Annex 4  Estimating the global disease burden of environmental lead exposure

The global disease burden for children and adults that results from environmental lead exposure was assessed in 14 regions (Prüss-Üstün et al., 2003). The regions were grouped as shown in Figure A4.1. The countries in each region are given in Annex 1.

Figure A4.1  Regions used to assess the global disease burden

![Map of regions used to assess the global disease burden](image)

Legend:
- Afh D
- Afh E
- Amr A
- Amr B
- Amr D
- Emr B
- Emr D
- Eur A
- Eur B
- Eur C
- no data
- Sear B
- Sear D
- Wpr A
- Wpr B

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.
Exposure was assessed by reviewing the literature for studies that measured the distribution of blood lead levels. Only recent studies were considered because of the changes in lead exposure that have occurred since the 1970s, mainly due to lead reduction programmes (e.g. the phasing out of leaded gasoline). If current data were not available for a study, and instead, data prior to the introduction of a lead reduction programme were used, current blood lead levels were estimated by reducing the reported levels by 7.8% for every year that the programme had been implemented. To account for the reduction in exposure from ongoing lead reduction programmes in countries for which there were no data, we extrapolated from known values. For countries with more than one blood lead sample, the samples were first adjusted for lead reduction efforts or missing data, as necessary, and then geometric means were calculated by weighting according to sample size. Regional means were calculated by weighting country means by the size of its urban population. Means for urban and rural populations were estimated separately.

The compiled data are shown in Table A4.1. It was estimated that 120 million people had blood lead levels of 5–10 µg/dl in 2000, and about the same number had levels above 10 µg/dl. Data for all of the children in the samples showed that 97% lived in developing regions; 40% had blood lead levels above 5 µg/dl, and 20% above 10 µg/dl. Less than 10% of the children had levels above 20 µg/dl, but 99% of them lived in developing regions.
Table A4.1  Blood lead levels in children and adults, by region and data source  

<table>
<thead>
<tr>
<th>Region</th>
<th>AfrD&lt;sup&gt;a&lt;/sup&gt;</th>
<th>AfrE&lt;sup&gt;a&lt;/sup&gt;</th>
<th>AmrA</th>
<th>AmrB</th>
<th>AmrD</th>
<th>EmrB</th>
<th>EmrD</th>
<th>EurA</th>
<th>EurB</th>
<th>EurC</th>
<th>SearB</th>
<th>SearD</th>
<th>WprA</th>
<th>WprB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional mean blood lead, urban children, (µg/dl)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.1</td>
<td>9.8</td>
<td>2.2</td>
<td>7.0</td>
<td>9.0</td>
<td>6.8</td>
<td>15.4</td>
<td>3.5</td>
<td>5.8</td>
<td>6.7</td>
<td>7.4</td>
<td>7.4</td>
<td>2.7</td>
<td>6.6</td>
</tr>
<tr>
<td>Regional mean blood lead, urban adults, (µg/dl)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.6</td>
<td>10.4</td>
<td>1.7</td>
<td>8.5</td>
<td>10.8</td>
<td>6.8</td>
<td>15.4</td>
<td>3.7</td>
<td>9.2</td>
<td>6.7</td>
<td>7.4</td>
<td>9.8</td>
<td>2.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Standard deviation (µg/dl)</td>
<td>5.6</td>
<td>5.6</td>
<td>2.9</td>
<td>3.9</td>
<td>3.9</td>
<td>3.9</td>
<td>5.6</td>
<td>1.9</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>5.6</td>
<td>1.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Urban population (%)</td>
<td>36</td>
<td>25</td>
<td>77</td>
<td>74</td>
<td>58</td>
<td>67</td>
<td>37</td>
<td>78</td>
<td>62</td>
<td>72</td>
<td>31</td>
<td>26</td>
<td>80</td>
<td>32</td>
</tr>
<tr>
<td>Countries for which recent data were available</td>
<td>Nigeria&lt;sup&gt;1&lt;/sup&gt;</td>
<td>South Africa&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Canada&lt;sup&gt;3&lt;/sup&gt;, USA&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Argentina&lt;sup&gt;5&lt;/sup&gt;, Brazil&lt;sup&gt;6&lt;/sup&gt;, Chile&lt;sup&gt;7&lt;/sup&gt;, Jamaica&lt;sup&gt;8&lt;/sup&gt;, Mexico&lt;sup&gt;9&lt;/sup&gt;, Uruguay&lt;sup&gt;10&lt;/sup&gt;, Venezuela&lt;sup&gt;11&lt;/sup&gt;</td>
<td>Ecuador&lt;sup&gt;12&lt;/sup&gt;, Nicaragua&lt;sup&gt;13&lt;/sup&gt;, Peru&lt;sup&gt;14&lt;/sup&gt;</td>
<td>Saudi Arabia&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Egypt&lt;sup&gt;16&lt;/sup&gt;, Morocco&lt;sup&gt;17&lt;/sup&gt;, Pakistan&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Denmark&lt;sup&gt;19&lt;/sup&gt;, France&lt;sup&gt;20&lt;/sup&gt;, Germany&lt;sup&gt;21&lt;/sup&gt;, Greece&lt;sup&gt;22&lt;/sup&gt;, Israel&lt;sup&gt;23&lt;/sup&gt;, Sweden&lt;sup&gt;24&lt;/sup&gt;</td>
<td>Poland&lt;sup&gt;25&lt;/sup&gt;, Turkey&lt;sup&gt;26&lt;/sup&gt;, Yugoslavia&lt;sup&gt;27&lt;/sup&gt;</td>
<td>Hungary&lt;sup&gt;28&lt;/sup&gt;, Russian Federation&lt;sup&gt;29&lt;/sup&gt;</td>
<td>Indonesia&lt;sup&gt;30&lt;/sup&gt;, Thailand&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Bangladesh&lt;sup&gt;32&lt;/sup&gt;, Australia&lt;sup&gt;33,&lt;/sup&gt; Japan&lt;sup&gt;34&lt;/sup&gt;, New Zealand&lt;sup&gt;35&lt;/sup&gt;, Singapore&lt;sup&gt;36&lt;/sup&gt;</td>
<td>China&lt;sup&gt;37&lt;/sup&gt;, Micronesia&lt;sup&gt;38&lt;/sup&gt;, Philippines&lt;sup&gt;39&lt;/sup&gt;, Republic of Korea&lt;sup&gt;40&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

| Children with 5–10 µg/dl blood lead (%) | 18.6 | 19.1 | 12.4 | 21.2 | 23.2 | 23.3 | 18.1 | 22.7 | 22.7 | 23.6 | 21.8 | 19.2 | 14.1 | 21.8 |
| Children with 10–20 µg/dl blood lead (%) | 10.0 | 8.9 | 4.7 | 16.3 | 16.4 | 15.7 | 10.1 | 5.1 | 13.8 | 16.3 | 11.2 | 8.8 | 2.9 | 10.9 |
| Children with blood lead >20 µg/dl (%) | 13.9 | 9.5 | 1.9 | 16.7 | 17.2 | 11.4 | 17.2 | 0.5 | 8.9 | 11.9 | 6.5 | 8.3 | 0.3 | 5.8 |
| Adults with 5–10 µg/dl blood lead (%) | 18.5 | 19.1 | 9.1 | 22.1 | 22.6 | 23.3 | 18.1 | 24.3 | 22.5 | 23.6 | 21.8 | 19.1 | 14.1 | 20.6 |
| Adults with 10–20 µg/dl blood lead (%) | 10.0 | 8.9 | 3.2 | 17.2 | 16.6 | 15.7 | 10.1 | 5.7 | 16.7 | 16.3 | 11.2 | 9.0 | 2.1 | 8.4 |
| Adults with blood lead >20 µg/dl (%) | 14.3 | 9.8 | 1.1 | 19.9 | 20.1 | 11.4 | 17.2 | 0.6 | 15.5 | 11.9 | 6.5 | 9.7 | 0.1 | 2.8 |

<sup>a</sup> Regional exposure data were combined for these analyses.

<sup>b</sup> High and low urban blood lead means were used in regions where countries were at different stages of phasing out of leaded gasoline; the distribution is therefore a superposition of two or three log-normal distributions, and the mean and standard deviation does not necessarily reflect the distributions; therefore only one mean and standard deviation, as well as the distribution of people in exposure categories 5–10, 10–15 and 15–20 µg/dl are displayed.
Sources of country data: 1Nriagu et al. (1997a), 1Omokhodion (1994); 2Deveaux et al. (1986), 2Grobler, Maresky & Kotze (1992), 2Karimi et al. (1999), 2Maresky & Grobler (1993),
for Disease Control and Prevention (2000, 2001); 5Garcia & Mercer (2001); 6Cordeiro, Lima Filho & Salgado (1996), 6 dos Santos et al. (1994), 6 Paolielo et al. (1997); 7Sepulveda,
Navarro et al. (1996), 9López Lara et al. (2000), 10Romieu (2001), 10Rothenberg et al. (1996), 11Schutz et al. (1997), 11Feo et al. (1993), 11Mujica (2001); 12Counter et al. (1998);
The lead-induced disease burden was estimated according to the methods outlined in this guide. We only considered loss of IQ points if this loss resulted in MMR, and the number of people affected was determined on the basis of a standardized intelligence curve. To account for an increased prevalence in developing countries of risk factors that result in MMR, such as malnutrition and disease, we adjusted the prevalences of lead-induced MMR in such countries for the known ratio of mental retardation caused by other factors. Rates of lead-induced loss of IQ points and MMR are shown in Table A4.2, and rates of increased systolic blood pressure in adults are presented in Table A4.3.

### Table A4.2
Proportion affected by loss of IQ points and MMR incidence rates in children (0-1 years old) due to lead exposure in the year 2000

<table>
<thead>
<tr>
<th>Region</th>
<th>AfrD</th>
<th>AfrE</th>
<th>AmrA</th>
<th>AmrB</th>
<th>AmrD</th>
<th>EmrB</th>
<th>EmrD</th>
<th>EurA</th>
<th>EurB</th>
<th>EurC</th>
<th>SearB</th>
<th>SearD</th>
<th>WprA</th>
<th>WprB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of IQ points (proportion per 1000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>186</td>
<td>191</td>
<td>124</td>
<td>222</td>
<td>232</td>
<td>233</td>
<td>181</td>
<td>227</td>
<td>227</td>
<td>236</td>
<td>218</td>
<td>192</td>
<td>141</td>
<td>218</td>
</tr>
<tr>
<td>1.95</td>
<td>66</td>
<td>61</td>
<td>104</td>
<td>105</td>
<td>102</td>
<td>66</td>
<td>41</td>
<td>92</td>
<td>106</td>
<td>76</td>
<td>61</td>
<td>23</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>3.25</td>
<td>34</td>
<td>28</td>
<td>59</td>
<td>58</td>
<td>54</td>
<td>35</td>
<td>10</td>
<td>46</td>
<td>57</td>
<td>36</td>
<td>28</td>
<td>6</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>139</td>
<td>95</td>
<td>21</td>
<td>167</td>
<td>172</td>
<td>114</td>
<td>35</td>
<td>10</td>
<td>46</td>
<td>57</td>
<td>36</td>
<td>28</td>
<td>6</td>
<td>34</td>
</tr>
<tr>
<td>Totals</td>
<td>425</td>
<td>375</td>
<td>192</td>
<td>552</td>
<td>567</td>
<td>503</td>
<td>283</td>
<td>454</td>
<td>454</td>
<td>518</td>
<td>395</td>
<td>364</td>
<td>173</td>
<td>385</td>
</tr>
<tr>
<td>Mild mental retardation (mean incidence rate per 1000 children)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best estimate</td>
<td>7.5</td>
<td>5.8</td>
<td>1.1</td>
<td>13.2</td>
<td>10.2</td>
<td>7.6</td>
<td>8.0</td>
<td>1.1</td>
<td>5.2</td>
<td>4.9</td>
<td>8.7</td>
<td>5.5</td>
<td>0.7</td>
<td>7.7</td>
</tr>
<tr>
<td>Lower estimate</td>
<td>4.2</td>
<td>3.0</td>
<td>0.5</td>
<td>7.0</td>
<td>5.3</td>
<td>3.6</td>
<td>4.6</td>
<td>0.3</td>
<td>2.4</td>
<td>2.3</td>
<td>3.9</td>
<td>2.8</td>
<td>0.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Upper estimate</td>
<td>12.5</td>
<td>10.0</td>
<td>2.1</td>
<td>22.0</td>
<td>17.2</td>
<td>13.3</td>
<td>13.0</td>
<td>2.7</td>
<td>9.3</td>
<td>8.6</td>
<td>16.3</td>
<td>9.7</td>
<td>1.7</td>
<td>14.6</td>
</tr>
</tbody>
</table>

### Table A4.3
Incidence rates of increased systolic blood pressure in adult men and women (ages 20–79 years) caused by environmental exposure to lead in 2000

<table>
<thead>
<tr>
<th>Region</th>
<th>AfrD</th>
<th>AfrE</th>
<th>AmrA</th>
<th>AmrB</th>
<th>AmrD</th>
<th>EmrB</th>
<th>EmrD</th>
<th>EurA</th>
<th>EurB</th>
<th>EurC</th>
<th>SearB</th>
<th>SearD</th>
<th>WprA</th>
<th>WprB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental increase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.625 mmHg in males, 0.4 mmHg in females</td>
<td>185</td>
<td>191</td>
<td>91</td>
<td>221</td>
<td>226</td>
<td>233</td>
<td>181</td>
<td>243</td>
<td>225</td>
<td>236</td>
<td>218</td>
<td>62</td>
<td>141</td>
<td>206</td>
</tr>
<tr>
<td>1.875 mmHg in males, 1.2 mmHg in females</td>
<td>66</td>
<td>61</td>
<td>23</td>
<td>108</td>
<td>106</td>
<td>102</td>
<td>66</td>
<td>46</td>
<td>106</td>
<td>76</td>
<td>29</td>
<td>17</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>3.125 mmHg in males, 2.0 mmHg in females</td>
<td>34</td>
<td>28</td>
<td>9</td>
<td>63</td>
<td>60</td>
<td>54</td>
<td>35</td>
<td>11</td>
<td>61</td>
<td>57</td>
<td>36</td>
<td>97</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>3.75 mmHg in males, 2.4 mmHg in females</td>
<td>143</td>
<td>98</td>
<td>11</td>
<td>199</td>
<td>201</td>
<td>114</td>
<td>172</td>
<td>6</td>
<td>155</td>
<td>119</td>
<td>65</td>
<td>97</td>
<td>1</td>
<td>28</td>
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<tr>
<td>Totals</td>
<td>428</td>
<td>378</td>
<td>134</td>
<td>591</td>
<td>593</td>
<td>503</td>
<td>503</td>
<td>454</td>
<td>306</td>
<td>547</td>
<td>518</td>
<td>395</td>
<td>285</td>
<td>162</td>
</tr>
</tbody>
</table>

The rates in Tables A4.2 & A4.3 can be converted into disease burden, measured in the number of deaths and DALYs (disability-adjusted life years). For example, the disease burden from lead-induced mental retardation is equivalent to 9.8 million DALYs, and that from cardiovascular diseases due to elevated blood pressure equivalent to 250 000 premature deaths and 3.5 million DALYs (Table A4.4).
### Table A4.4 DALYs and deaths caused by lead-induced MMR and cardiovascular disease (CVD)

<table>
<thead>
<tr>
<th>Region</th>
<th>AfrD</th>
<th>AfrE</th>
<th>AmrA</th>
<th>AmrB</th>
<th>AmrD</th>
<th>EmrB</th>
<th>EmrD</th>
<th>EurA</th>
<th>EurB</th>
<th>EurC</th>
<th>SearB</th>
<th>SearD</th>
<th>WprA</th>
<th>WprB</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>DALYs due to MMR (in thousands)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>871</td>
<td>768</td>
<td>82</td>
<td>1393</td>
<td>225</td>
<td>334</td>
<td>868</td>
<td>55</td>
<td>212</td>
<td>153</td>
<td>582</td>
<td>1912</td>
<td>16</td>
<td>2361</td>
<td>9813</td>
<td></td>
</tr>
<tr>
<td>DALYs due to CVD (in thousands)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IHD(^1)</td>
<td>44</td>
<td>38</td>
<td>19</td>
<td>112</td>
<td>12</td>
<td>51</td>
<td>125</td>
<td>30</td>
<td>125</td>
<td>249</td>
<td>49</td>
<td>447</td>
<td>3</td>
<td>86</td>
<td>1391</td>
</tr>
<tr>
<td>CVA(^2)</td>
<td>58</td>
<td>60</td>
<td>10</td>
<td>134</td>
<td>16</td>
<td>19</td>
<td>70</td>
<td>25</td>
<td>111</td>
<td>196</td>
<td>54</td>
<td>250</td>
<td>6</td>
<td>256</td>
<td>1266</td>
</tr>
<tr>
<td>HTD(^3)</td>
<td>16</td>
<td>17</td>
<td>4</td>
<td>46</td>
<td>10</td>
<td>16</td>
<td>34</td>
<td>3</td>
<td>33</td>
<td>22</td>
<td>25</td>
<td>46</td>
<td>6</td>
<td>57</td>
<td>329</td>
</tr>
<tr>
<td>OCD(^4)</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>4</td>
<td>11</td>
<td>15</td>
<td>5</td>
<td>32</td>
<td>0</td>
<td>8</td>
<td>126</td>
</tr>
<tr>
<td>Totals</td>
<td>128</td>
<td>124</td>
<td>35</td>
<td>304</td>
<td>40</td>
<td>90</td>
<td>241</td>
<td>63</td>
<td>280</td>
<td>482</td>
<td>133</td>
<td>775</td>
<td>9</td>
<td>407</td>
<td>3112</td>
</tr>
<tr>
<td>CVD mortality (deaths in thousands)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>20</td>
<td>6</td>
<td>17</td>
<td>5</td>
<td>22</td>
<td>39</td>
<td>57</td>
<td>9</td>
<td>57</td>
<td>1</td>
<td>31</td>
<td>229</td>
</tr>
</tbody>
</table>

\(^1\) ischaemic heart disease \(^2\) cerebrovascular disease \(^3\) hypertensive disease \(^4\) other cardiac diseases

Tables A4.5 and A4.6 summarize the rates of people at risk of gastrointestinal effects and anaemia at any point in time, assuming that people are not removed from the source, or treated to reduce their lead levels. The disease burden in DALYs has not yet been assessed for these two conditions, since the burden of these disease categories has not yet been estimated at global level.

### Table A4.5 Number of people per 1000 affected by anaemia caused by environmental exposure to lead in 2000

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of people affected per 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AfrD</td>
</tr>
<tr>
<td>Children</td>
<td></td>
</tr>
<tr>
<td>Best estimate</td>
<td>10</td>
</tr>
<tr>
<td>Lower estimate</td>
<td>4</td>
</tr>
<tr>
<td>Upper estimate</td>
<td>20</td>
</tr>
<tr>
<td>Adults</td>
<td></td>
</tr>
<tr>
<td>Best estimate</td>
<td>9</td>
</tr>
<tr>
<td>Lower estimate</td>
<td>4</td>
</tr>
<tr>
<td>Upper estimate</td>
<td>18</td>
</tr>
</tbody>
</table>

### Table A4.6 Number of children per 1000 affected by gastrointestinal effects in environmental exposure to lead in 2000

<table>
<thead>
<tr>
<th>Regions/ rates per 1000</th>
<th>AfrD</th>
<th>AfrE</th>
<th>AmrA</th>
<th>AmrB</th>
<th>AmrD</th>
<th>EmrB</th>
<th>EmrD</th>
<th>EurA</th>
<th>EurB</th>
<th>EurC</th>
<th>SearB</th>
<th>SearD</th>
<th>WprA</th>
<th>WprB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best estimate</td>
<td>12</td>
<td>7</td>
<td>0</td>
<td>8</td>
<td>9</td>
<td>3</td>
<td>16</td>
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<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lower estimate</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Upper estimate</td>
<td>22</td>
<td>14</td>
<td>1</td>
<td>20</td>
<td>22</td>
<td>11</td>
<td>30</td>
<td>0</td>
<td>8</td>
<td>11</td>
<td>6</td>
<td>11</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

\(^1\) Rates per 1000 children.

Together, MMR and increased systolic blood pressure account for approximately 0.9% of the global burden of disease. As several outcomes caused by lead could not be quantified in this analysis (in particular, increased delinquent behaviour and its impact on injuries), the true burden probably exceeds 1.0%. Health impacts from anaemia and gastrointestinal effects are relatively small.
Lead in the environment is still a major risk factor and its effects are mainly concentrated in developing countries. The disease burden associated with environmental exposure to lead could be virtually eliminated through interventions that have proven successful in developed countries, most importantly the removal of lead from gasoline (see current status in Figure A4.2). The burden of disease due to environmental lead exposure is likely to be underestimated because of a lack of data; the exclusion of geographical “hotspots”; the adoption of conservative assumptions; and because a number of health outcomes and social consequences of lead exposure could not be quantified due to insufficient evidence (e.g. increased risk of criminality and drug abuse).

**Figure A4.2**  Sales of leaded gasoline as a percentage of total gasoline sales, by country

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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Annex 5 Calculation spreadsheet for lead

Two spreadsheets based on Microsoft Excel are available to assist in calculating the burden of disease from lead:

1. The “lead spreadsheet”, to estimate morbidity, mortality and the attributable fraction of disease due to lead (available on request from: ebd@who.int).
2. The “DALY calculation template”, to convert disease incidence and deaths into DALYs. This is available on: www.who.int/evidence/nbd, under “other files”.

The parameters required to estimate disease burden from lead, using the two spreadsheets, are briefly described below. In addition, WHO assists countries to establish their own burden of disease estimates (see Chapter 5, or ebd@who.int).

Required input parameters for the lead spreadsheet
- one or more parameters from a blood lead study that represent the population to be assessed (e.g. mean, standard deviation and sample size);
- the population size for the age groups 0–4 years, 5–14 years and older than 15 years;
- the percentage of the population to be assessed that is urban.

Output parameters of the lead spreadsheet
- the incidence rates per 1000, for lead-induced MMR, anaemia and gastrointestinal effects;
- the attributable fraction of ischaemic heart disease, cerebrovascular disease, hypertensive disease and “other cardiac diseases” (which can be multiplied by the disease burden data per disease to obtain the attributable burden).

Input parameters for the DALY calculation template
- population per age group;
- severity weight (0.361 for MMR);
- incidence rates per 1000, for lead-induced MMR, anaemia and gastrointestinal effects;
- duration of the illness.

Output parameters of the DALY calculation template
- MMR measured in DALYs.