Integrated Programme for Better Air Quality in Asia (IBAQ Programme)

CITY SOLUTIONS TOOLKIT:

HEALTH IMPACTS ASSESSMENT TOOLS FOR CITIES

THE SITUATION

In air quality management (AQM), a Health Impacts Assessment (HIA) is a process of assessing to what extent an event, scenario, intervention, or control measure related to air pollution affects health. The scope of the assessment may cover an individual, group or community level. Health Impacts Assessment helps AQM policy and decision making by providing information on possible future health problems due to current or projected quality of air. Conducting HIAs contributes to an effective clean air action plan, which will inform the development of policies, strategies, and programs for improved air quality.

Health Impact Assessments can be done through various techniques using different tools that make data compilation and analysis more efficient. There is no standard or prescribed tool to use for all, as the tool of choice should match with the resources and technical capacity of the group who will conduct the assessment. The task of deciding which tool to use from a range of choices becomes challenging for AQM practitioners. While the module on Stages and types of health impacts assessment for cities focuses on the general considerations to understand and prepare for an HIA, this toolkit, some of the most commonly used HIA tools are described to guide the reader in understanding the advantages and requirements of each tool. Some case studies are also incorporated to share lessons and successes that other cities have gained from conducting an HIA.

THE APPROACH

While HIAs directly involve medical and public health experts, air quality managers must also be familiar with the HIA process to properly inform the development of AQM policies (See module on Step-by-step guide for cities to develop clean air action plans). This will also ensure the proper allocation of budgetary and human resources needed to collect the necessary data.

Available tools make HIA easier, and familiarity with them will help air quality managers make informed decisions on which tool(s) to use. A consolidated reference of available computer-based tools is thus presented, aimed at providing the necessary information to guide decision makers in preparations for the HIA process.

Most of the HIA tools described in this module are software-based; it is expected that at least one computer with the most updated version of the tool is available for use by the team. Some of these tools require licensed software while others are widely studied methods that can be accessed freely online. Depending on the existing technical capacity of the team performing the HIA, additional capacity building may be required to be able to use the tool with ease. The total time it would take to perform an HIA will depend on the specific tool used, as well as the volume of data that must be collected, checked, and inputted to the software for analysis. More scenarios to be analyzed would also mean longer run time. In some cases, additional mapping software may also be needed to prepare the data input before the HIA analysis (e.g. ArcGIS or QGIS) (See module on Data visualization of emissions inventory results).

STAKEHOLDER ENGAGEMENT

Processing data for HIA analysis requires minimal stakeholder engagement given that the type of HIA method and tools to be used have already been decided. More stakeholder engagement is expected during the Scoping/Planning stage, as described in the module on Stages and types of health impacts assessment for cities. The stakeholders, mainly local government with experts on HIA, academia, and people's organizations, however, can provide input once preliminary runs have been made to check if the software output matches available local knowledge or on-the-ground-data, if available.

SUGGESTED HIA TOOLS AND CASE STUDIES

In using HIA tools, it's important to understand the concept of epidemiology and risk assessment, which can be embedded in some HIA software:

Epidemiology Studies – study of how often diseases occur in different groups of people and why. These are already integrated to HIAs. Its use is dependent on the expert's interpretation of epidemiological data and validation of methods. There are several types of epidemiological studies (Clean Air Asia and UN Environment, 2019):

- Ecological studies - Looks at hypothesized associations between environmental exposures
- Cohort studies - Follows a group of individuals over a given period. Measures exposure, health outcomes, and confounding factors at specific point
- Case control studies - Cases (with disease) are compared with appropriate controls (without disease). This is widely used in air pollution studies
- Cross-sectional studies - Measures exposure, health outcomes and confounders simultaneously (past or present). Sample participants are investigated at one point in time
- Time Series studies - Measure effects of short-term air pollution exposure on morbidity and mortality. Correlate daily variations in air pollution levels with variations in daily incidence of ill health, hospital admissions, or deaths in a given area.
- Case crossover studies - Examine effects of transient, short-term exposures on the risk of acute events. Allow use of routinely monitored air pollution information and at the same time to study individuals rather than days as the unit of observation
- Panel studies - Involves repeated observations on exposure and health outcomes of individuals in the panel to analyze the time-varying relationship between exposure and health

outcomes. Widely used to investigate the mechanisms of adverse cardiovascular effects associated with exposure to particulate matter (PM).

- Meta-analyses - Used to reduce uncertainty associated with individual studies and to obtain more reliable dose-response function

Health Risk Assessment tools - Risk assessment is an approach to quantify the burden of disease/injury resulting from risk factors. Factors are the probability that something bad happens due to the quality of the air. Risk assessment is part of the appraisal stage of Health Impact Assessment (See module on Stages and types of health impacts assessment for cities).

Rapid Epidemiological Assessment (REA) – Also a tool for risk assessment, REA is designed to be used with ease in gathering health information especially in surveys of small areas. REAs can be applied to many scenarios listed below:

- Identify released chemicals and their sources
- Probable health effects of chemicals
- Spatial and temporal distributions (mapping)
- Describe population at risk
- Mortality, hospital admissions, ER visits, out-patient visits

Cost Benefit Analysis (CBA) - Building on the risk assessment work that quantifies burden of disease, cost benefit analysis of interventions is undertaken to help identify interventions that will reduce burden of disease. Mainly it shows how beneficial it is to do the control measure or intervention.

Cost-effectiveness analysis (CEA) – a form of economic analysis that compares the relative costs and outcomes (effects) of different courses of action.

Listed below are some software-specific HIA tools:

Environmental Benefits Mapping and Analysis Program (BenMAP) developed by the US EPA

- Open sourced software developed in C#
- Main tool to understand health and economic benefits of improving air quality

The latest version of BenMAP gives the advantage of flexibility for users. The BenMAP – CE (community edition) can perform a full-scale benefits assessment but easy enough for beginners to use. Users can load their own data or use pre-loaded data such as:

- Air quality data
- Demographic data
- Economic values
- Concentration – response relationships

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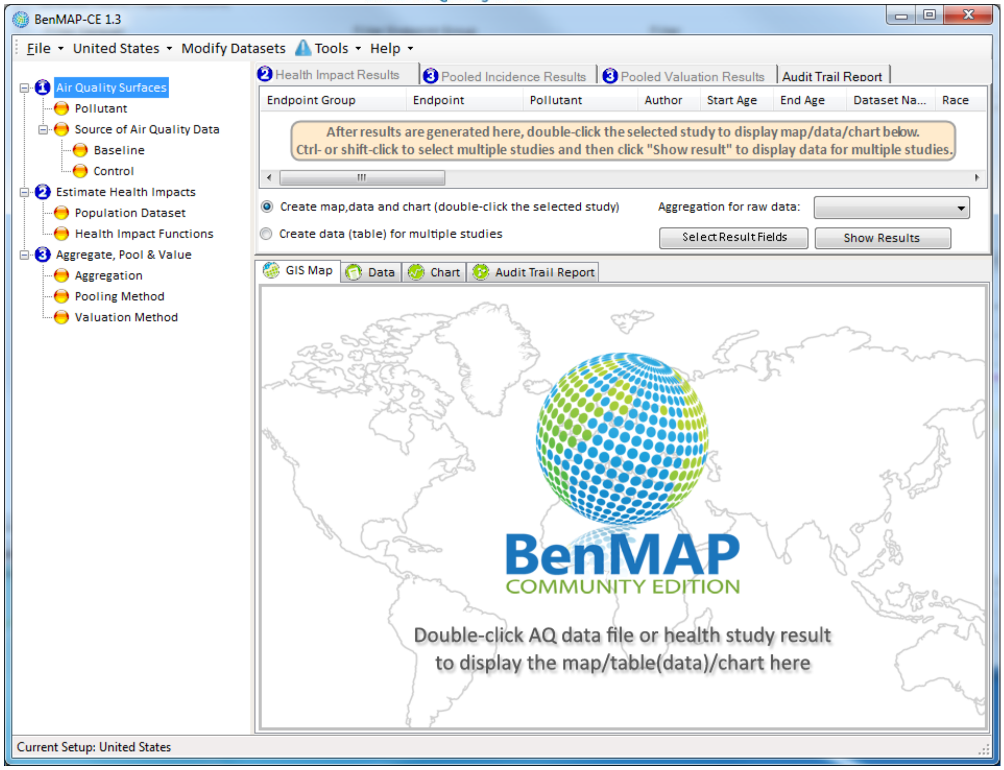


Image Screenshot of the BenMAP – CE software

Sample visuals generated by BenMAP CE are presented below, illustrating how the program calculates for health benefits due to improved air quality. The assumption is that through a policy or measure to reduce air pollution, there will be change in the level of pollutants. The pollution change is related to the population in the study area, and the baseline incidence of health impacts. A built-in dose response function will lead to the calculation of the estimated effects, and ultimately the health impacts, which are represented by the number of deaths and morbidity avoided because of the decreased pollution level.

The economic benefits can also be quantified if economic input value such as cost of illness (COI) and value of statistical life (VSL) are available. The main output is that given the number of deaths and sicknesses avoided, this is the amount of money saved because we improved the quality of air.

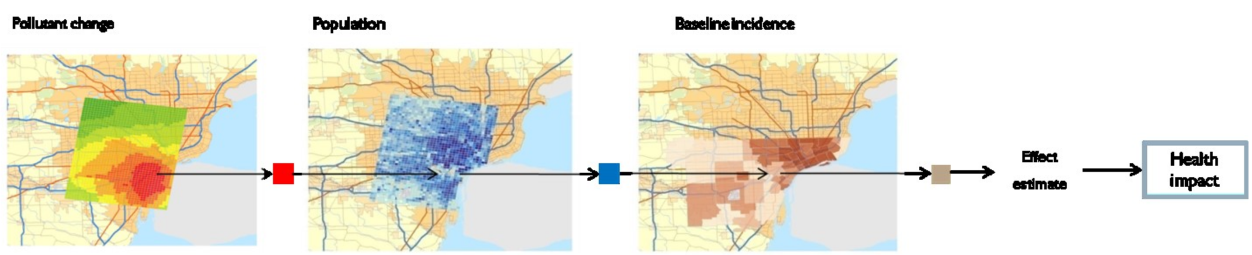
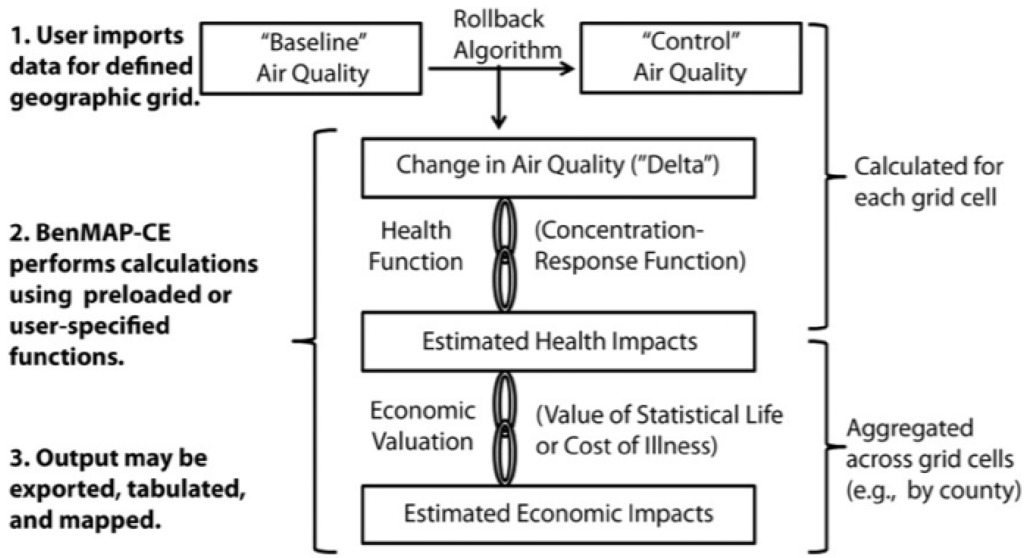


Image source: EPA BenMAP website

Carvour, et al. (2018), further explained the BenMAP process through the diagram below:



In their analyses, they looked into the health impacts of ozone changes in a region in Texas. Two scenarios of pollution reduction were considered for a period of three years: (1) incremental rollback of the daily 8-hour maximum ozone levels by 10 parts per billion, and (2) a rollback-to-a-standard ambient level of 65 parts per billion. Various health impact functions can be run per scenario. Results show that for an incremental rollback scenario, as much as 116 deaths would have been avoided (year 2011), avoiding as much as 932 million USD in related costs. The full summary data can be seen in Table 2 of the journal that can be accessed through this link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5922206/pdf/AJPH.2017.304252.pdf.

Air Quality Benefits Assessment Tool (AQBAT) used by Health Canada

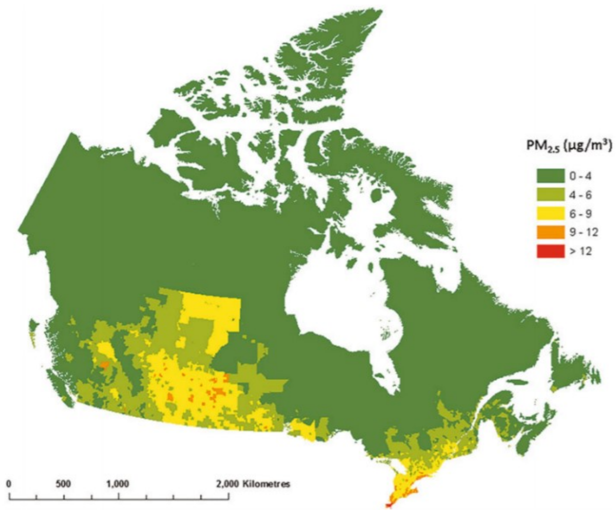
- Reports impacts as attributable cases and monetized impacts
- Model produces an estimate of the number of premature deaths (and other health outcomes)

Similar to BenMAP, it is a health benefits model and one of its strengths is that it looks at the net difference between scenarios, so results are not entirely dependent on the absolute accuracy of the input data. The main pollutants it models for are:

- Carbon monoxide
- Nitrogen dioxide
- Ozone
- Sulfur dioxide
- Particulate matter

While an additional software is needed to run in BenMAP, AQBAT utilizes a Microsoft Excel file tool that can be downloaded from their website. AQBAT's relevant information and downloads can be found in the weblink provided.

The estimated public health impacts of changes in concentrations of fine particulate matter air pollution in Canada was analyzed by Stieb et al. (2015), from 2000 to 2011, using AQBAT. The factors that were modeled were impacts on life expectancy, mortality, and morbidity, by employing nationally comprehensive exposure estimates.



The study recognized that tools such as BenMAP and AQBAT provide background information to emphasize point that air pollution is a public health priority by weighing the costs and benefits of proposed policies. The study projected health impacts of modelled changes in air pollution concentrations resulting from specific proposed policies or programs. Although some of the work could be considered hypothetical because of the extensive scenarios, it can still be informative in understanding the effectiveness of past control measures, as well as identifying priorities for new initiatives. The table below shows the calculated expected change in health impacts given the estimated change in $PM_{2.5}$ levels as shown by the figure on the left. The figure was generated using estimated $PM_{2.5}$ concentrations by census dissemination area, 2010 - 2012

Outcome	**Change***	**95% CI***
Life expectancy (years)	0.10	0.03–0.23
Deaths†	−2500	−(780–6100)
Respiratory hospital admissions	−230	−(150–310)
Cardiac hospital admissions	−340	−(180–490)
Cardiac emergency room visits	−440	−(240–650)
Respiratory emergency room visits	−1200	−(770–1600)
Adult chronic bronchitis cases	−4000	−(0–7800)
Child acute bronchitis episodes	−19,000	−(0–41,000)
Asthma symptom days	−770,000	−(160,000–1,400,000)
Restricted activity days	−5,700,000	− (3,400,000–8,000,000)
Acute respiratory symptom days	−11,000,000	− (0–22,000,000)

* Values are rounded to two significant figures.
† From ischemic heart disease, cerebrovascular disease, lung cancer and chronic obstructive pulmonary disease.
CI = confidence interval.

(Source: Stieb, et al., 2015)

In summary, the study learned that at the national level, changes in $PM_{2.5}$ concentrations had a positive impact on national population weighted average life expectancy and a net reduction in mortality and morbidity.

AirQ+ – Software designed for risk assessment. Developed by the World Health Organization, this tool is mainly for the health risk assessment of air pollution.

- Estimates the effect of short-term changes in air pollution (based on risk estimates from time-series studies)
- Estimates the effects of long-term exposures (using life-tables approach based on cohort studies)
- Can be used in cities to determine how much of a particular effect is due to selected air pollutants
- Compared to the current scenario, what would be the change in health effects if air pollution levels changed in the future

As sample case study in India which used AirQ+ can be found in this link: https://www.tandfonline.com/doi/abs/10.1080/09603123.2019.1651257. In this study by Manojkumar and Srimuruganandam (2019), short-term (hospital admissions due to respiratory disease and CVD) and long-term (mortality, ALRI, COPD, LC, IHD, stroke) effects of ambient PM2.5 are quantified using AirQ+ software (version 1.2).

For more information and download details please visit: http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/activities/airq-software-tool-for-health-risk-assessment-of-air-pollution

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