Air Pollution Impact Model for Transport (AIRPOLIM-T)

Short methodology note

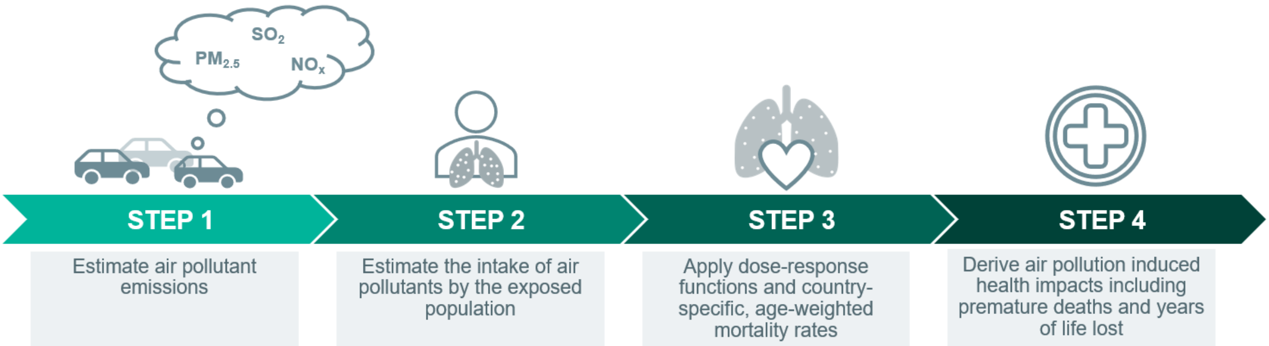
Motor vehicles are the largest contributors to ambient air pollution in urban areas worldwide. Reducing vehicle journeys, increasing vehicle occupancy, shifting to mass (public) transport, using more efficient vehicles as well as electrifying the transport fleet all reduce local air pollutants with direct health benefits for those living and working in cities as well as a reduction of public health costs.

Quantifying air pollution health impacts

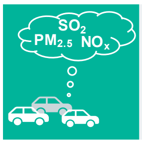
The Air Pollution Impact Model for Transport (AIRPOLIM-T), developed by NewClimate Institute under the Ambition to Action (A2A)[1] project, is used to estimate health impacts from air pollution caused by urban transport activity.

AIRPOLIM-T uses an accessible methodology for quantifying the health impacts of air pollution from the transport sector that can be applied in multiple countries/ cities in the form of an open-source Excel tool. It calculates the impacts on mortality from four adulthood diseases: lung cancer, chronic obstructive pulmonary disease (COPD), ischemic heart disease and stroke, as well as lower respiratory infections (LRI) in children and adults - all of whose prevalence is increased with the intake of pollution (WHO, 2016).

Calculations steps

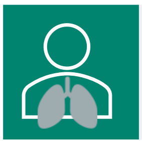


[1] The Ambition to Action project is funded by the International Climate Initiative (IKI) of the German Federal Government. Details on the project as well as outputs are available at: https://ambitiontoaction.net/



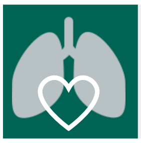
STEP 1
Estimate air pollutant emissions

The health impact assessment is based on transport sector emissions of (primary) particulate matter, or dust ($PM_{2.5}$); nitrogen oxides (NO_x); and sulphur dioxide (SO_2). Users can insert annual emissions directly into the tool or input fuel use, broken down into fuel type, from which the tool can estimate emissions using country-specific default emission factors from the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model developed by the International Institute for Applied Systems Analysis (IIASA) or emission factors put in by the user.



STEP 2
Estimate the intake of air pollutants by theexposed population

The intake fraction concept is used to estimate the change in $PM_{2.5}$ concentration in the ambient air, dependent on the calculated pollutant emissions to avoid complex and resource intensive air dispersion modelling. Intake fractions indicate the grams of $PM_{2.5}$ inhaled by the exposed population per tonne of $PM_{2.5}$, NO_x and SO_2 emissions. These fractions allow us to infer (via a backwards calculation) the change in $PM_{2.5}$ concentration. Intake fractions for individual cities or countries are derived from Fantke et al. (2017).



STEP 3
Apply dose-response functions and country-specific, age-weighted mortality rates

To then calculate the increased mortality risk per additional tonne of pollutant emissions, we multiply the estimated change in $PM_{2.5}$ concentration with the respective concentration-response function. Concentration-response functions are estimated based on long-term medical cohort studies and indicate the increase in cause-specific mortalities per 10 µg/m³ increase in $PM_{2.5}$ (e.g. Burnett et al., 2014; Torfs, Hurley, Miller, & Rabl, 2007). For simplicity we assume that the response functions are linear in the model, meaning that each extra unit of pollution has the same impact on mortality, regardless of the magnitude of additional pollution or the initial pollution concentration level.

The Global Burden of Disease project (2021) provides mortality rates by disease for 12 different age classifications (above 25 years) at the country level. We obtain age-weighted mortality rates by disease by using the share of the country's population in each age class based on data from the World Bank (2021). To calculate the number of years of life lost (YLL) we use life expectancy values at exact age from the UN World Population Prospects (2019).

STEP 4
Derive air pollution induced health impacts including premature deaths and years of life lost

The mortality risk estimates (step 3), the age-weighted mortality rates (step 3) and the exposed population (step 2) are combined to derive an estimate of the number of premature deaths per tonne of pollutant emissions for lung cancer, COPD, ischemic heart disease and stroke. Finally, we multiply these numbers with the estimated pollutant emissions (step 1) to obtain the total number of premature deaths, per pollutant and cause, as well as the estimated number of YLL by multiplying with the respective life expectancy value.

Additional premature deaths caused by lower respiratory infections (LRI) are estimated scaling up the results for COPD, lung cancer, ischemic heart disease and stroke calculated in the previous steps. Scaling factors are calculated based on the results of the Global Burden of Disease study (2021) for seven different world regions. Due to general population health, life expectancy and availability or quality of health care these can differ significantly (*see table below*). The scaling factors are derived by summing up all premature deaths associated with the risk factor "ambient air pollution" caused by COPD, lung cancer, ischemic heart disease and stroke in the specific region, and dividing the total number of premature deaths caused by LRI (for both children and adults) with that estimate. This is a simplified approach but provides an approximate indication of the additional disease burden from LRI on adults and children.

Region	**Scaling factor** LRI	**Share of deaths in children (LRI)**
East Asia & Pacific	0.048	0.370
Europe & Central Asia	0.064	0.421
Latin America & Caribbean	0.184	0.377
Middle East & North Africa	0.099	0.562
North America	0.042	0.060
South Asia	0.262	0.716
Sub-Saharan Africa	1.510	0.807

Source: Own calculations based on Global Burden of Disease (2021)

Additional materials

The Excel-based tool and the user guide are available at newclimate.org/resources/tools

Contact

Tessa Schiefer, NewClimate Institute, t.schiefer@newclimate.org

Harry Fearnehough, NewClimate Institute, h.fearnehough@newclimate.org

References

Burnett, R. T., Arden Pope, C., Ezzati, M., Olives, C., Lim, S. S., Mehta, S., … Cohen, A. (2014). An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter exposure. Environmental Health Perspectives, 122(4), 397–403. https://doi.org/10.1289/ehp.1307049

Fantke, P. et al. (2017) 'Characterizing Aggregated Exposure to Primary Particulate Matter: Recommended Intake Fractions for Indoor and Outdoor Sources', Environmental Science and Technology, 51(16), pp. 9089–9100. doi: 10.1021/acs.est.7b02589.

Global Burden of Disease Collaborative Network. (2021). Global Burden of Disease Study 2019 (GBD 2019) Burden by Risk 1990-2019. Seattle, Washington, USA: Institute for Health Metrics and Evaluation (IHME).

Humbert S, Marshall JD, Shaked S, Spadaro JV, Nishioka Y, Preiss P, McKone TE, Horvath A, Jolliet O. Intake fraction for particulate matter: recommendations for life cycle impact assessment. Environmental Science and Technology. 2011 Jun 1;45(11):4808-16. doi: 10.1021/es103563z. Epub 2011 May 12. PMID: 21563817.

Parry, I., Heine, D., Lis, E., & Li, S. (2014). Getting energy prices right: from principle to practice (1st ed.). Washington, D.C.: International Monetary Fund.

Torfs, R., Hurley, F., Miller, B., & Rabl, A. (2007). A set of concentration-response functions.

United Nations, Department of Economic and Social Affairs, P. D. (2019). World Population Prospects 2019.

World Bank. (2021). World Development Indicators. Washington D.C.