AirQ+ - example of calculations

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Introduction

AirQ+ is a software tool for quantifying the health burden and impact of air pollution developed by the WHO Regional Office for Europe. AirQ+ includes in a user-friendly way methodologies to assess the effects of long-term (and short-term exposure) to ambient air pollution. It can handle the following pollutants: PM$_{2.5}$, PM$_{10}$, NO$_2$, O$_3$ and black carbon (BC). Additionally, AirQ+ can estimate the effects of household air pollution related to Solid Fuel Use (SFU). Various health outcomes related to mortality and morbidity, both in terms of acute and chronic conditions can be considered for the calculations. The underlying scientific evidence on health effects from ambient air pollution used in the software comes mainly from studies conducted in Western Europe and North America. As a result, the applicability of the results generated by the software for assessments carried outside of these regions can be associated with additional uncertainties and should be considered with caution and involves expert judgment.

Installation of AirQ+

The AirQ+ files and folders are distributed in a compressed zip folder. There is no dedicated installation necessary. It is recommended to create a dedicated folder for AirQ+ on your local hard drive. All files must be copied to that folder without changing their names or relative location. The program can be started by double-clicking AirQPlus.

AirQ+ defaults to the English version when first opened. Users may then select the desired language in the top-right corner. The program then needs to be closed and when reopened, AirQ+ will then launch in the language chosen.

Prerequisites

AirQ+ is a stand-alone application using Java technologies. Therefore, Java needs to be installed on the target computer. The program has been tested with Windows 7, Windows 10, Linux/Ubuntu, and Macintosh. Since only a limited number of all possible configurations could be tested, WHO rejects all kinds of responsibilities for malfunctions of any kind.

Dedicated folders

In the root folder, AirQ+ has three subfolders: ‘testData’, ‘dist’, and ‘resources’. ‘dist’ and ‘resources’ must neither be moved, nor deleted or renamed. Their content must also remain unchanged for proper functioning of the program.

Number format

Numerical values are always processed and stored by AirQ+ using decimal points, even if the language and number format settings of the target machine are different. It is possible to use csv-files for data in- and output. “csv” stands for “comma separated values”, but since commas are

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1 For contacts: http://www.euro.who.int/en/about-us/contact-us or email to euroceh@who.int.

The AirQ+ project was partially financed by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Thanks for comments and suggestions to Michal Krzyżanowski, Brian Miller and Sophie Gumy.

2 Please refer to the Glossary for details on key terms.
used as decimal delimiter in many languages this can lead to confusion. The separation character used by AirQ+ is always the semicolon (;).

What AirQ+ does understand: 7.5; 8.002; 17.3

Such input data results into AirQ+ correctly reading three numbers: 7.5, 8.002, and 17.3

What AirQ+ does not understand: 7.5,8.002,17.3 (comma as separator), or 7,5; 8,002; 17,3 (comma as decimal symbol).

The procedures necessary for defining the semicolon as separation character depends on the operating system of the target machine. Please consult the respective system help information. In Windows 7, for example, the separating character is globally defined in the Control Panel through Control Panel – Region and Language – Formats – Additional settings – List separator.

**Starting AirQ+ the first time**

AirQ+ was developed aiming at presenting an easy to use interface. Before performing a proper analysis it is recommended to get familiar with the various functions using the sample data supplied. AirQ+ is a stand-alone program that does not need or establish internet connections. Data and results are automatically saved and presented in a project tree for ease of management.

When the program is started for the first time, the entry window is displayed (Fig. 1). On the left is the empty project tree for short-term and long-term analyses. Next to ‘Project overview’ are five icons representing the following functions for managing analyses, from left to right: adding, deleting, exporting, comparing, and filtering.

*Fig. 1 AirQ+ detail of available functions*

If users wish to know which version of AirQ+ they are using, they can either see the bottom of the start-up screen or click the information button in the top right corner of the start-up screen (Fig. 1). Please carefully read the disclaimer, which is accessible beneath the info button.

Note: The test data used in the examples of this tutorial are part of the AirQ+ package. They can be found in the folder ‘testData’.

**Entry fields colour codes**

The colours of the fields for data entry indicate:

**White**: white fields in the ‘Analysis Properties’ tab indicate optional data. In tables used for measurement data in tab ‘Air Quality Data’ fields are always white. Depending on the type of field, some obvious plausibility checks are performed. For example, it is not possible to enter negative values into a ‘Number of days’ field.

**Green**: this color indicates correct values in mandatory and voluntary fields. Mandatory fields must be filled for AirQ+ computations.
Note: when a new analysis is created, those fields contain formally correct defaults. For example, the concentration mean value is initially set to zero.

**Yellow:** voluntary fields; it is strongly recommended to fill in those fields for documentation purposes. Voluntary fields are not necessary for the computation.

**Red:** if incorrect values are supplied in a mandatory field, the field turns red. For example, concentration mean values must not be negative.

*Fig. 2 AirQ+ start-up screen*
The test input datasets

The test input data provided with AirQ+ comprise of real data from one European city and a country. In order to get familiar with the sample data it is highly recommended to also study the content of the files using standard text editors like Gedit for Ubuntu or the Notepad utility of Windows. Make sure to always keep backup copies of the original files.

The CityData datasets

Two dataset are referred to a European city.

1. **CityData_PM10_minmaxdays.csv**
   The file consists of sample PM10 data for an impact analysis using a frequency distribution for a period of one year. First line: min;max;days
   Lines 2 to 19: values.
   Example, line 8: 60;70;23
   Meaning: in that period, average daily PM10 concentrations were between 60 and 70 µg/m³ at 23 days. For that interval, AirQ+ uses the middle value for calculations, i.e. 65 µg/m³.

2. **CityData_daily_2004-2006.csv**
   The file consists of sample PM10 data for an impact analysis using daily mean concentrations for a period of three years.
   First line: Date;Daily Mean PM10;Estimated Daily Mean PM2.5 (=0.58*PM10);Daily 8h-max Ozone
   Lines 2 to 1097: values.
   Example, line 10: 09/01/2004;87.8;50.9;44.9
   Meaning: on 09/01/2004 the daily average PM10 concentration was 87.8 µg/m³, the daily average PM2.5 concentration was 50.9 µg/m³, and the daily eight-hours-maximum concentration for ozone was 44.9 µg/m³.
   Note: the date field is a text field that is checked for duplicates only; any duplicate date record would be ignored, even if concentration values are different. The format of the date field is not relevant. “9 April 2004” would work as well as “2004 April 9”. Specific dates are not needed for AirQ+ computations.

The first line of an input file is always needed and used by AirQ+ for its input module, but the content is quite flexible. For example, a first line “Minimum PM10;Maximum PM10;Number of Days” would work as well as “min;max;days”.

The CountryLifeTable dataset

**CountryLifeTable.csv**

The data provided allow making life table calculations for the country of CountryLifeTable for one year. The CountryLifeTable data are referred to a European country.

Data include:

- Population (total population, 5 years groups until 100, followed by 100 and over); and
- Health data (all non-external causes mortality – all ages).
The file consists of population and mortality data by age for one year.
First line: from;to end;mid year;death
Lines 2 to 22: values.
Example, line 8: 30;34;4234400;3344
Meaning: that age group has a width of five years. It includes people between 30 years of age and below 35.

Note: a 35-year-old person does belong to the next age group. The size of the mid-year population is 4 234 400 individuals, and the number of deaths for the year in question in that age group is 3 344.

The first line of an input file is always needed and used by AirQ+ for its input module, but the content is quite flexible. For example, a first line “From age;Including age;Mid-year population, Number of deaths” would work as well.

Please refer to the specific document AirQ+_Life Tables to see the use of life tables for calculations.
Analysis of the CityData data: ambient air pollution – PM2.5 – long-term – adult mortality

Question to be addressed: how many deaths (out of the total number of total deaths for natural causes) are attributable to long-term exposure to PM$_{2.5}$ exceeding WHO AQG level (10 µg/m³)?

The average of the monitoring results form 2004-2006, 27.95 µg/m$^3$, is considered here as an indicator of long term exposure of CityData residents. The user can answer this question with two types of air pollution data: 1) the yearly mean value; and 2) frequency distribution data for the air pollution. In the second case it is important that the user checks whether the amount of available data reasonably represents the period considered.

Solution for data input PM$_{2.5}$ yearly mean value

In the ‘Create New Analysis’ window (Fig. 3) select Long term effects, Ambient pollution and the Pollutant PM$_{2.5}$.

Fig. 3 AirQ+ ‘Create New Analysis’ window for ambient air pollution – PM$_{2.5}$ – long-term

In ‘Analysis Properties’ as only the mean value is needed for a straightforward, simple assessment, enter 27.95 µg/m$^3$ into the ‘mean Value’ field. In addition, enter 1 690 109 into the total population field (Fig. 4).

Note: in most cases the mean value (average) would be an annual mean. But AirQ+ does not require that mean values are annual averages. It is also possible to use three year averages instead, for example.
Now press the ‘Create new Impact Evaluation’ button to complete the input data (Fig. 5). The following data must be entered:

- title of the analysis (for example: AAP PM$_{2.5}$ log-term adult mortality);
- mortality (all non-external causes, mortality is an incidence rate as per 100 000 population), enter: 939.73;
- the total number of adults ($\geq 30$) exposed to the pollutant (the user can input for the ‘population at risk’ in the ‘Impact Evaluation’ either the absolute number or the percent of the ‘Total Population’); that number is smaller than the total population entered previously, enter: 1 156 588;
- use the default Relative Risk values: 1.062 (CI 1.040-1.083)$^3$;
- cut-off concentration: the burden or impact of exposure exceeding this concentration will be calculated by the program. Default value is: 10 µg/m$^3$.

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$^3$ The relative risk values are the results of the meta-analysis of 13 cohort studies by Hoek et al. (2013).
**Fig. 5 AirQ+ Impact Evaluation screen for ambient air pollution – PM$_{2.5}$ – long-term – adult mortality**

Results: long-term effects using as data input PM$_{2.5}$ long term average

The results are obtained by pressing the Calculate button (Fig. 6).

**Fig. 6 AirQ+ results for Ambient air pollution – PM$_{2.5}$ – Long-term – adult mortality**

The results indicate that more than 1,112 premature deaths (Fig. 6) caused by long term exposure to PM$_{2.5}$ could be “avoided” if concentration of PM$_{2.5}$ would not exceed 10 µg/m$^3$, which happens to be the threshold recommendation by the WHO Air Quality Guidelines (2005). The values in the ‘Lower’ and ‘Upper’ columns correspond to the estimates calculated with, respectively, lower and upper confidence interval limits of the RR. The interval between the lower and upper values represents a part of the uncertainty associated with the estimation.
**Uncertainty**

The uncertainty associated with the exposure assessment should be assessed by selecting different pollutant concentrations. Other changes in input parameters could be used to study sensitivity of the impact estimates to various assumptions made.

Users can export the results in csv format by pressing the export button and select which data to export (Fig. 7 and Fig. 8).

*Fig. 7 AirQ+ Export button*

![Fig. 7 AirQ+ Export button](image)

*Fig. 8 AirQ+ Export button options*

![Fig. 8 AirQ+ Export button options](image)

Note: AirQ+ automatically saves the projects, users do not need to save them.
Option for data input – PM$_{2.5}$ daily frequency data

In the ‘Create New Analysis’ window (Fig. 9) the user selects long term effects, ambient pollution and the pollutant PM$_{2.5}$, as in the previous solution.

![Fig. 9 AirQ+ ‘Create New Analysis’ window for ambient air pollution – PM$_{2.5}$ – long-term](image)

In ‘Analysis Properties’ (Fig. 10) enter the total population: 1 690 109. As we are considering daily data, select the option of ‘Input Air Quality Data’. See Comments on data input solutions for differences between the two input methods.

![Fig. 10 AirQ+ Analysis Properties window for ambient air pollution – PM$_{2.5}$ – long-term – adult mortality (Data input – PM$_{2.5}$ daily frequency data)](image)
After creating a new ‘Impact Evaluation’, enter the following data:

- mortality (all non-external causes, per 100,000 population): 939.73;
- the total number of adults (≥30) affected by the pollutant: 1,156,588;
- the Relative Risk values, suggested values for all-cause mortality are: 1.062 (CI 1.040-1.083);
- impact of concentration: 10 µg/m³ as suggested by WHO Air Quality Guidelines (2005).
- Import the air pollution data that will produce an average value of 28.018 µg/m³ after pressing the EnterAirQualityData button (Fig. 11). In this example the mean value is a three years average of available daily values\(^4\). Remember to select the PM2.5 data in the Daily mean option (highlighted in red in Fig. 11).

**Fig. 11 Data import window for ambient air pollution – PM2.5 – long-term – adult mortality (Data input – PM2.5 yearly average)**

Note: When importing the data, in the ‘Select Input Format’ it is important to press the right radio button. If the input file has a frequency distribution, it means that it aggregates daily data. Therefore ‘Aggregated’ needs to be marked. Otherwise AirQ+ interprets the first values in a row as a date, which results in wrong input data. The user can input manually data by adding rows (expansion of the table by using the Tab key is possible) with air pollution values.

\(^4\) The user has to check if the availability of data is reasonably representative of the period considered. The mean concentration value must be based on days with valid data. In each year, 75% of days with valid measurements should be available. In the case of CityData data, only 15 days lack valid PM data (13 days in 2004 and 2 days in 2006).
Results: long-term effects using PM$_{2.5}$ daily frequency data

Note: if the air pollution mean calculations are performed with the mean from value the daily data import (28.018 µg/m$^3$), the same results are obtained (Fig. 13), indicating that the methods perform equally well. The results indicate that more than one thousand excess deaths (1116) could be “avoided” if WHO AQG for PM$_{2.5}$ are respected.

Comments on data input solutions

Mean values should be computed from original daily data (raw data), not from a frequency distribution. Though obtained mean values can be close, they are not identical and results obtained may differ.
Analysis of the CityData data: ambient air pollution – PM$_{2.5}$ – short-term – mortality

The user has to consider that “[...] quantification of the effects of short-term exposure should be done for information only; it is not proposed as an alternative to quantification of long-term PM$_{2.5}$ exposure” (WHO, 2014).

Question to be addressed: how many deaths (out of the total annual number of total deaths for natural causes) are attributable to short-term (daily) exposure to air pollution CityData exceeding a selected daily concentration (e.g. 25 µg/m³, WHO AQG for daily mean PM$_{2.5}$)?

In the ‘Create New Analysis’ window (Fig. 14) the user must select short-term effects, ambient pollution and the pollutant PM$_{2.5}$.

Fig. 14 AirQ+ ‘Create New Analysis’ window for ambient air pollution – PM$_{2.5}$ – short-term – adult mortality (Data input – PM$_{2.5}$ daily frequency data)

In Analysis Properties the user can input the total population, 1 690 109. As we are considering daily data, the option of Input Air Quality Data must be selected such that the option of importing detailed PM$_{2.5}$ air quality data is made available. See previous “Comments on data input solutions”.

AirQ+ example of calculations - Page 15 of 31
After the user has created an ‘Impact Evaluation’ (Fig. 16) the following data must be input:

- mortality incidence (all non-external causes): 939.73 per 100,000;
- the total number of adults affected by the pollutant: 1,156,588;
- the Relative Risk values, suggested values for all-cause mortality are: 1.0123 (CI 1.0045-1.0201);
- impact of concentration: 25 µg/m$^3$ as indicated by WHO AQG.
As expected the short-term effects are minor compared to the long-term effects. In fact, the results indicate that 95 excess deaths could be “avoided” if WHO AQG for PM$_{2.5}$ are respected. It is worth noticing that effects of short term exposure to PM$_{2.5}$ are already included in the estimates of effects of long term exposure.
Analysis of the CityData data: ambient air pollution – PM2.5 – long-term – adult mortality – use of integrated exposure-response function (IER)

The use of IER is suggested when there is interest to cause specific mortality, an exposure at high levels of PM (for example PM$_{2.5}$ > 40 μg/m$^3$) or in absence of any Regional or local RR. The user is suggested to refer always to the last updates of the IER.

Question to be addressed: What is the burden on health for lung cancer (LC) for adults, at the current level of air pollution measured using PM$_{2.5}$ data?

In this case one run of AirQ+ is required.

**Option for data input PM$_{2.5}$ yearly average**

In the ‘Create New Analysis’ window the user must select long term effects, ambient pollution and the pollutant PM$_{2.5}$. In ‘Analysis Properties’ they must input the total adult population: 1 156 588. The user can choose to enter the mean value 27.95 or daily data.

In *Impact Evaluation* the following data must be input:

- mortality incidence (LC): 51.6 per 100,000; and
- the total number of adults affected by the pollutant: 100% right now as default.

Relative risk values need not be inserted as the integrated risk function is used.

*Fig. 17 AirQ+ ‘Impact Evaluation’ screen for ambient air pollution – PM$_{2.5}$ – long-term – adults LC mortality – Use of IER*
Results data input – PM$_{2.5}$ yearly average (mean 27.95 µg/m$^3$)

Fig. 18 AirQ+ results for Ambient air pollution – PM$_{2.5}$ – Long-term – Adults mortality – Use of IER (mean 27.95)

The percentages for the attributable proportion are high, due to the high hypothesized incidence, and this produces a relevant estimate of 91 deaths among adults of CityData (Fig. 18).

Question to be addressed: What is the burden on health for LC for adults, at different levels of pollution?

In this case at least two runs of AirQ+ are required for the different levels considered. The user has to consider that CI cannot be assumed equal to the difference between the CI used in the two calculations.

Option for data input PM$_{2.5}$ yearly average

The user chooses an additional mean to consider, in this example 127.95 µg/m$^3$ is chosen. This leads to the results in Fig. 19.
Using the compare-browser function the two estimations can be compared (Fig. 20).

The percentage difference is more than 23% as high as the percentage in the case with lower pollution. The excess deaths are 61% higher than that at the lower pollution concentration of 27.95 µg/m³.
Analysis of the CityData data: ambient air pollution – Ozone – long-term – adult mortality

Question to be addressed: How many deaths (out of the total number of total deaths for natural causes) of adults in city 1 are due to the long term exposure to ozone in exceeding annual mean concentration of 100 µg/m³?

The user can make calculations having two type of air pollution data: 1) the SOMO35 and number of valid days of measurement (Data Input SOMO35); 2) daily frequency data for ozone measured as max daily 8h means (for example 10 µg/m³ units range (Data Input – Ozone daily data).

Option for Data input – SOMO35

In the ‘Create New Analysis’ window the user must select long term effects, ambient pollution and the pollutant O3. In ‘Analysis Properties’ the user must input the total population: 1 690 109 (Fig. 21). As we are considering daily data, the option of ‘Input Air Quality Data’ must be selected such that the option of importing detailed SOMO35 air quality data is made available. SOMO35⁵ is calculated by

\[
\text{SOMO35uncorrected} = \sum \text{max}(0; C_i - 35\text{ppb}) \cdot \frac{N_{\text{valid}}}{N_{\text{total}}}.
\]

Since our 8 hour means are given in µg/m³, we change the 35ppb in the equation to 70 µg/m³. For the CityData data SOMO35 is 9.7473.

In fact, SOMO35uncorrected is 10 653.8 and there are 1 093 valid days.

Fig. 21 AirQ+ Analysis Properties screen for ambient air pollution – Ozone – long-term – adult mortality
In *Impact Evaluation* the following data must be input:

- Mortality incidence (respiratory diseases), hypothetically 160 per 100,000;
- The total number of adults (≥ 30) affected by the pollutant: 1,156,588;
- The Relative Risk values, recommended values for respiratory mortality are: 1.014 (CI 1.005-1.024); and
- Impact of concentration: 70 µg/m³ for the 8 hour mean as suggested by the SOMO calculations. This corresponds to 35 ppb or a cut off of 0.

**Fig. 22 AirQ+ results for ambient air pollution – Ozone – long-term – adult mortality**

With an annual mean of 9.7473 µg/m³ O₃ there are 25 deaths that could have been “avoided” if there was 70 µg/m³ (35 ppb) for the 8-hour mean.

**Option for Data input – Ozone daily data**

This is not currently possible in AirQ+. The user must convert the data to SOMO35 using the formula used in the previous example.
Analysis of the CityData data: household air pollution – solid fuel use – long-term – children mortality

The household air pollution is a work in progress extension of AirQ+. It is intended to give rough estimation of the impacts of household air pollution and it is aimed to promote the collection of data on the issue.

**Question to be addressed:** How many children are affected by current level of household (indoor) air pollution due to solid fuel use (SFU) in the city of CityData?

**Solution**

First, the user has to ‘Create new Analysis’, selecting SFU as the pollutant to be analysed (Fig. 23). Then the population of interest (children under five years) must be inserted in the ‘Analysis Properties’ (105 352). For the ‘Impact Evaluation’, the following data are needed:

- Estimate of exposure to solid fuel use for children, for example 11% of children, equal to 11,589
- Incidence for ALRI for example input equal to 5,000 per 100,000
- Relative risk equal to 2.9 (CI 2.0-3.8)

![Fig. 23 AirQ+ ‘Create New Analysis’ window for solid fuel use – children mortality (Data input – PM_{2.5} daily frequency data)](image)
### Results

#### Fig. 24 AirQ+ results for household air pollution – solid fuel use – children mortality

<table>
<thead>
<tr>
<th>Impact Evaluation (Solid Fuel Use)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evaluation Name:</strong> ALRI for children</td>
</tr>
<tr>
<td><strong>Health Endpoint:</strong> ALRI</td>
</tr>
<tr>
<td><strong>Incidence</strong> (per 100,000 per year): <strong>3000</strong></td>
</tr>
<tr>
<td><strong>Pop. at risk (11%):</strong> <strong>11589</strong></td>
</tr>
</tbody>
</table>

The population at risk for household air pollution is defined by the affected population for the health endpoint multiplied with the percentage of people that use solid fuel. Please use the following table to determine the solid fuel usage rate for your region.

<table>
<thead>
<tr>
<th>Calculation Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calculation Method:</strong> Household Air Pollution</td>
</tr>
<tr>
<td><strong>Subjects:</strong> Children (age 0-5 years)</td>
</tr>
<tr>
<td><strong>Relative Risk:</strong> 2.9 Lower 3.6 Upper</td>
</tr>
</tbody>
</table>

**Results** (last calculation 2019-10-23 1:02:01.51)

<table>
<thead>
<tr>
<th></th>
<th>Central</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Attributable Proportion</td>
<td>17.29%</td>
<td>9.91%</td>
<td>23.55%</td>
</tr>
<tr>
<td>Estimated number of Attributable Cases</td>
<td>100</td>
<td>57</td>
<td>136</td>
</tr>
<tr>
<td>Estimated number of Attributable Cases per 100,000 Population at Risk</td>
<td>864.27</td>
<td>495.51</td>
<td>1,177.29</td>
</tr>
</tbody>
</table>
Analysis of the CountryLifeTable data: ambient air pollution – PM2.5 – long-term – adult mortality – use of life tables

The four life table examples presented require familiarity with the epidemiological definitions related to life table calculations, such as mid-year population and deaths by age, hazard rates, survival probabilities, life expectancy, years of life lost. Please consult specific epidemiological standard literature for life table concepts and methodologies.

Question 1: What are the years of life lost after 13 years of exposure to 25.2 µg/m$^3$ PM$_{2.5}$?

At start the user has to ‘Create new Analysis’, selecting PM$_{2.5}$ as the pollutant (Fig. 26). Next, the population of interest (adults) must be inserted in the ‘Analysis Properties’ (51 814 800). Enter 25.2 µg/m$^3$ as the mean PM$_{2.5}$ value for the considered year of calculations.

For the ‘Life Table Evaluation’ test data regarding both men and women is provided and can be imported in the ‘Input Life Table’ screen with the ‘Import Data’ function (Fig. 25). By default the maximum age considered is 120, that is referring to the date a subject turns 120. This can be changed in the ‘Life Table Parameters’ section (Fig. 26).

Note: the meaning of the age in the ‘to end’ column is crucial to remember. This has to be considered literally. In fact, this means that, for example, ‘from 0 to end 4’ is mathematically identical to the half-open interval [0, 5[. Therefore, ‘from 100 to end 100’ would be a valid entry, since that age group runs from the 100$^{th}$ birthday to the day just before the 101$^{th}$. If the maximum age is 120 years in the data, and the oldest age group starts at 95, the following has to be entered: ‘from 95 to end 119’. If 120 were entered instead of 119, AirQ would issue an error message. The maximum age hand able by AirQ+ can be altered in the ‘Evaluation Parameters’ tab.

Warning: if the oldest age group ends at the end of age 100, i.e. ‘from 95 to end 100’, do not change to ‘from 95 to end 120’! That would give different results since then AirQ+ would calculate with ages beyond 100, but data really stops at 100.
In **Evaluation Parameter**, the following values are needed:

- cut off value, $x_0$ of 10 $\mu g/m^3$;
- relative risk equal to 1.062 (lower estimate 1.04, higher estimate 1.083);
- starting year 2003;
- relative risk applied to ages 30 to 120.
Results

Fig. 27 AirQ+ results for a Life Table Evaluation for ambient air pollution – PM$_{2.5}$ – long-term – adult mortality

Over ten years, the results show a large increase of 1 996 536.78 (1 314 718.55 – 2 621 898.08) years of life lost for all ages and an increase of 298 223.61 (197 437.43 – 389 715.37) for ages 0-64 years.

Question 2: What is the expected life remaining of a 64 year old exposed to 25.2 µg/m$^3$ PM$_{2.5}$?

Solution to question 2

In order to obtain the expected life remaining values, the user must click the vertical button right of the table.
Fig. 28 AirQ+ ‘Expected Life Remaining’ button

Results
Fig. 29 AirQ+ detail of results for a ‘Life Table Evaluation’ for ambient air pollution – PM$_{2.5}$ – long-term – adult mortality

The following table of data generated by AirQ+ summarizes relevant data for discussion

<table>
<thead>
<tr>
<th>Age</th>
<th>ELR</th>
<th>delta ELR Central</th>
<th>delta ELR Lower</th>
<th>delta ELR Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>76.81</td>
<td>0.93</td>
<td>0.61</td>
<td>1.23</td>
</tr>
<tr>
<td>1</td>
<td>75.92</td>
<td>0.93</td>
<td>0.61</td>
<td>1.24</td>
</tr>
<tr>
<td>2</td>
<td>75.02</td>
<td>0.93</td>
<td>0.61</td>
<td>1.24</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
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</tr>
<tr>
<td>63</td>
<td>18.13</td>
<td>0.76</td>
<td>0.49</td>
<td>1.01</td>
</tr>
<tr>
<td>64</td>
<td>17.35</td>
<td>0.75</td>
<td>0.49</td>
<td>0.99</td>
</tr>
<tr>
<td>65</td>
<td>16.56</td>
<td>0.74</td>
<td>0.48</td>
<td>0.98</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

We see that a 64 year old can expect to live 17 more years at current air pollution exposure (25.2 µg/m$^3$). However, if the exposure level would get reduced to mean annual concentrations (cut off) of 10 µg/m$^3$, the 64 year old gains 0.75 years.
Question 3: What is the impact on a population of teenagers (13-19 year olds) after 60 years of being exposed to 25.2 µg/m³ PM$_{2.5}$?

Solution to question 3

In order to see these types of results, the user needs to select the ‘Detailed Results’ tab (Fig. 30). Here the user can decide whether or not they would like to consider the life table with or without pollution.

Fig. 30 AirQ+ life table evaluation for ambient air pollution – PM$_{2.5}$ – long-term – teenagers mortality

<table>
<thead>
<tr>
<th>Central</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Entry Population</td>
<td>Years of Life</td>
</tr>
<tr>
<td>15</td>
<td>674,865</td>
<td>674,865</td>
</tr>
<tr>
<td>14</td>
<td>674,776</td>
<td>674,772</td>
</tr>
<tr>
<td>13</td>
<td>674,689</td>
<td>674,535</td>
</tr>
<tr>
<td>16</td>
<td>674,400</td>
<td>674,205</td>
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<td>673,997</td>
</tr>
<tr>
<td>18</td>
<td>673,802</td>
<td>673,728</td>
</tr>
<tr>
<td>19</td>
<td>673,594</td>
<td>673,492</td>
</tr>
<tr>
<td>20</td>
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<td>673,142</td>
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<td>672,798</td>
</tr>
<tr>
<td>22</td>
<td>672,596</td>
<td>672,413</td>
</tr>
</tbody>
</table>
Results

We can compare the values of the 2063 scenario to the 2003 scenario when our analysis was set to start.

Fig. 31 Teenager population in 2003 in the presence of pollution

The teenager population in 2003 is 4,311,459. This number rises to 4,716,567 in 2063, a 6% increase caused by reducing the annual mean concentration of PM$_{2.5}$ from 25.2 $\mu$g/m$^3$ to 10 $\mu$g/m$^3$ (the cut off).

Question 4: Is possible to provide more articulated scenarios with Life Tables?

Yes, it is possible. For example, we can address a question such as: what will happen to the calculations done to answer the first question, if we assume that in the period from 2010 to 2060, the level of pollution will be increased annually by 5%, and the birth rate will increase annually by 2%?.
**Results**

The results do not present big changes, which means that the interaction of various effects within this scenario probably does not produce large variations compared to the previous results (Fig. 33).