Decision support for risk prioritisation of environmental health hazards in a UK city

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Appendix A1.

Modelling mortality and morbidity risks for environmental hazards and interventions

For the criteria mortality, the MCDA ratings correspond to the number of environmental hazard attributable deaths that can be prevented by implementing an intervention. We assume that the health impact of each intervention is independent and we use the following equation to calculate the relative risk for each intervention.

\[ RR_H = \exp(\beta_H \Delta e) \]  (1)

where \( RR_H \) is the relative risk associated with an increase or decrease in the chosen measure of exposure to the hazard (H). \( \beta_H \) is the exposure response coefficient for the hazard (H) for a unit change in exposure and \( \Delta e \) is the change in exposure. The value of \( RR_H \) for a specific change in exposure is obtained from the epidemiological literature. Based on this value, the risk coefficient can be calculated from equation (2)

\[ \beta_H = \frac{\log(RR_H)}{\Delta e} \] (2)

which is obtained by re-arranging equation (1). For any change in exposure \( \Delta e_i \) associated with intervention \( i \), the relative risk is then given by,

\[ RR_{H_i} = \exp(\beta_H \Delta e_i) \] (3)
In equation (3), the relative risk $RR_{H_i}$ corresponds to the change in exposure $\Delta e_i$ to the hazard (H) induced by intervention ($i$). From equation (3), the excess health risk due to the intervention is given by:

$$ERR_{H_i} = RR_{H_i} - 1.$$ (4)

If $ERR_{H_i} > 0$ the excess relative risk due to the intervention is used to calculate a point (central) estimate of the number of preventable deaths ($D_{H_i}$) and to represent the population, $ERR_{H_i}$ is multiplied by the baseline mortality rate for the city $M_{R_P}$ and the size of the population that benefits from the intervention, $N_{P_i}$:

$$D_{H_i} = ERR_{H_i} \times M_{R_P} \times N_{P_i}.$$ (5)

Equation (5) models the evidence that is associated with the environmental hazard and intervention and calculates an approximate number of deaths prevented through hazard management.

The estimated changes in exposure due to an intervention in all cases presented in this study were obtained from existing models in the literature. As such, these estimates will be uncertain. In addition, the parameter $\beta_H$ used to calculate the relative risk was also derived from existing epidemiological models.

The calculations that were used to generate the central estimates of the preventable number of deaths from mitigation for each intervention are listed below.

**Outdoor air quality and heavy goods vehicle controls**

**Mortality (per year)**

$$\beta_{PM} = \log(1.1006)/10 \equiv 0.01$$

$$RR_{PM} = e^{0.01 \times (-2.5)} \equiv 0.98$$

$$ERR_{PM} = 0.98 - 1 \equiv -0.02$$

$$d_R = \frac{578.3}{100000}, N_{PM} = 258700$$

$$D_{PM} = \left( \frac{578.3}{100000} \right) \times 258700 \times (-0.02) \equiv -30$$

**Morbidity (per year)**

$$\beta_{PM} = \log(1.38)/10 \equiv 0.03$$

$$RR_{PM} = e^{0.03 \times (-2.5)} \equiv 0.93$$

$$ERR_{PM} = 0.976321 - 1 \equiv -0.07$$

$$d_R = 0.002, N_{PM} = 258700$$

$$m_{PM} = (0.002) \times 258700 \times (-0.077) \equiv -36$$
Remediation to control levels of indoor radon

**Mortality (per year)**

\[ \beta_R = \log(1.16) / 100 \]
\[ \beta_R = 0.0014842 \]

where \( \beta_R \) is the exposure response coefficient taken from the literature [1].

\[ RR_R = e^{0.001482 \times (-243)} \approx 0.70 \]

where \( RR_R \) is the relative risk for radon and \( \Delta e_R = -243 \text{Bq/m}^3 \) is the expected reduction in radon.

\[ ERR_R \approx 0.70 - 1 = -0.30 \]
\[ d_R = 73.45/100,000, N_R = 5520 \]
\[ D_R = (73.45/100,000) \times 5520 \times (-0.3) \approx -1.2 \]

\( D_R \) is the population preventable number of deaths, \( d_R \) is the age standardized mortality rate of lung cancer from 2011-2013, taken from [2] for our city per 100,000 population. We have taken the mean value for men and women between the years so that \( d_R = 73.45/100000 \).

**The quality of indoor air and fitting carbon monoxide alarms**

**Morbidity (per year)**

\[ \beta_{CO} = \log(1.22) / 10 \]
\[ \beta_{CO} \approx 0.02 \]
\[ RR_{CO} = e^{0.02 \times (-50)} \approx 0.37 \]
\[ ERR_{CO} = 0.37 - 1 \approx -0.63 \]
\[ d_R = \frac{0.7}{100}, N_{CO} = 2305 \]
\[ D_{CO} = (0.007) \times 2305 \times (-0.63) \approx -10 \]

**The obesogenic environment. Encouraging cycling through the provision of cycle routes**

**Mortality (per year)**

\[ \beta_{PA} = \log(0.81) / 11 \]
\[ \beta_{PA} \approx -0.019 \]
\[ RR_{PA} = e^{-0.019 \times (59.8)} \approx 0.32 \]
\[ ERR_{PA} = 0.31 - 1 \equiv -0.68 \]
\[ d_R = \frac{578.3}{100000}, N_{PA} = 3055 \]
\[ D_{PA} = \left( \frac{578.3}{100000} \right) \times 3055 \times (-0.68) \equiv -12 \]

**Morbidity (per year)**

\[ \beta_{PA} = \log(0.68) / 6 \]
\[ \beta_{PA} \equiv -0.06 \]
\[ RR_{PA} \equiv e^{-0.06 \times (59.8)} \approx 0.03 \]
\[ ERR_{PA} \equiv -0.97 \]
\[ d_R = 0.002, N_{PA} = 3055 \]
\[ m_{PA} = (0.002) \times 3055 \times (-0.97) \equiv -6 \]

**Table A1 - List of environmental parameters and ratings for quantitative criteria.**

<table>
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<tr>
<th>Hazard</th>
<th>Mortality statistic</th>
<th>Morbidity statistic</th>
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<tbody>
<tr>
<td>Radon</td>
<td>( \beta_R = 0.00148 )</td>
<td>( \beta_R = 0 )</td>
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<tr>
<td></td>
<td>( RR_R = 0.7 )</td>
<td>( RR_R = 0 )</td>
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<tr>
<td></td>
<td>( ERR_R = -0.3 )</td>
<td>( ERR_R = 0 )</td>
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<tr>
<td></td>
<td>( d_R = 73.45/100,000 )</td>
<td>( d_R = 0 )</td>
</tr>
<tr>
<td></td>
<td>( N_R = 5,520 )</td>
<td>( N_R = 0 )</td>
</tr>
<tr>
<td></td>
<td>( D_R = -1.2 )</td>
<td>( D_R = 0 )</td>
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<tr>
<td>Outdoor air pollution</td>
<td>( \beta_{PM} = 0.01 )</td>
<td>( \beta_{PM} = 0.03 )</td>
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<tr>
<td></td>
<td>( RR_{PM} = 0.98 )</td>
<td>( RR_{PM} = 0.93 )</td>
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<td>( ERR_{PM} = -0.02 )</td>
<td>( ERR_{PM} = -0.07 )</td>
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<td></td>
<td>( d_R = 578.3/100,000 )</td>
<td>( d_R = 0.002 )</td>
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<tr>
<td></td>
<td>( N_{PM} = 258,700 )</td>
<td>( N_{PM} = 258,700 )</td>
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<tr>
<td></td>
<td>( D_{PM} = -30 )</td>
<td>( D_{PM} = -36 )</td>
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<td>Indoor Carbon Monoxide</td>
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<td>------------------------</td>
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<tr>
<td>$\beta_{CO} = 0$</td>
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<tr>
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<tr>
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<tr>
<td>$D_{CO} = 0$</td>
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<table>
<thead>
<tr>
<th>Obesogenic environment</th>
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<td>$\beta_{PA} = -0.019$</td>
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