

**Ambient pollen and air quality on children's lung function:  
is there a synergy?**

Yutong Cai<sup>1,2,3</sup>

1: Nuffield Department of Women's & Reproductive Health, University of Oxford,  
Oxford, United Kingdom

2: Deep Medicine programme, Oxford Martin School, University of Oxford, Oxford,  
United Kingdom

3: MRC Centre for Environment and Health, Department of Epidemiology and  
Biostatistics, School of Public Health, Imperial College London, London, United  
Kingdom

Correspondence to: Dr Yutong Cai, Nuffield Department of Women's & Reproductive  
Health, Women's Centre, John Radcliffe Hospital, University of Oxford, Oxford, OX3  
9DU, UK. Email: [yutong.cai@wrh.ox.ac.uk](mailto:yutong.cai@wrh.ox.ac.uk)

Children are particularly vulnerable to airborne pollutants due to their immature lungs and immune system. Many studies have reported deleterious effects of exposure to ambient air pollution, in acute or chronic timeframe, on respiratory health in children<sup>(1)</sup>. Airborne pollen are microscopic grains that are released from trees, grasses and weeds. Ample epidemiological evidence has suggested associations between high airborne pollen count and emergency hospital visits for allergies and asthma exacerbation in children<sup>(2)</sup>.

The interplay between air pollutants and pollen is well described in many experimental studies. Particulate matter and gaseous pollutants (e.g. Nitrogen Dioxide [NO<sub>2</sub>], Ozone[O<sub>3</sub>]) can increase allergen absorption into the lungs by binding to pollen grains, facilitate faster release of allergens, and/or modulate pollen allergenic potency<sup>(3)</sup>. In epidemiological studies, whilst it is clear that both ambient air pollution and pollen have independent associations with poor respiratory health, their interactive effects are less certain<sup>(3,4)</sup>. These mixed results, in fact, reflect the complexity in concentration, toxicity/allergenicity and seasonality of both air pollutants and pollen in diverse geographical settings. To date, most studies in this field were of time-series or case-crossover design, and focused primarily on asthma and respiratory symptoms.

To address this knowledge gap, in this issue of *Thorax*, Amazouz and colleagues investigated whether recent exposure to both air pollution and pollen could affect levels of spirometric lung function and fractional exhaled nitric oxide (FeNO) among 1,063 8-year-old children from the population-based PARIS (Pollution and Asthma Risk: an Infant Study) cohort<sup>(5)</sup>. Daily air quality index for PM<sub>10</sub> (particulate matter with a diameter less than 10µm), NO<sub>2</sub> and O<sub>3</sub> for the Greater Paris region were collected for four days preceding the lung function measurement. Similarly, daily

pollen data for the four-day period were collected from a single aerobiological monitoring station in central Paris. For the first time, a daily allergenic risk index, combining both pollen grain count and allergenicity, was computed for nine taxa. A daily total pollen count was also calculated. Using these 13 exposure variables, an unsupervised cluster analysis was performed to assign children to four clusters with distinct exposure profiles. The authors went on to analyse the associations between these exposure clusters and lung function, and additionally to investigate the joint impacts on lung function from exposures to high grass pollen (i.e.  $>10$  grains/m<sup>3</sup>) and poor air quality (i.e. daily air quality index  $\geq 6$  on a scale from 1 to 10, based on the daily average concentrations of PM<sub>10</sub>, NO<sub>2</sub>, O<sub>3</sub> and sulphur dioxide [SO<sub>2</sub>]).

Comparing children in the low exposure cluster, children with moderate exposure to grass pollen and low level air pollution exposure (i.e. grass pollen cluster) in the four days prior to lung function testing had significantly lower FEV<sub>1</sub> and FVC levels by 40 and 57ml respectively. Children with high PM<sub>10</sub> exposure but low pollen exposure (i.e. PM<sub>10</sub> cluster) had higher levels of FeNO, a biomarker of airway inflammation. These associations tended to be stronger among asthmatic children but not pollen-sensitised children. It is important to mention that numbers of asthmatic children in both grass pollen and PM<sub>10</sub> clusters are relatively small and hence the observed effect estimates are subject to a larger degree of uncertainty. The joint analysis showed that children (5% of total 973) with simultaneous exposures to high grass pollen and poor air quality had lower FEV<sub>1</sub> and FVC levels by 70 and 92 ml respectively, as compared to children (51% of total 973) with low exposure to both grass pollen and air pollution.

Whilst the study by Amazouz et al is an important addition to the current knowledge, several issues merit further discussion. First and foremost, it is still

51 uncertain whether there is a synergistic effect between ambient pollen and air pollution  
52 on children's lung function levels. Data from the joint analysis seem to suggest a  
53 multiplicative interaction; however, a formal test of interaction is unlikely to reach  
54 conventional levels of significance given the inadequate statistical power in this  
55 relatively small cohort. In addition, as only air quality index, rather than individual air  
56 pollutants, was used in this joint analysis, it is unclear which air pollutant (PM, NO<sub>2</sub> or  
57 O<sub>3</sub>) is more likely to interact with grass pollen on lung function. In general, current  
58 evidence<sup>(3,4)</sup> is inconsistent with regard to pollen-air pollutant interactions on  
59 respiratory outcomes. Second, unlike air pollution monitoring, pollen monitoring is still  
60 insufficient in many cities and countries. The majority of existing studies, including that  
61 by Amazouz et al, relied on only one monitoring station to assign daily average pollen  
62 count for the entire study area. It remains crucial to capture greater spatial variations  
63 of different pollen taxa, in particular when considering the interactive effects with air  
64 pollution on health outcomes. Given that pollen count is not an ideal proxy to represent  
65 allergen exposure, future studies on respiratory and other health outcomes are  
66 recommended to measure amount of airborne allergenic load (i.e. pollen allergenicity)  
67 in each type of pollen. Pollen allergenicity could vary by different grains, throughout  
68 the season under different meteorological conditions, and across locations, posing  
69 significant challenges in its assessment. New methods developed in the field of  
70 molecular aerobiology<sup>(6)</sup>, together with continuous enhancement of the monitoring  
71 network and novel deployment of portable pollen monitors<sup>(7)</sup>, hold great promise to  
72 enable a more accurate assessment and improve our understanding in the health  
73 impacts at both population- and individual-level. It should be noted that the method  
74 leading to the calculation of a daily allergenic risk index was not explicitly described  
75 by Amazouz et al and the associated health risk with this index cannot be assessed

76 due to the statistical design. Third, all current studies only investigated potentially  
77 transient health effects of both pollen and air pollution exposures. Large cohort studies  
78 of long-term exposures at an individual level on longitudinal changes in health  
79 outcomes are needed to address this knowledge gap.

80         Human-caused climate change has been shown to lengthen the pollen seasons  
81 (+20d) as well as to increase pollen concentrations (+21%) significantly across North  
82 American continent over the last three decades<sup>(8)</sup>. Climate-driven trends in pollen, air  
83 pollutants and temperature are likely to further exacerbate respiratory health in coming  
84 decades if global actions are not taken firmly. Health impacts of these climate-driven  
85 trends may be collectively larger than previously estimated risk of each individual  
86 exposure if future evidence did support synergistic effects among these exposures.  
87 Locally, in the wake of the COVID-19 pandemic, many cities are now considering  
88 greening projects that aim to provide an oasis to their residents as well as to mitigate  
89 harmful urban pollution. In order to safeguard public health, a delicate balance should  
90 be supported by scientific evidence in planning urban green spaces, with careful  
91 considerations on pollen allergenicity in different plant species, as well as air pollution  
92 and traffic noise mitigation<sup>(9)</sup>.

93    **Funding**

94    This article was completed with support from the PEAK Urban program, funded by UK  
95    Research and Innovation's Global Challenge Research Fund (grant number:  
96    ES/P011055/1).

97    **Competing interests**

98    None declared

99    **Patient consent**

100   Not required

## References

1. World Health Organization. Air pollution and child health: prescribing clean air. 2018. <https://www.who.int/ceh/publications/air-pollution-child-health/en/> (accessed 22 March 2021)
2. Erbas B, Jazayeri M, Lambert KA, et al. Outdoor pollen is a trigger of child and adolescent asthma emergency department presentations: A systematic review and meta-analysis. *Allergy* [Internet]. 2018;73(8):1632–41.
3. Lam HCY, Jarvis D, Fuertes E. Interactive effects of allergens and air pollution on respiratory health: A systematic review. *Sci Total Environ*. 2021 Feb;757:143924.
4. Anenberg SC, Haines S, Wang E, et al. Synergistic health effects of air pollution, temperature, and pollen exposure: a systematic review of epidemiological evidence. *Environ Health*. 2020 Dec;19(1):130.
5. Amazouz H, Bougas N, Thibaudon M, et al. Association between lung function of school age children and short-term exposure to air pollution and pollen: the PARIS cohort. *Thorax*. 2021;
6. Cecchi L. From pollen count to pollen potency: the molecular era of aerobiology. *Eur Respir J* [Internet]. 2013;42(4):898–900.
7. de Weger LA, Molster F, de Raat K, et al. A new portable sampler to monitor pollen at street level in the environment of patients. *Sci Total Environ* [Internet]. 2020;741:140404.
8. Anderegg WRL, Abatzoglou JT, Anderegg LDL, et al. Anthropogenic climate change is worsening North American pollen seasons. *Proc Natl Acad Sci U S A*. 2021 Feb;118(7).
9. Cariñanos P, Grilo F, Pinho P, et al. Estimation of the Allergenic Potential of Urban Trees and Urban Parks: Towards the Healthy Design of Urban Green Spaces of the Future. *Int J Environ Res Public Health*. 2019 Apr;16(8).