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Residential greenness and allergic respiratory diseases in children and adolescents – A systematic review and meta-analysis

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A R T I C L E I N F O

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A B S T R A C T

Background: The aetiology of allergic respiratory disease in children is not yet fully understood. Environmental factors are believed to play a major part. The amount of green vegetation surrounding the home (residential greenness) has been recently identified as a potentially important exposure

Objectives: Our goal was to provide a systematic review and quantitative summary of the evidence regarding the relationship between residential greenness and allergic respiratory diseases in children.

Methods: Peer-reviewed literature published prior to 1 March 2017 was systematically searched using nine electronic databases. Meta-analyses were conducted if at least three studies published risk estimates for the same outcome and exposure measures.

Results: We included 11 articles across broad outcomes of asthma and allergic rhinitis. Reported effects were inconsistent with varying measures to define residential greenness. Only limited meta-analysis could be conducted, with the pooled odds ratios for asthma (OR 1.01 95%CI 0.93, 1.09; I^2 68.1%) and allergic rhinitis (OR 0.99 95%CI 0.87, 1.12; I^2 72.9%) being significantly heterogeneous.

Conclusions: Inconsistencies between the studies were too large to accurately assess the association between residential greenness and allergic respiratory disease. A standardised global measure of greenness which accounts for seasonal variation at a specific relevant buffer size is needed to create a more cohesive body of evidence and for future examination of the effect of residential greenness on allergic respiratory diseases.

1. Introduction

Allergic respiratory diseases are an important public health problem in children globally. The prevalence of asthma and allergic rhinitis has increased rapidly over the last 50 years (Asher et al., 2006). While the rates are stabilising in developed countries (Chawla et al., 2012), they are still increasing in many other countries including Latin America and China (Pearce et al., 2007). Persistent allergic rhinitis and uncontrolled severe asthma can significantly impair the quality of life of affected individuals (Guilbert et al., 2011; Meltzer, 2001; Silva et al., 2015). Allergic respiratory diseases place a substantial economic burden on society (Barnett and Nurmagambetov, 2011) and the families of affected children (Bahadori et al., 2009).

Although the causes of allergic respiratory diseases in children are not yet fully understood, environmental factors are key contributors to these epidemics. Traffic related air pollutants (TRAP) have been implicated in the development of asthma and sensitisation to aeroallergens (Bowatte et al., 2015), as well as exacerbations of existing respiratory conditions in children (Evans et al., 2014; Li et al., 2011). Exposure to both outdoor fungal spores and pollen have been shown to increase exacerbations of existing asthmatic patients (Cakmak et al., 2002; Erbas et al., 2012; Pongracic et al., 2010) and of incident asthma and allergic rhinitis (Erbas et al., 2013).

Recently there has been great interest in the amount of green vegetation surrounding the home (residential greenness) as a potential environmental component in the aetiology of allergic respiratory

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diseases. The literature has been inconsistent, with some studies reporting benefits associated with an increase in greenness and others finding the opposite. Reduced asthma prevalence was associated with an increase in street tree density in New York City (Lovasi et al., 2008). Reduced odds of incident asthma during pre-school years were associated with an increases in the Normalized Difference Vegetation Index (NDVI) within 100 m around the participants' homes (Sbihi et al., 2015). Others have reported adverse effects, such as an increase in risk of asthma with increased NDVI within 100 m around the participants' homes (Andrusaityte et al., 2016) or percentage green space as determined by Light Detection and Ranging (LiDAR) imagery within 250 m around the participants' homes (Lovasi et al., 2013). No published systematic reviews have assessed the role of residential greenness on allergic respiratory diseases in children and adolescents.

The aim of this systematic review and meta-analysis was to synthesise the current literature to assess whether surrounding residential greenness was an important factor associated with allergic respiratory diseases in children and adolescents.

2. Methods

2.1. Search strategy

The literature was systematically searched using the following bibliographic databases: Medline, EMBASE, CINAHL, AMED, Scopus, Informit Health, Web of Science, ProQuest central and Google Scholar for English language peer reviewed original articles. Given the lack of consensus on how to measure residential greenness, an extensive list of search terms was used (Table S1). Further hand searches were conducted using citations from included publications.

2.2. Inclusion criteria and definitions

We included cohort, case-control, cross-sectional and ecological studies. Specific inclusion criteria ensured selection of human studies whose study population comprised of children and adolescents aged less than 18 years of age. Outcome measures included asthma, wheeze, allergic rhinitis or lung function. In all cases, multiple definitions including doctor diagnosis, self-report and hospital records data were considered. For inclusion, the studies must have defined the exposure metric and reported on the relationship between residential greenness and at least one of the outcome measures.

2.3. Selection of included articles

The abstracts of all identified papers were independently reviewed for initial inclusion by KL and GB; then full papers were read by KL and GB to determine if all inclusion criteria were met. If disagreement arose between reviewers, the paper was referred to a third reviewer (BE) for assessment.

2.4. Data extraction

Data extraction in each article included was performed by KL in a standardised manner. This process was duplicated by GB. Data were extracted from each article included: author, year of publication, type of study, study population/country, number of children in sample, age range, exposure definition, season of exposure measurement, allergic respiratory disease(s) assessed, outcome definition, risk estimates along with 95%CI/p value, confounders and any interactions assessed.

2.5. Assessment of quality and risk of bias

A validated quality assessment framework (Zaza et al., 2000) was adapted to assess and rate the design, execution (threats to validity and reliability), generalisability, risk of bias and reporting of each study. Individual study quality was assessed using a checklist that categorised and graded: study design; description of the study population and how they were selected; how exposure and outcome were measured and whether these were valid and reliable; the appropriateness of the statistical testing and controlling for study design effects; identification and controlling for potential bias (selection, measurement, recall and analytical biases related to sample size, buffer zones and statistical methods) and potential confounders (season, air pollution, aeroallergens, socioeconomic status, parental atopy, biodiversity of vegetation, nature of built environment); and whether problems with data analysis limited interpretation of the results. Quality assessment data were extracted independently by two authors (KL and RT) (Scoring Matrix included in supplement E1). The quality assessment of this scale is based on the selection of study sample, outcome assessment, exposure assessment and adjustment for confounders.

The assessment of overall risk of bias across all the studies was guided by the GRADE guidelines for rating the quality of the evidence and study limitations of observational studies. Risk of bias in each individual study was categorised from none to high risk of bias in order to assess overall biases and limitations in this research field (Guyatt et al., 2011).

2.6. Standardisation of data

To ensure consistency in the interpretation of effect sizes from different studies, quantitative synthesis was focused on the odds of a given outcome for an increase in residential greenness. To enable comparisons across studies the effect sizes used to generate the meta-analysis estimate were scaled and standardised into the same magnitude (0.1 increase in NDVI) for those studies where NDVI was used. We were unable to do this for studies with different metrics for residential greenness and they were excluded from the meta-analysis.

2.7. Meta-analysis methods

Statistical software R version 3.2.5 (R Foundation for Statistical Computing, Vienna, Austria Foundation for R Foundation for Statistical Computing, Vienna, Austriatatistical Computing, Vienna, Austria) and the package 'metafor' (Viechtbauer, 2010) was used to perform meta-analyses. Given that this review includes studies measuring a number of different allergic respiratory disease outcomes, a threshold number of three studies measuring the same outcome with the same exposure was chosen in order to decide whether to conduct a meta-analysis on a particular outcome. In the meta-analysis, the effect related to the most common exposure buffer was selected. To estimate pooled effect sizes and 95% Confidence Intervals, random effects models were used. I^2 statistics (Higgins and Thompson, 2002) were calculated as measures of between study heterogeneity. A high value of I^2 meant that most of the variability across studies was due to heterogeneity rather than chance, pooling results with an I^2 above 80% was not recommended (Higgins and Thompson, 2002).

Statistical software STATA version 14.1 (Stata Corp LP, College Station, TX, USA) was used to create forest plots of these analyses.

3. Results

The electronic literature search and hand searching found 484 peer-reviewed scientific articles after duplicate papers were removed (Fig. 1). Of these, 463 were excluded following review of titles and abstracts. A large number of these papers were not relevant to the role of residential greenness on childhood allergic respiratory diseases or were conference abstracts, commentary articles or reviews of other articles. Of the remaining 21 articles, 10 were excluded following full-text assessment as they did not assess the relevant exposures (residential greenness) and health outcomes (any form of allergic respiratory disease) in the defined study population (children and/or