the cumulative effect group. Figure a is the result of the $PM_{2.5}$ group, and figure b is the result of the cumulative group of $PM_{2.5}$. Figure c is the result of the PM_{10} group, figure d is the result of the cumulative group of PM_{10}.

CI of (0.954, 1.007), with no statistically significant association between them (Fig. 3/c). When considering cumulative effects, the result was 0.964 (0.830, 1.121), with no statistically significant association between the two (Fig. 3/d).

3.6. NO_2 exposure and TB

In total, five papers focused on NO_2 and four were about cumulative effects. We only analyzed NO_2 and its cumulative effect. The heterogeneity test for NO_2 showed an $I^2 = 80.5\%$, $P < 0.001$ (the cumulative effect was $I^2 = 74.1\%$, $P = 0.009$), and the statistical analysis for both subgroups used a random effect model. The final relative risk for NO_2 was 1.011 with a 95% CI of (0.994, 1.027) and there was no statistically significant association between the two (Fig. 3/a). When considering cumulative effects, the result was 1.037 (1.010, 1.065), demonstrating that NO_2 contributes to the development of TB (Fig. 3/d).

3.7. O_3 exposure and TB

In total, three papers focused on O_3 and its cumulative effect. Similar to the $PM_{2.5}$ group, here we only analyzed O_3 and its cumulative effects. The heterogeneity test for O_3 showed an $I^2 = 91.4\%$, $P < 0.001$ (the cumulative effect was $I^2 = 91.4\%$, $P < 0.001$), and the statistical analysis for both subgroups used a random effects model. The final relative risk for O_3 was 0.994 with a 95% CI of (0.980, 1.008), with no statistically significant association between them. When considering cumulative effects, the result was 0.982 (0.954, 1.010), with no statistically significant association between the two.

3.8. Heterogeneity analysis

Subgroup analyses were conducted for each pollutant group by exposure time unit, selected model, and study region to analyze the sources of heterogeneity. When exploring the heterogeneity brought about by the regions selected for the study, we classified Hebei Province as the group north, Hong Kong SAR as the group south, and Hubei Province, Jiangsu Province, and Anhui Province as the group central, according to the geographical characteristics of these regions. The results showed that the sources of heterogeneity for the $PM_{2.5}$ group were study region and time units, and for the $PM_{2.5}$ cumulative effects group, it was time units. The NO_2 group was the time unit (Fig. 4/a-b). The NO_2 cumulative effect group was the selected model and time unit (Fig. 4/c-d). The heterogeneity of the

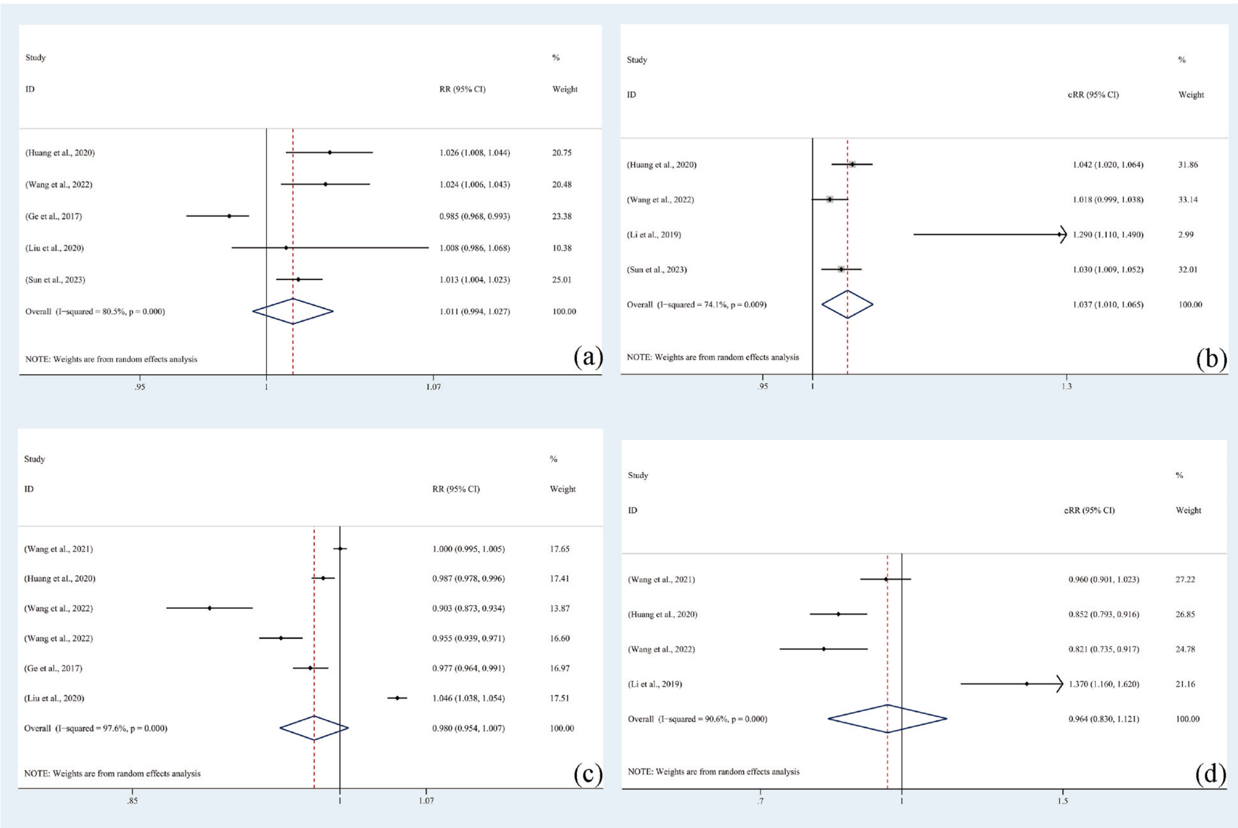

Fig. 3. Results of the SO_2 and NO_2 groups, both include the cumulative effect group. Figure a is the result of the NO_2 group, and figure b is the result of the cumulative group of NO_2. Figure c is the result of the SO_2 group, figure d is the result of the cumulative group of SO_2.

PM_{10} group comes from the exposure time unit, selected model and study region (Fig. 6/a-b). The heterogeneity of PM_{10} cumulative effects group comes from the exposure time unit and model (Fig. 6/c-d). SO_2 group got its heterogeneity from model and time (Fig. 5/a-b). The heterogeneity of the SO_2 cumulative effect group came from the selected model (Fig. 5/c-d). The heterogeneity of the O_3 group and its cumulative effect group were all generated from the study region.

3.9. Publication bias and sensitivity analysis

Publication bias was not noticeable for any of the five groups of contaminants. We found that the results after conducting the sensitivity analysis were more in line with the results before it was carried out and the results can be considered robust.

4. Discussion

Although there were several studies on the relationship between air pollutants and the development of TB, the results of these studies were contradictory. For example, Kun et al.'s study showed that chronic exposure to PM_{10}, nitrogen dioxide, and sulfur dioxide promoted the development of TB, whereas the relationship between $PM_{2.5}$, ozone, and nitrous oxide and the development of TB was not so precise [24]. Dimala et al. used a random effects model to investigate the relationship between $PM_{2.5}$, PM_{10}, CO, sulfur dioxide, nitrogen dioxide, and ozone and the incidence of TB, and their results indicated that the first three pollutants were positively associated with the incidence of TB, while the last three were not associated with the incidence of TB [25].

The results explored in this paper further confirm that air pollution is highly probably a risk factor for the development of TB. The rapid development of many countries today, especially in the third world, has brought them a problem of air pollution that cannot be ignored. The results of this study provide new dimensions for policy development in the control of TB. Air pollution control will likely be an important component of the World Health Organization's goal to eliminate TB.

In the results of the study, chronic exposure to PM_{10} and NO_2 is thought to increase the incidence of TB. NO_2 is mainly derived from Volatile Organic Compounds (VOCS), combustion processes including heating, power generation, vehicle, and ship engines, and industrial emissions, dissolved in water, nitrogen dioxide produces an acid that reacts violently with many organic compounds and can also be used as an oxidizing factor. PM_{10}, on the other hand, is often referred to as particulate matter with a particle size of fewer than 10 μm and is mainly organic or inorganic particles of various origins suspended in the air [26]. They usually come from unsurfaced

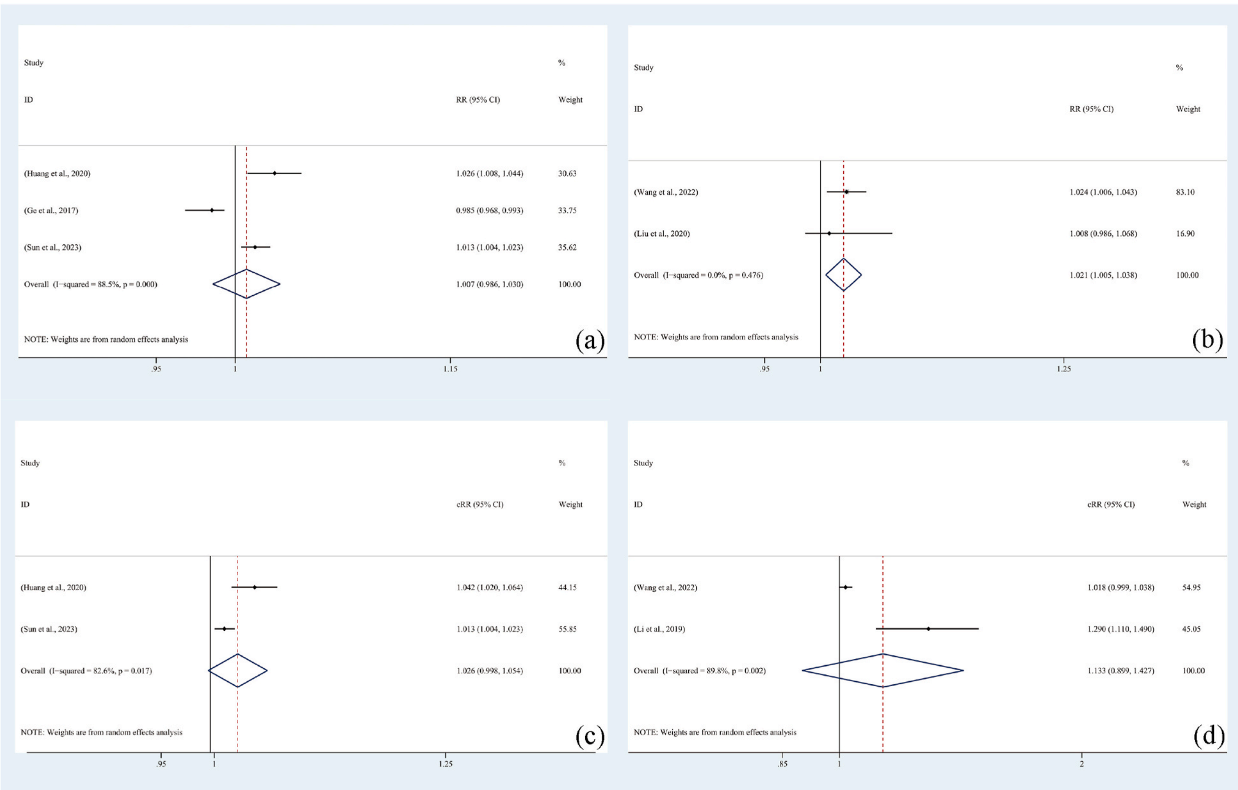

Fig. 4. Results of heterogeneity analysis. Figure a and b are the result of the NO_2 group, while a is the result of the studies using days as time units, and b is the result of the studies using months as time units. Figure c and d are the results of the cumulative effect group of NO_2, where figure c is the result of using DLNM, and figure d is the result of the studies using months as time units.

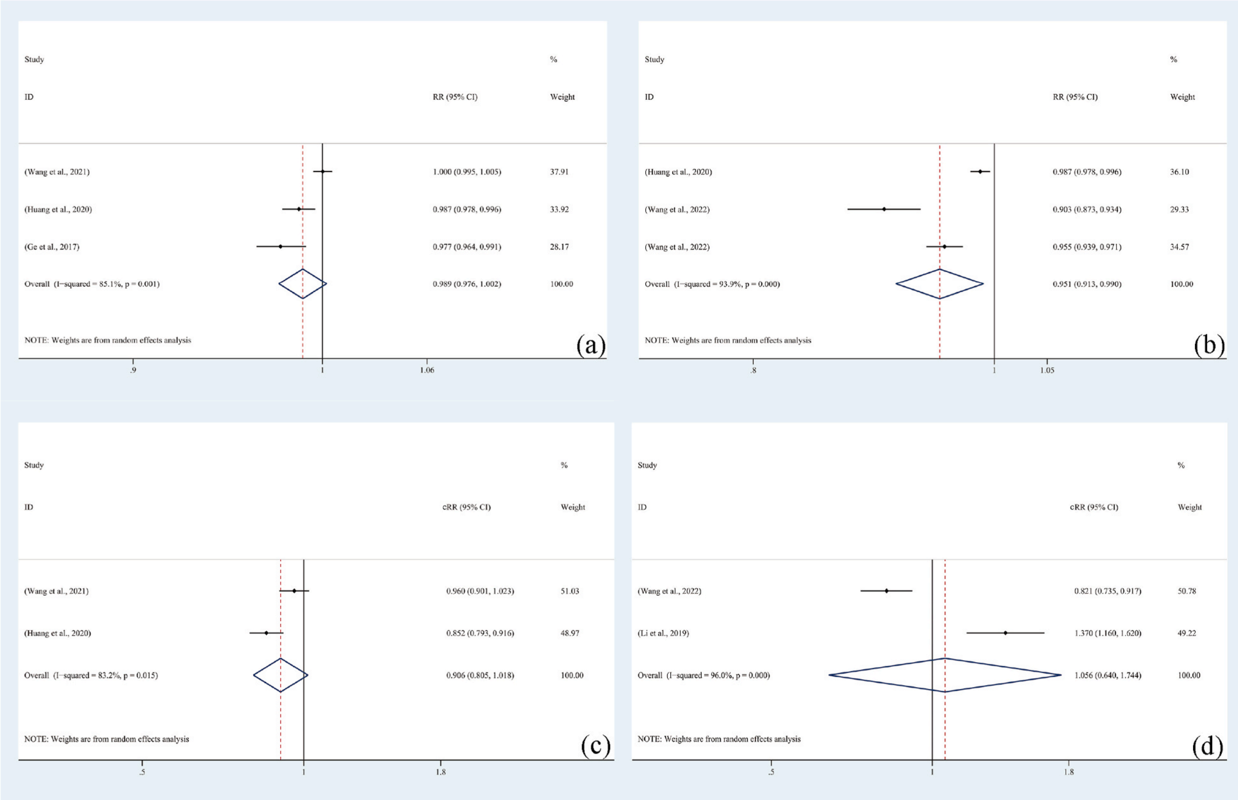

Fig. 5. Results of heterogeneity analysis. Figure a and b are the result of the SO_2 group, while a is the result of the studies using days as time units, and b is the result of the studies using DLNM. Figure c and d are the results of the cumulative effect group of SO_2, c is the result of using days as time units, and d is the result of the studies using months as time units.

asphalt, motor vehicles driving on concrete roads, the crushing and grinding of materials, and dust raised by the wind. The solubility of these two types of pollutants makes them more likely to irritate the respiratory mucosa and, as a result, cause overreaction and inflammation of the upper respiratory tract [27]. Such contaminants increase the susceptibility of the body to TB by producing TNF-α and IFN-g, which can weak the immune system [28,29], inhibit the formation of serum-neutralizing antibodies [30], and alter the phagocytosis of alveolar macrophages and blood monocytes as well as upregulate the expression of receptors involved in pathogen invasion [15,31]. PM_{10} is known to infiltrate the lungs and can cause inflammation and other upper respiratory tract diseases such as asthma, chronic bronchitis, and airway obstruction [31]. It is evident that the results of the studies on PM_{10} and nitrogen dioxide are consistent with each other and will be a guide for future similar studies and the control of TB.

It is important to note that the relationship between $PM_{2.5}$ and sulfur dioxide and TB, which is unknown in the present study, will be a breakthrough for future generations. Sulfur dioxide is produced in volcanic eruptions and many industrial processes. Sulfur dioxide reacts with water and water vapor to produce toxic and corrosive vapors. Excessive concentrations of sulfur dioxide can also be hazardous to human life, as in the case of the London smog. Inhalation of particulate matter can cause airway overreaction and DNA damage, causing injury to the body's respiratory system, which can lead to the entry of bacteria and predisposition to disease [32,33]. When the body inhales SO_2, the water in the mucous membranes of the upper respiratory tract can undergo a series of chemical reactions, leading to severe respiratory irritation [17]. However, it has also been proposed that sulfur dioxide is negatively associated with the incidence of TB in low-pollution areas [17]. Low levels of sulfur dioxide exposure may lead to oxidative damage to lipids and proteins, activating human cells against Mycobacterium TB and then reducing the risk of TB [17,34]. The relationship between sulfur dioxide, $PM_{2.5}$, and the incidence of TB needs to be further elucidated.

There are a few limitations in our systematic review and meta-analysis. First, it can be observed that the selected geographic areas are all located within China, and this selection may result in some bias due to the lack of consideration of geographical disparities. While we are conducting the search, we found that there are few studies met our request, and most of them are conducted by Chinese researchers. We did many manul search to find out more studies carried out in other countries, but after we completed all of the filtering works, rest of the researches included are all conducted in China. We will continue to focus on this issue and do an updated meta-analysis as more eligible literature becomes available.

In addition, the social lifestyle of the people being surveyed is one of the variables that we should be aware of. The number of smoking/second-hand smoke occasions, the severity of indoor air pollution and the sanitation of the living environment are all variables that need adjustments. Controlling such variables is challenging due to many unavoidable factors, and measuring these variables

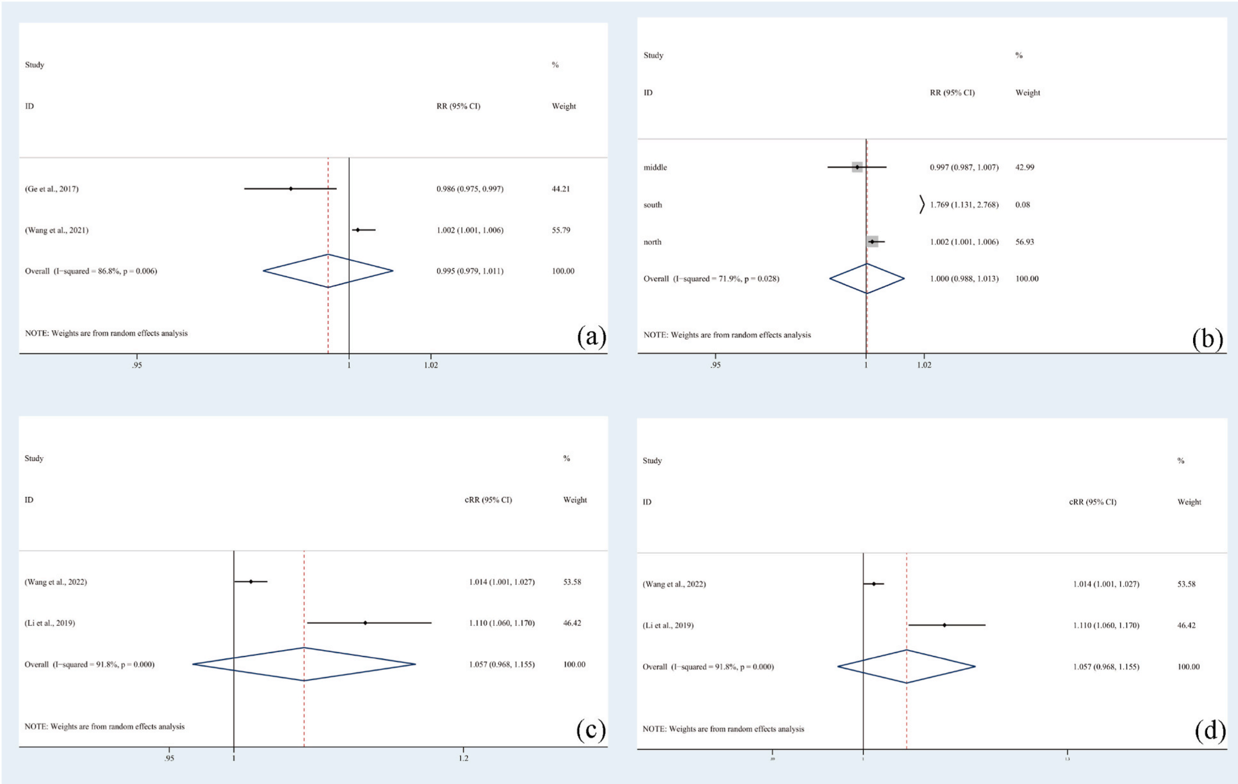

Fig. 6. Results of heterogeneity analysis. Figure a and b are the result of PM_{10} group, while a is the result of the studies using days as time units, b is the result of different study regions. Figure c and d are the result of cumulative effect group of PM_{10}, figure c is the result of using DLNM models, figure d is the result of using month as time units.

become an area where future research can be upgraded.

This study investigated the relationship between five types of air pollutants and the prevalence of TB. The relationship between $PM_{2.5}$ and sulfur dioxide and the occurrence of TB was unknown, while chronic exposure to PM_{10} and nitrogen dioxide was shown to promote the development of TB. This study offered a reference for future research and provided a guideline for the control of TB. The management of air pollution should be an important direction for TB control regulations, and more comprehensive exploration of the relationship between air pollutants and TB incidence and its mechanisms would be a direction for such research to be refined.

5. Conclusion

This study explored the relationship between five types of air pollutants and the incidence of TB. From our study, we can know that $PM_{2.5}$, sulfur dioxide, and ozone have an unidentified association with the incidence of TB. When we are considering cumulative lag effect, PM_{10} and nitrogen dioxide were shown to promote the incidence of TB. This study provides a direction for subsequent research and informs policy on TB control as a reference. The treatment of air pollution should be an important direction in the development of TB control policies, and a further systematic investigation of the relationship between air pollutants and TB incidence and the underlying mechanisms would be a direction for such research.

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Data availability statement

The authors declare that they hadn't deposited their data associated with their study into a publicly available repository. Data associated with our study will be made available on request.

Credit authorship contribution statement

Jianshi Song: Writing – review & editing, Writing – original draft. **Yaxiong Nie:** Resources, Conceptualization. **Binhao Wang:** Writing – review & editing. **Yuechen Yang:** Writing – review & editing. **Ning Ma:** Writing – review & editing. **Jiaming Tian:** Writing – review & editing. **Zitong Zhao:** Writing – review & editing. **Xinzhu Zhang:** Writing – review & editing. **Jianning Cai:** Project administration, Data curation. **Xiaolin Zhang:** Writing – original draft, Project administration, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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