Burden of disease from Ambient Air Pollution for 2012

Description of method

Version 1.3

The burden of disease attributable to ambient air pollution was estimated for the year 2012 based on Comparable Risk Assessment methods (1) and methods developed by IHME (Institute for Health Metrics and Evaluation) and expert groups for the Global Burden of Disease (GBD) 2010 study (2).

Source of the data

Health data
The total number of deaths and DALYs (disability-adjusted life years) by disease, country, sex and age group have been developed by the World Health Organization (3).

Exposure data
Annual mean estimates of particulate matter of a diameter of less than 2.5 µg/m³ (PM2.5) were modelled using a combination of estimates from data provided by satellites, outputs from the global chemical transport model TM5, and ground measurements (4). The output of the model was based on a grid of 0.1° x 0.1°. Values were developed for 1990 and 2005, and extrapolated estimates for 2010 were used as basis for disease burden estimation (2).

Exposure-risk relationships
The integrated exposure-response functions (IER) developed for the GBD 2010 study were used for ALRI (acute lower respiratory infections), lung cancer, COPD (chronic obstructive pulmonary disease), stroke and IHD (ischaemic heart disease) (5).

Demographic data
Population data used were from the United Nations Population Division, Revision 2012 (6).

Methods

Estimation of disease burden
The percentage of the population exposed to PM2.5 was provided by country and by increment of 1 µg/m³; relative risks were calculated for each PM2.5 increment, based on the integrated exposure-response functions (IER). The counterfactual concentration was selected to be between 5.8 and 8.8 µg/m³, as described in (2) and (5). The country population attributable fractions for ALRI, COPD, LC, stroke and IHD were calculated using the following formula:

\[ PAF = \frac{\sum_{i=1}^{n} P_i (RR-1)}{\sum_{i=1}^{n} P_i (RR-1) + 1} \]

where i is the level of PM2.5 in µg/m³, and Pi is the percentage of the population exposed to that level of air pollution.

Uncertainty analysis
The uncertainty intervals are based on the following sources of uncertainty: (a) uncertainty around relative risks of the integrated exposure-response function, and (b) a semi-quantitative estimation of uncertainty in exposure to PM2.5 based on the difference between modelled exposures and ground level measurements. For the integrated exposure-response function, 1,000 draws of each parameter of the function were obtained from Burnett and co-workers (5) and population attributable fractions were calculated for each draw. To account for
uncertainty in exposure, alternative burden of disease estimates were developed based on ground level measurements available for urban areas, combined with modelled PM data for rural areas. These were used as upper or lower ends of triangular uncertainty distribution by region. The other end of the triangular distribution was calculated as by halving the difference in burden. The final uncertainty intervals were obtained as the 2.5 and 97.5 percentiles of the draws from the combined uncertainties. Uncertainty for baseline mortality was not taken into account.

**Further rationale and information on exposure data used**

Previous burden of disease estimates have mainly been based on urban ground measurements (7). While reliable ground measurements, when performed in locations representative for human exposure such as in residential or commercial areas, are best representing exposure in those specific locations, they are unfortunately only available in a limited number of locations and cities worldwide. Furthermore, in many developing countries measurements are often limited to PM10 and a conversion factor needs to be applied to estimate PM2.5 levels which are needed to estimate health risks. Finally, exposure in rural areas have been poorly documented in many areas. Particularly where urban emissions travel outside urban agglomerations, and where solid fuels are burned in households for cooking or heating, rural exposures to particulate matter can be substantial. For these reasons, a more comprehensive set of modelled exposure has been used as a basis for burden of disease estimation (4).

Apart from the strengths, the modelled dataset also has a number of weaknesses, and further improvement is required in order to improve accuracy. The main weaknesses include the following: (a) Time of estimation. The currently available modelled data are based on satellite data, emission inventories and ground measurements some of which date back several years. Collecting and processing all the required data represents a heavy process and a full cycle can take several years. A new cycle is currently under way, and data will be updated as soon as they become available. (b) Divergence of modelled data from measured data. Modelled data do not always match measured data. This can be due for example to measurement error or non-representative locations in ground measurements, inadequate calibration of the model to ground measurements, insufficient information in the emission inventory or time lag between the modelling cycle and the availability of new ground measurement data. (c) Limited information on rural exposure. Limited information is currently available on rural exposures, and the validity of the model therefore needs to be further evaluated for these areas. The use of combined data from remote sensing and emission models which have been verified in urban areas nevertheless represents an advancement over assuming no exposure in rural areas as done previously.

The combined remote sensing/chemical transport/ground measurement model should, for the reasons enumerated above, be seen as work in progress, but they nevertheless present an advantage over the use of ground measurement alone as a basis for burden of disease estimation. It is anticipated that future rounds will gradually improve accuracy. Countries are further encouraged to improve ground measurements in order to improved calibration of the model and thereby produce more comprehensive and coherent exposure estimates for the entire population within a country. A number of sensitivity analyses have been performed in order to estimate the variation on results according to various exposure assumptions and datasets, in view of further characterizing uncertainty. Given those uncertainties, results are currently provided only for the regional and global level. Further improvements in the methods used for modelling exposure should lead to improved country estimates. These are currently being refined in particular for certain low- and middle-income countries.
References


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