An update on mortality in Denmark caused by fine particulate matter air pollution

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Background

The first attempt to quantify effects on mortality from long-term exposure to particulate matter (PM) in Denmark was published in 20021. At the time urban background PM10 data were unavailable and had to be estimated from other data. Population weighted exposure levels were then estimated for urban and rural areas. In the 14 years since 2002 the air pollution data have significantly improved.

PM10 and PM2.5 measurements are now routinely available from monitors, and modelled PM levels can be gridded at 1x1 km grids in which the population is also known in detail.

Fourteen years ago, European data on the effects on mortality from PM exposure were lacking. Epidemiologic evidence has since emerged that allow for better quantification of the effects of PM10 and even PM2.5.

Aim

With recent data, to investigate to what extent changes in the estimates of effects on mortality are due to changes in the PM levels; or changes in baseline mortality; or more detailed modelling of the exposures.

Model 1

The 2002 study used the estimated PM10 exposure for 2001 at 22.26 µg/m3, the population, and the mortality (all cause except violent deaths in all models) for 1996 to calculate the expected mortality at a counterfactual exposure level of 7.5µg/m3. From this level the N of additional deaths were calculated. Table 1 shows the data for 2002 and the result of performing the same calculation with PM10 and mid-year population data from 2012 with and without a counterfactual exposure level. A relative risk (RR) for mortality of 1.043/10µg/m3 was applied.

Model 2

Mortality caused by PM was calculated with EVA23, a model based on the impact-pathway methodology, where site-specific emissions result, via atmospheric transport and chemistry, in a concentration distribution, which together with detailed and gridded population data, is used to estimate the population-level exposure. A RR of 1.06/10 µg/m3 of PM2.5 was applied. Results are shown in table 2.

Model 3 & 4

Life table calculations4 were performed on the 2012 age distributed Danish population and mortality (as of Jan 1 2012) assuming a RR of 1.062/10 µg/m3 of PM2.5. In model 3 a log-linear relationship and in model 4 a linear relationship was applied. Results are shown in table 3.

Conclusions

Decreased PM air pollution and decreased baseline rates of mortality appear to be responsible for almost similar number of avoided deaths due to PM air pollution since 2002. It is just as important to use updated data on mortality as it is to use accurate PM levels. Despite major differences in their methods, the results are in the same range. However, it appears that higher resolution of exposure data, the use of a counterfactual exposure level and the use of life table calculations have important effects on the results. In contrast, at the Danish exposure levels, there is little difference between the use of a log-linear and a linear response.

Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>PM10 (µg/m3)</th>
<th>N population</th>
<th>N deaths (adults ≥30 yr)</th>
<th>N avoidable deaths/10µg/m3</th>
<th>N avoidable deaths total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>22.26</td>
<td>5261503</td>
<td>56640</td>
<td>435</td>
<td>5098</td>
</tr>
<tr>
<td>2012</td>
<td>18</td>
<td>5587085</td>
<td>49530</td>
<td>385</td>
<td>3668</td>
</tr>
</tbody>
</table>

Without assuming a counterfactual level:

<table>
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<tr>
<th>Year</th>
<th>PM10 (µg/m3)</th>
<th>N population</th>
<th>N deaths (adults ≥30 yr)</th>
<th>N avoidable deaths/10µg/m3</th>
<th>N avoidable deaths total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>18</td>
<td>5587085</td>
<td>ND</td>
<td></td>
<td>3558</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Model</th>
<th>Grid</th>
<th>N avoidable deaths total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Regional</td>
<td>1x1 km</td>
<td>3750</td>
</tr>
<tr>
<td>2013 Regional + urban background</td>
<td>16.7x16.7 km</td>
<td>3500</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Year</th>
<th>PM2.5 (µg/m3)</th>
<th>N population</th>
<th>N deaths (adults ≥30 yr)</th>
<th>Years of lives gained</th>
<th>N avoidable deaths total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>11</td>
<td>5587065</td>
<td>56640</td>
<td>37351</td>
<td>3124</td>
</tr>
<tr>
<td>2012</td>
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<td>37238</td>
<td>3115</td>
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