International Journal of Pediatric Otorhinolaryngology 112 (2018) 82–90

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Review Article

Exposure to air pollution and risk of prevalence of childhood allergic rhinitis: A meta-analysis

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ARTICLE INFO

Keywords:
Allergic rhinitis
Air pollution
Risk
Prevalence
Childhood
Odds ratio
Meta-analysis

ABSTRACT

Objectives: Allergic rhinitis (AR), a common chronic inflammatory disease in the upper airways. The prevalence of AR in children seems to be increasing recently, and the most significant causes of the increase are thought to be changes in environmental factors, especially air pollution. However, we could not find any meta-analysis on the risk of air pollution exposure on the prevalence of AR in childhood. The aim of this research was to carry out a meta-analysis on the results of recent studies (21 s t century) to present valid information about exposure to air pollution and risk of prevalence of childhood AR.

Methods: PubMed, Science, Google Scholar, Elsevier and MDPI web database were searched up to January 1, 2000 to February 28, 2018. Including of air pollution and AR in childhood related to the observation of literature. Meta-analysis, study quality assessment, heterogeneity analysis and publication bias test were using Stata-MP 14.1 and Review Manager version 5.3 software.

Results: 13 studies will be included in the meta-analysis (8 cross-sectional studies, 5 cohort studies). Exposure to NO_2 (OR_{Europe} = 1.031, 95%CI [1.002,1.060], P = 0.033; OR_{Asia} = 1.236, 95%CI [1.099,1.390], P = 0.000; $OR_{overall}$ = 1.138, 95%CI [1.052,1.231], P = 0.001); Exposure to SO_2 (OR_{Europe} = 1.148, 95%CI [1.030,1.279], P = 0.012; OR_{Asia} = 1.044, 95%CI [0.954,1.142], P = 0.352; $OR_{overall}$ = 1.085, 95%CI [1.013,1.163], P = 0.020); Exposure to PM_{10} (OR_{Europe} = 1.190, 95%CI [1.092,1.297], P = 0.000; OR_{Asia} = 1.075, 95%CI [0.995,1.161], P = 0.066; $OR_{overall}$ = 1.125, 95%CI [1.062,1.191], P = 0.000); Exposure to $PM_{2.5}$ (OR_{Europe} = 1.195, 95%CI [1.050,1.360], P = 0.007; OR_{Asia} = 1.163, 95%CI [1.074,1.260], P = 0.000; $OR_{overall}$ = 1.172, 95%CI [1.095,1.254], P = 0.000).

Conclusions: Exposed to air pollution probable is a risk of prevalence of childhood AR. And the prevalence of AR will be increase when exposed to NO_2, SO_2, PM_{10} and $PM_{2.5}$, but maybe the relationship between SO_2/PM_{10} and prevalence of AR are not closely in Asia.

1. Introduction

Allergic rhinitis (AR), a common chronic inflammatory disease in the upper airways, affects about 30–40% of the population worldwide. Also, AR is a common problem for children, which develops based on disruptions in the immune system. The probability of human gene mutation has not changed significantly, but reports that over the past few decades indicated that the prevalence of AR in children seems to be increasing [1–4]. The most significant causes of the increase are thought to be changes in environmental factors, such as air pollution, socioeconomic status, cultural difference, lifestyle changes or exposure to new allergens [5,6]. Among them, air pollution is regarded as the most important one. The existing evidences provides considerable support for the existing literature, if childhood exposure to airborne pollutants is a considerable predictor of respiratory morbidity in childhood, early [7].

Air pollution, it is a major and rising danger in an environment associated with persistent increases in medical expense and morbidity. Air pollution refers to ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and particulate matter (PM), and so on [8]. Their harmful effects on respiratory system have acquired much awareness. It has been reported that exposure to outdoor air pollutants such as NO_2, SO_2, O_3 and PM have adverse effects on immune competent cells and airway responsiveness [9], and there are also different air pollutants in different regions. Recent reports have demonstrated an association between high levels of bad air quality and an increased risk of allergic sensitization and prevalence of airway inflammatory diseases, such as COPD, bronchitis, asthma and AR.

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https://doi.org/10.1016/j.ijporl.2018.06.039
Received 7 June 2018; Received in revised form 22 June 2018; Accepted 23 June 2018
Available online 27 June 2018
0165-5876/

As we all know, AR has a significant impact on the quality of life of patients by causing uncomfortable symptoms such as nasal congestion, nasal pruritus, sneezing, rhinorrhea and nasal obstruction. Furthermore, AR is a risk factor for asthma, allergic conjunctivitis, rhinosinusitis, nasal polyposis, and secretory otitis media, resulting in important medical and social problems, especially in childhood. Thus, in this study, we focused on the associations between air pollution and children's AR. The aim of this research was to carry out a meta-analysis on the results of all conducted studies to present valid information about the correlations between the concentration of airborne pollutants and the prevalence of AR in childhood. Then, we aimed to assess the impact of specific pollutants exposure on the risk of AR in children.

2. Methods

Two researchers performed a systematic search independently to find the studies on AR and air pollution in childhood. Several web databases including PubMed, Science, Google Scholar, Elsevier and MDPI were searched for relevant articles, and searched up to January 1, 2000 to February 28, 2018.

Relevant studies were identified using four sets of keyword combinations.

1. 'Children/Kids/childhood' and 'air pollution/air pollutants' and 'allergic rhinitis/respiratory allergic diseases';
2. 'Children/Kids/childhood' and 'air quality' and 'allergic rhinitis/respiratory allergic diseases';
3. 'Children/Kids/childhood' and 'environment' and 'allergic rhinitis/respiratory allergic diseases';
4. 'Children/Kids/childhood' and 'nitrogen dioxide (NO_2)/sulfur dioxide (SO_2)/particulate matter (PM)' and 'allergic rhinitis/respiratory allergic diseases'.

We limited the language to English when searched. And we searched manually the reference lists of all included studies.

The inclusion criteria of meta-analysis included three points. The first, only observational studies including cross-sectional, cohort and case-control studies that have examined the association between air pollution exposure in childhood (age:0–18) and AR reported, which all can offer data to calculate the adjusted odds ratio (including gender, age, family history of asthma and allergic diseases, etc.) of AR with corresponding 95% confidence intervals (CI) for exposure to air pollutants (NO_2/SO_2/PM_{10}/$PM_{2.5}$).

The second explicitly specified the term 'AR' as an outcome for investigation.

The third all documents contain data on air pollutants, including nitrogen dioxide (NO_2), sulfur dioxide (SO_2), Particulate Matter < 10 μm in diameter (PM_{10}) and Particulate Matter diameter < 2.5 μm ($PM_{2.5}$) in their respective regions and the international evaluation standard for AR.

The exclusion criteria excluded adulthood AR and reviews, comments, incomplete information, governmental reports, letters, experimental studies or abstract.

Two authors independently extracted the parameters of the study design from each article, the age of the participants, and calculated the adjusted effect size and the corresponding 95% CI of the corrected odds ratio of the children after exposure to air pollutants (NO_2, SO_2, $PM_{2.5}$, PM_{10}). If necessary, resolve differences by discussing, examining, and negotiating with a third author.

Heterogeneity between study results was assessed using the Cochran Q statistic test and sensitivity analysis. I^2 statistic to determine the percentage of variability due to heterogeneity in the use. Study results were considered consistent when there was less than 50% variation due to heterogeneity, using fixed effects models, on the contrary, using random effects models ($I^2 > 50\%$). Using random-effect meta-regression to study significant heterogeneity to determine which study-level factors explained heterogeneity [10]. Sensitivity analysis was used to evaluate the stability of the included literature and subgroup analysis by region. And subgroup analysis by region. All analyses were performed using the software Stata-MP 14.1(Stata Corporation, College Station, TX) and Review Manager version 5.3.

According to population scale research design, air pollution exposure measurement, contact time measurement method, doctor diagnosis, methodological quality of assessment study, international classification of diseases and questionnaire of ISAAC, confounding controls utilized, and statistical methods used. The quality of the study was evaluated using the Combie [11] for cross-sectional studies and the Newcastle Ottawa Scale (NOS) [12] for cohort studies. The total 7.0 points, 6.0–7.0 points evaluated level A, 4.0–5.5 points evaluated level B, less than 4.0 point was level C when using the Combie. And in cohort studies, full score was 9 points, 5–9 points can be assessed high level by NOS.

3. Results

Following the development of our search strategy, Totally, 547 relevant articles were resulted from primary research in web databases including PubMed, Science, Google Scholar, Elsevier and MDPI. After deleting duplicate articles and reviews, 389 relatively articles were obtained. Then, 344 articles were excluded due to irrelevance to study the subject after evaluation of titles and abstracts, so 45 articles included in the study for reviewing full-text. Next, 32 articles were excluded after reviewing full-texts due to incomplete information and low-quality studies. Thus, 13 studies that met inclusive criteria were included in the meta-analysis (Fig. 1).

These studies were published from January 1, 2000 to February 28, 2018. Eight of the included articles had been carried out as cross-sectional surveys and five of them had been carried out as cohort studies, including 123266 A R children contributed to the meta-analysis. Of these studies, 12 analyzed the correlations between NO_2; 9 articles related to SO_2; 11 studies related to PM_{10} concentrations and AR risk, and 4 reported the correlation between $PM_{2.5}$ concentration and AR risk.

The basic information of 13 included studies is summarized in Table 1.

Verification of heterogeneity analysis mainly through sensitivity analysis and the Cochran Q statistic test. For sensitivity analysis, the results were overall more stable in our analyses.

12 studies [13–23,25] (totally, 92607 children with AR) about air pollutants and AR were selected in this research. Because of the heterogeneity $P_{Europe} = 0.73$, $I^2 = 0\%$; $P_{Asia} = 0.054$, $I^2 = 49.5\%$; $P_{overall} = 0.001$, $I^2 = 66.6\%$, so we used the random effect method to evaluate. Our results showed statistical correlations between the concentration of NO_2 and the prevalence of childhood AR ($OR_{Europe} = 1.031$, 95%CI [1.002,1.060], P = 0.033; $OR_{Asia} = 1.236$, 95%CI [1.099,1.390], P = 0.000; $OR_{overall} = 1.138$, 95%CI [1.052,1.231], P = 0.001). The results demonstrated that air pollutant–NO_2 might significantly increase the risk of AR in childhood (Fig. 2).

Nine studies [13,15–17,19–23] (totally, 46392 children with AR) about SO_2 and AR were selected in this research. Based on the results of fixed effect method ($P_{Europe} = 0.817$, $I^2 = 0\%$; $P_{Asia} = 0.611$, $I^2 = 0\%$; $P_{overall} = 0.613$, $I^2 = 0\%$), statistical correlations between the concentration of SO_2 and the prevalence of childhood AR were not been found ($OR_{Europe} = 1.148$, 95%CI [1.030,1.279], P = 0.012; $OR_{Asia} = 1.044$, 95%CI [0.954,1.142], P = 0.352; $OR_{overall} = 1.085$, 95%CI [1.013,1.163], P = 0.020). There is no correlation between SO_2 and AR in Asia, but overall analysis of SO_2 has a risk for AR in childhood (Fig. 3).

Associations between PM_{10} and AR were reported in eleven studies [13,15–23,25] (totally, 87169 children with AR). Because of low heterogeneity ($P_{Europe} = 0.623$, $I^2 = 0\%$; $P_{Asia} = 0.693$, $I^2 = 0\%$; $P_{overall} = 0.568$, $I^2 = 0\%$), fixed effect method was used. Our results showed that there was an obvious association between exposure to