



Improvements in air quality: whose lungs benefit?

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The benefits of improved air quality extend across the life span into the elderly population
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Exposure to ambient air pollution is a major contributor to the global burden of disease, and is associated with increased risk of mortality and morbidity, in particular from pulmonary and cardiovascular diseases [1, 2]. The health effects of air pollution have been intensively studied during the past decades. Acute effects have been demonstrated by short-term studies linking day-to-day variation in air pollution to day-to-day variation in health; chronic effects have been shown in long-term cohort studies following subjects with different levels of exposure over time [3].

Lung function is an objective marker of respiratory health and a predictor of cardiorespiratory morbidity and mortality [4]. It has been linked to air pollution in many cross-sectional and prospective cohort studies. The findings of these studies provide strong evidence for the adverse effects of long-term air pollution exposure on the lung function and lung function growth of children [5–8]. The reported effects of air pollution on lung function are generally small on the population level, in the order of a few percent [5, 7]. Nevertheless, the public health impact is considerable due to the widespread nature of the exposure and the fact that small shifts in lung function at the population level result in significant increases in the percentage of subjects with lung function levels below clinical thresholds [9–11]. Moreover, lung function tracks throughout life, which means that the maximum attained lung function in early adulthood likely will be suboptimal in those with a low lung function in childhood, which puts them at an increased risk of developing chronic obstructive pulmonary disease (COPD) in adulthood [12]. Fewer studies have been performed in adults. Very few have specifically assessed the association between long-term air pollution exposure and lung function in the elderly. However, there is increasing evidence that the adverse effects of long-term exposure to air pollution are not limited to the developing lungs of children and that higher levels of air pollution are associated with a lower lung function and a faster decline in lung function in adults [5, 6, 13–15]. Also, certain people may be at increased risk, such as those with asthma or obesity, or those who are more genetically susceptible to the harmful effects of air pollution [16].

Evidence from longitudinal studies on beneficial effects of reductions in air pollution on lung function development is scarce. The Californian Children's Health Study (CHS) assessed the impact of changes in air pollution exposure on the developing lungs of children. In a small study of 110 children participating in the

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CHS, it has been shown that lung function growth is larger in children who moved to an area with lower levels of air pollution compared to children who moved to an area with higher levels of air pollution [17]. A more recent study within three cohorts of the CHS (n=2120) showed that improvements in air quality from 1994 to 2011 in southern California were associated with measurable improvements in lung function growth from age 11 to 15 years and significant reductions in the proportion of children with a clinically low forced expiratory volume in 1 s [18]. The Swiss SAPALDIA cohort followed more than 4700 adults aged 42 ± 11 years over a period of 11 years and found that reductions in air pollution levels during that period were associated with a slower decline in lung function [19]. The study by HÜLS *et al.* [20] from the German SALIA cohort that has been published in this month's issue of the *European Respiratory Journal* is a welcome addition to the currently limited evidence on the beneficial effects of reductions in air pollution exposure on the aging lungs. HÜLS *et al.* [20] followed 601 women aged 55 years living in North Rhine-Westphalia, including the Ruhr area, one of Europe's largest industrial areas, over a period of 30 years during which air pollution levels decreased drastically. They linked data on lung function from three follow-ups to changes in air pollution levels during that 30-year period and found that reductions in air pollution levels, in particular levels of nitrogen oxides and PM₁₀, were associated with a relative improvement in lung function [20]. These findings together with the findings of previous studies suggest that our lungs benefit from reduced air pollution exposure across the entire lifespan. The authors also addressed the important question of who benefits most from the reduction of air pollution and investigated potential effect modifications by body mass index (BMI) and genetic susceptibility to low lung function. Whereas no interactions with BMI were found, the authors report that subjects with a high genetic risk of having low lung function benefitted less from the improvements in air pollution than those with a low genetic risk.

There are several methodological challenges when studying health effects of air pollution in the elderly. Firstly, attrition, especially from mortality and disability, is a concern in longitudinal studies of older persons as a greater physical disability is associated with an increased likelihood of being lost to follow-up [21]. If the risk factor of interest also influences attrition, which can be assumed to be the case for air pollution, the resulting differential attrition can cause bias in the estimated association between that factor and lung function decline [22], as for example those who survive may have other beneficial characteristics (*e.g.* genetic background) that protect them and their lungs from the adverse effects of air pollution. In their study, HÜLS *et al.* [20] did not perform a formal analysis of the potential impact of selective attrition on the estimated relationship between improved air quality and lung function of the elderly. However, they acknowledge that loss-to follow-up was selective and that amongst others, women with higher exposures to air pollution and worse respiratory health were more often lost to follow-up, which may have biased their findings. Secondly, loss to follow-up resulted in a study sample that was about 22% (601/2785) of the original study population. When combining this with genetic data, this number dropped to 462. This sample size is rather limited for genetic studies, and none of the genetic variants were significantly associated with lung function. However, rather than studying the genetic variants one by one, a weighted genetic risk score was calculated based on the number and strength of the risk variants from a previous large genome-wide association study [23]. Using this risk score, the authors showed that the largest benefits of the reduction in air pollution were observed in women with a low genetic risk score. This interesting observation adds to the currently limited evidence about the potential modifying role of genetics in the association between improved air quality and lung function decline in adults from the SAPALDIA cohort that suggests that, in particular, cell cycle control genes may be involved [24]. However, further investigation is warranted of how genetic and environmental factors interact in causing low lung function in the elderly, possibly resulting in COPD, leading to identification of susceptible subgroups, and larger studies in both sexes, as well as in patients with asthma or cardiovascular disease, are needed. Thirdly, the assessment of air pollution over a 30-year period is challenging and exposure measurement error is a concern. The authors estimated individual exposures at the home addresses with a purely spatial land-use regression model that is based on an air pollution measurement campaign performed in 2008–2009. They then back-extrapolated and forecasted estimated exposures to the time points of the medical examinations using the temporal trend measured at a single routine air quality monitor in the study area assuming spatial contrasts being stable over the 30-year period study, which is a rather strong assumption.

In conclusion, the study by HÜLS *et al.* [20] illustrates that the benefits of improved air quality extend across the life span into the elderly population and that the fetal period and childhood, although critical for the development of lung function, are thus not the only windows of opportunity for preventing the adverse effects of air pollution. This is an important finding as in 2017, one-fifth of the population of the European Union was 65 years or older [25] and this number is expected to increase in the coming years. Clean air contributes to healthy ageing, benefitting the lungs of the ageing population.

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