AirQ+: burden of disease due to air pollution manual
Abstract

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 methodologies to assess the impacts of short- and long-term exposure to ambient air pollution. The main methodologies use evidence generated by epidemiological cohort studies showing a relationship between average long-term air pollution concentration levels and the mortality risks in exposed populations. Assessing the impact of air pollution is suggested when evaluating the consequences of policies and interventions or of hypothetical scenarios. AirQ+ should always be used with the support of an epidemiologist or air pollution impact assessment expert. To facilitate users in their analyses, AirQ+ comes with manuals that require increasing levels of expertise. This one shows how to carry out a burden of disease assessment for particulate matter with a diameter of 2.5 µm or less (PM$_{2.5}$) ambient air pollution. This is calculated by combining estimates of exposure to air pollution and its distribution in the population with results from epidemiological studies that indicate the additional disease burden from different levels of exposure to air pollution for specific causes of death. This calculation is particularly useful for global comparisons. For locations with high PM$_{2.5}$ ambient air concentration levels, it is recommended to use the integrated exposure–response functions (used for the Global Burden of Disease study) that cover cause-specific mortality for five causes of death: acute lower respiratory infections, chronic obstructive pulmonary disease, lung cancer, ischaemic heart disease and stroke.

Keywords

AIR POLLUTANTS
AIR POLLUTION – exposure
AIR POLLUTION – health impacts
AIR POLLUTION – burden of disease

Document number: WHO/EURO.2020-1560-41311-56213

© World Health Organization 2020

Some rights reserved. This work is available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO, https://creativecommons.org/licenses/by-nc-sa/3.0/igo/)

Under the terms of this licence, you may copy, redistribute and adapt the work for non-commercial purposes, provided the work is appropriately cited, as indicated below. In any use of this work, there should be no suggestion that WHO endorses any specific organization, product or services. The use of the WHO logo is not permitted. If you adapt the work, then you must license your work under the same or equivalent Creative Commons licence. If you create a translation of this work, you should add the following disclaimer along with the suggested citation: “This translation was not created by the World Health Organization (WHO). WHO is not responsible for the content or accuracy of this translation. The original English edition shall be the binding and authentic edition: AirQ+: burden of disease due to air pollution manual. Copenhagen: WHO Regional Office for Europe, 2007.”

Any mediation relating to disputes arising under the licence shall be conducted in accordance with the mediation rules of the World Intellectual Property Organization. (http://www.wipo.int/amc/en/mediation/rules/)


Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Sales, rights and licensing. To purchase WHO publications, see http://apps.who.int/bookorders. To submit requests for commercial use and queries on rights and licensing, see http://www.who.int/about/licensing.

Third-party materials. If you wish to reuse material from this work that is attributed to a third party, such as tables, figures or images, it is your responsibility to determine whether permission is needed for that reuse and to obtain permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

General disclaimers. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers’ products does not imply that they are endorsed or recommended by WHO in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by WHO to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall WHO be liable for damages arising from its use.
Acknowledgments ................................................................................................................................. iv

Introduction ................................................................................................................................................ 1

Create new burden of disease analysis ...................................................................................................... 2

Example CityData analysis: ambient air pollution – PM$_{2.5}$
  – long-term – adult mortality – use of IER .................................................................................................. 3
  Data input: PM$_{2.5}$ yearly average .............................................................................................................. 3
  Results ......................................................................................................................................................... 4

Example CityData analysis: household air pollution – SFU
  – long-term – child mortality due to ALRI .................................................................................................. 5
  Data input ..................................................................................................................................................... 5
  Results ......................................................................................................................................................... 6
Acknowledgments

The authors of this publication are: Joseph Spadaro (Spadaro Environmental Research Consultants, Philadelphia, Pennsylvania, United States of America) and Pierpaolo Mudu (European Centre for Environment and Health, WHO Regional Office for Europe).

The WHO Regional Office for Europe gratefully acknowledges Francesco Forastiere (King’s College London, United Kingdom of Great Britain and Northern Ireland), Michal Krzyzanowski (King’s College London, United Kingdom of Great Britain and Northern Ireland) and Myriam Tobollik (German Environment Agency) for their comments and suggestions. The AirQ+ project was partially financed by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.
Introduction

According to WHO (2016), the burden of disease of ambient air pollution is estimated using methodology based on combining estimates of exposure to air pollution and its distribution in the population, with results from epidemiological studies that indicate the additional disease burden from different levels of exposure to air pollution, after adjusting for other risk factors (e.g. tobacco smoke).

The burden of disease calculation for air pollution has generated various estimates, and the user should be aware of the changes in methodology that have occurred over the years (Ostro et al., 2018). For locations where high PM$_{2.5}$ ambient air concentrations (say, exceeding 40 µg/m$^3$) are prevalent, it is recommended to use the integrated exposure–response (IER) functions of the Global Burden of Disease (GBD) study to quantify the mortality burden of air pollution. These risk functions cover cause-specific mortality for five specific causes of death: acute lower respiratory infections (ALRI), chronic obstructive pulmonary disease (COPD), lung cancer (LC), ischaemic heart disease (IHD) and stroke. Other health outcomes are associated with long-term exposure to particulate matter, such as adverse birth outcomes, childhood respiratory disease, diabetes and neurodegenerative disorders, but they are not considered in this version of AirQ+.

This manual shows how to carry out a burden of disease assessment for PM$_{2.5}$ ambient air pollution (a well-established risk factor), using the default GBD IER functions included in the current version of the AirQ+ software. It is worth noting that the GBD Risk Factor Collaborators update the IER functions periodically. Consequently, reproducing and comparing with GBD results is difficult given the changes in methodology and the modelling used to produce GBD input data (Ostro et al., 2018).

AirQ+ can also be used to estimate the burden of household air pollution related to solid fuel use (SFU) using a simplified method that provides a rough estimate of the implied burden of indoor air pollution.

---

3 PM$_{2.5}$: particulate matter with a diameter of 2.5 µm or less
5 Burden of disease estimates are important because they highlight the adverse health effects of air pollutions, put a spotlight on the importance of environmental protection measures that aim to safeguard public health, and support evidence-based policymaking. This type of information is also often used for cross-country comparisons, assuming age-standardized population distributions, with the underlying scope to show the avoidable health losses that could be achieved from improvements in air quality due to control measures that reduce pollutant emissions.
7 For details on key terms please refer to the AirQ+ Glossary, which is accessible on the main welcome window.
It is recommended to always use AirQ+ with the support of an epidemiologist or air pollution impact assessment expert.

Create new burden of disease analysis

From the main AirQ+ welcome window, click the “Create new Burden of Disease” button to get to the “New Burden of Disease” window (Fig. 1).

Fig. 1. New Burden of Disease window

The user selects options from the drop-down boxes to indicate the type of analysis to perform and clicks OK. This brings up the Analysis Properties window, where the user can enter data for the analysis. After entering data, the user moves to the New Burden Evaluation window where the Health Endpoint drop-down box lists all specific causes of mortality for which IER functions are available. In the current version of AirQ+, the user may select from IER 2013, 2015 and 2016. Each of these models has an implied cut-off value, and the lowest level at which health effects have been found is indicated in the Burden Evaluation window. The cut-off value cannot be modified by the user (refer to the Glossary for details on the methodology). The user should check the age groups to which the IER function refers. IER functions are age-specific to the cause of death. For example, both IHD and stroke analyses can be performed on adults by age group (in years): 25–29, 30–34, 35–39 ... 95+. The most recent IER functions support analyses on ALRI in children (0–5 years old), COPD in adults (>25 years old) and lung cancer in adults (>25 years old).

The burden of disease attributable to ambient air pollution is estimated by combining exposure to air pollution and its distribution in the population with IER estimates at each level of exposure. The attributable burden is calculated by multiplying the population-attributable fraction by the health outcome for each health outcome, sex and age group (WHO, 2016). The total number of deaths for the selected study area has to be estimated using the IER functions for each health outcome: ALRI, lung cancer, COPD, IHD and stroke. The next example discusses the calculations for one health outcome, lung cancer.
Example CityData analysis:

ambient air pollution – PM\textsubscript{2.5} – long-term – adult mortality – use of IER

**Question to be addressed:** What is the health burden from lung cancer in adults at the current level of PM\textsubscript{2.5} air pollution?

**Data input:** PM\textsubscript{2.5} yearly average

In the “New Burden of Disease” window (Fig.1), select long-term effects, ambient pollution and the pollutant PM\textsubscript{2.5}. In the Analysis Properties window, select the Input Mean Value option and enter 27.95 µg/m\textsuperscript{3} into the Mean Value field as the value for ambient air PM\textsubscript{2.5} concentration. Enter “1156588” into the Total Population field. AirQ+ does not use the total population for the analysis, so the user can consider this as additional descriptive information.

In the Burden Evaluation window, select “Mortality due to LC for adults” in the Health Endpoint drop-down box and enter:

- mortality incidence for adults, LC, per 100 000 population: 51.6
- the default percentage of the total number of adults exposed to the pollutant: 100%.

**Fig. 2.** AirQ+ Burden Evaluation window for ambient air pollution – PM\textsubscript{2.5} – long-term – adult LC mortality – use of IER

---

8 AirQ+ uses the total number of adults (≥ 30 years) exposed to the pollutant, a value the user enters when creating a new Burden Analysis.
Results

The percentages for the attributable proportion of air pollution on lung cancer are high, due to the high hypothesized incidence, and this produces the estimate of 92 deaths (central estimate) (Fig. 3). If the user has other cause-specific mortality data available, the results can be summed up and the whole mortality due to ambient air pollution can be estimated.

Fig. 3. AirQ+ results for air pollution – PM$_{2.5}$ – long-term –use of IER LC mortality (mean concentration: 27.95 µg/m$^3$)
Example CityData analysis:

**household air pollution – SFU – long-term – child mortality due to ALRI**

The household air pollution module in AirQ+ provides a rough estimate of the health burden from exposure to indoor air pollution. It is also meant to promote the collection of data on household air pollution.

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

**Data input**

In the New Analysis window, select household, long-term and SFU as the pollutant to analyse (Fig. 4). In the Analysis Properties window, enter “105352” for the population of interest (children under 5 years. In the Burden Evaluation window, enter the following data:

- estimate of population (children) exposed to the pollutant (SFU) as either the percentage (11%) of or total number (“11589”) of children;
- mortality incidence for children, ALRI per 100 000 population: 5000; and
- the default relative risk values for mortality due to ALRI (GBD 2012): 2.9 (95% CI 2.0–3.8).

**Fig. 4.** AirQ+ New Analysis window for household air pollution – SFU – long-term – child mortality due to ALRI (data input – SFU)
Results

Fig. 5 summarizes the results of this analysis. The \( \text{PM}_{2.5} \) attributable mortality due to ALRI is just over 17\% (95% CI: 10–24\%), with 100 (95% CI: 57–136) deaths among children younger than 5 years in this hypothetical case study.

Fig. 5. AirQ+ results for household air pollution – SFU – long-term – child mortality due to ALRI
The WHO Regional Office for Europe

The World Health Organization (WHO) is a specialized agency of the United Nations created in 1948 with the primary responsibility for international health matters and public health. The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health conditions of the countries it serves.

### Member States

<table>
<thead>
<tr>
<th>Albania</th>
<th>Andorra</th>
<th>Armenia</th>
<th>Austria</th>
<th>Azerbaijan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belarus</td>
<td>Belgium</td>
<td>Bosnia and Herzegovina</td>
<td>Bulgaria</td>
<td>Croatia</td>
</tr>
<tr>
<td>Croatia</td>
<td>Cyprus</td>
<td>Czechia</td>
<td>Denmark</td>
<td>Estonia</td>
</tr>
<tr>
<td>Denmark</td>
<td>Estonia</td>
<td>Finland</td>
<td>France</td>
<td>Georgia</td>
</tr>
<tr>
<td>Finland</td>
<td>France</td>
<td>Georgia</td>
<td>Germany</td>
<td>Greece</td>
</tr>
<tr>
<td>Germany</td>
<td>Greece</td>
<td>Hungary</td>
<td>Iceland</td>
<td>Ireland</td>
</tr>
<tr>
<td>Hungary</td>
<td>Iceland</td>
<td>Ireland</td>
<td>Israel</td>
<td>Italy</td>
</tr>
<tr>
<td>Ireland</td>
<td>Israel</td>
<td>Italy</td>
<td>Kazakhstan</td>
<td>Kyrgyzstan</td>
</tr>
<tr>
<td>Israel</td>
<td>Kazakhstan</td>
<td>Kyrgyzstan</td>
<td>Latvia</td>
<td>Lithuania</td>
</tr>
<tr>
<td>Latvia</td>
<td>Luxembourg</td>
<td>Luxembourg</td>
<td>Malta</td>
<td>Monaco</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>Malta</td>
<td>Monaco</td>
<td>Montenegro</td>
<td>Netherlands</td>
</tr>
<tr>
<td>Montenegro</td>
<td>Netherlands</td>
<td>North Macedonia</td>
<td>Norway</td>
<td>Poland</td>
</tr>
<tr>
<td>North Macedonia</td>
<td>Norway</td>
<td>Poland</td>
<td>Portugal</td>
<td>Portugal</td>
</tr>
<tr>
<td>Norway</td>
<td>Portugal</td>
<td>Republic of Moldova</td>
<td>Romania</td>
<td>Russian Federation</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Republic of Moldova</td>
<td>Romania</td>
<td>Russian Federation</td>
<td>San Marino</td>
</tr>
<tr>
<td>Republic of Moldova</td>
<td>Russian Federation</td>
<td>San Marino</td>
<td>Serbia</td>
<td>Serbia</td>
</tr>
<tr>
<td>San Marino</td>
<td>Serbia</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WHO/EURO:2020-1560-41311-56213

WHO European Centre for Environment and Health
Platz der Vereinten Nationen 1, D-53113 Bonn, Germany
Tel: +49 228 815 0400
E-mail: euroeceh@who.int
Website: http://www.euro.who.int/ecehbonn