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Ozone is bad for health – but only for some?

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In recent years there has been accumulating evidence that high levels of ozone exacerbate pre-existing respiratory disease and cause increases in emergency attendances, admissions to hospital, and mortality.[1–12] In this issue of *Thorax* Stedman *et al* present a first attempt to derive from such studies an estimate of the number of additional hospital admissions attributable to ozone effects, given the distribution of respiratory admissions and ozone levels in Great Britain in the summers of 1993 and 1995.[13] They present an interpolated estimate of each day's spatial ozone concentration distribution in Great Britain, use an average number of respiratory admissions per small region per day, and use a published respiratory hospital admissions/ozone dose response curve from a study based on London data to predict the number of extra cases per day and region caused by ozone values above a chosen cut off point. They then present the reader with the sum of those extra cases. This approach to the public health problems caused by ozone is innovative and, in principle, is important. However, the estimates produced are dependent on the accuracy of the predicted exposure estimate, which is difficult to assess from the methodological information given by the authors, and the use of a dose response curve from a slightly different time and place (London 1987–91) may also be a problem, though in fact effect estimates tend to be similar between places at least in Europe.[12] Alternatively, it might be more appropriate to use a coefficient from a model with a threshold assumption to predict effects above this threshold instead of a model with no threshold assumption. Whether this would improve the procedure needs to be further investigated. Finally, in the future one might want to see confidence intervals for those estimates of additional cases that take into account the error of both the spatial interpolation (exposure prediction) and the temporal effect prediction.

Apart from these purely methodological considerations, two medical questions come to mind. (1) Why can it not be said, for sure, how many additional cases there are? After all, the paper gives estimates between 317 and 11 195 additional admissions for the summer of 1995. (2) Why is the figure the authors give as the main result (+0.1% in 1993 and +0.35% in 1995) so low when there is so much evidence of the dangers of air pollution in general and ozone in particular?

Health care planners would certainly like to be able to put a price tag on certain levels of ozone. Statisticians and epidemiologists would very much like to do this too, so let me try to explain why this is so difficult and why it is consequently so important that Stedman *et al* do present an attempt to put this on a sound scientific basis – something rarely done before.[14 15] The first question is related to the problem of thresholds. The authors present estimates for various choices of cut off points on a monotonic dose response curve. Further research – and not only epidemiological research – is needed to identify which of those values does come close to a medically justified effect limit. Attempts to find such a threshold have rarely been made with this type of data, and some may not have been published due to lack of success in identifying a threshold. Any such threshold is likely to be at the lower end of the ozone value distribution and this is the region where the signal to noise ratio in such data sets tends to become unfavourable. A threshold found may really be an "effect detection limit", which is dependent mostly on the size of the data set. The existing evidence is inconclusive to say the least.[6 16] Thus, the question of determining a threshold even for small homogenous risk groups is currently open and a topic for further toxicological and epidemiological research. Consequently, the researchers presented estimates for a choice of possible thresholds.

The second question relates to the specific type of study results used here. These are not "ozone effects on respiratory health" but are a subset of all possible "short term ozone effects on respiratory health". Probably few – maybe none – of the persons admitted to hospital on or following a high ozone day moved from a perfectly healthy respiratory tract to needing stationary treatment for a respiratory condition in one day. Practically all cases would be exacerbations of an existing chronic problem. For some patients this might mean entering a worse stage of their disease. It is likely that most chronic cases would react to an irritant by increasing their medication or reducing their activity, some of them thus causing work or school absences, while only a small fraction of the most sensitive ones would actually end up in hospital.[17] This might explain why the effects seen on hospital admissions are, indeed, fairly small – usually 2–5% per 25 ppb.[12] The effect estimates for all summer in this study are further diminished by the fact that only a small fraction of the summer days exceeded any one of the thresholds examined (except for "zero").

However, it is likely that short term effects are only part of the profile of the effects of ozone. There are a few studies that link lifetime exposure to ozone to the development of chronic disease, but the exposure assessment is necessarily very difficult.[18–20] Some studies and experiments point out that individuals and populations seem to be able to adapt to higher levels of ozone in terms of short term effects on lung function parameters, while in animal experiments long term exposure is seen to cause lasting damage to the lung tissue.[21–24] Without being able to quantify this it must be assumed that a certain fraction of the cases exacerbated by an ozone episode would not – or not yet – have been suffering from that condition at that time had the person not been repeatedly exposed to increased levels of ozone previously. In terms of costs, several years of additional treatment (and possibly work absences or early retirement) are perhaps more relevant than some days with a few additional patients in hospital.

More research on the quantification of disease and costs caused by air pollution must be greatly encouraged. The paper by Stedman *et al* may not be the ultimate solution as to how to conduct such studies methodologically, but it is certainly a good starting point for the necessary discussion on these matters.

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