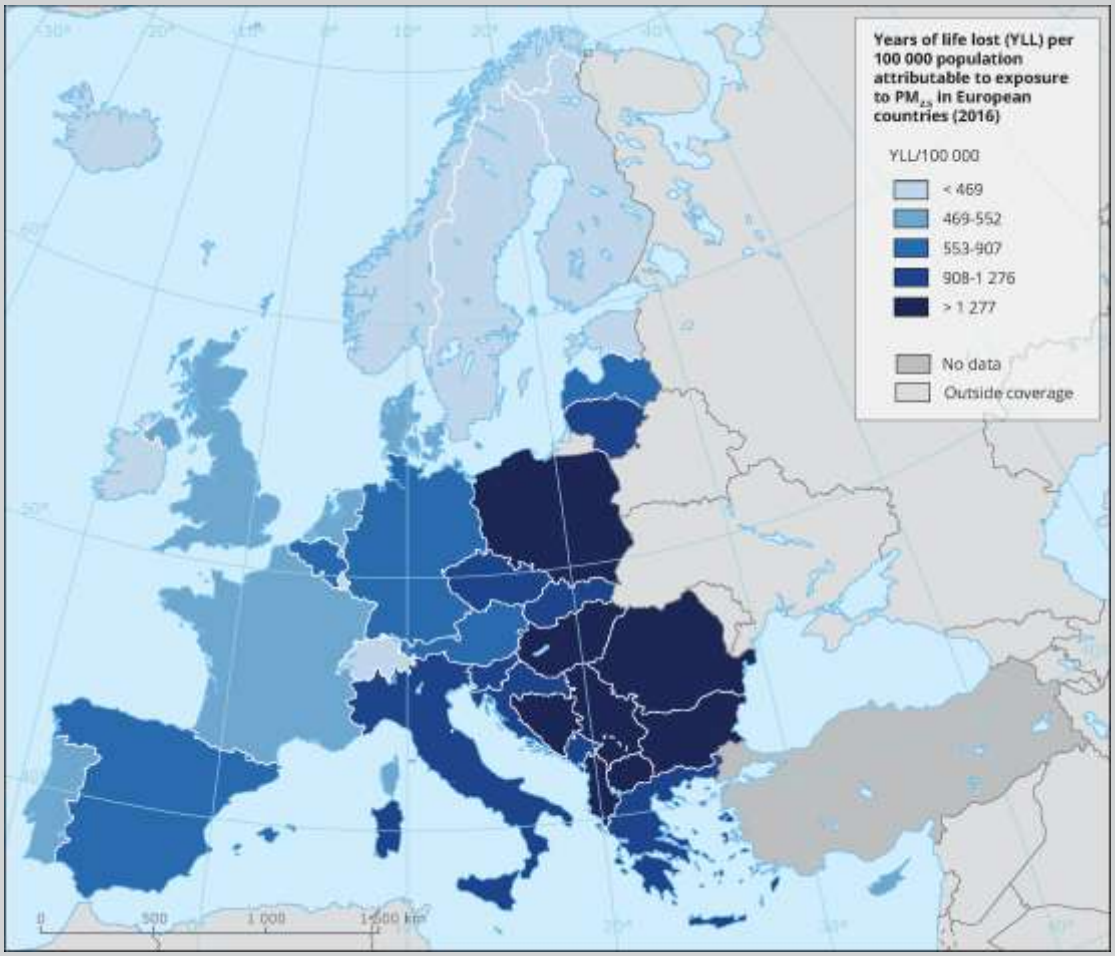
Health Risk Assessment of Air Pollution in Europe

Methodology description and 2017 results

November 2019



Authors:
Joana Soares (NILU), Jan Horálek (CHMI), Alberto González Ortiz (EEA), Cristina Guerreiro (NILU), Artur Gsella (EEA)

ETC/ATNI consortium partners:
NILU – Norwegian Institute for Air Research, Aether Limited, Czech Hydrometeorological Institute (CHMI), EMISIA SA, Institut National de l'Environnement Industriel et des risques (INERIS), Universitat Autònoma de Barcelona (UAB), Umweltbundesamt GmbH (UBA-V), 4sfera Innova, Transport & Mobility Leuven NV (TML)

European Environment Agency
European Topic Centre on Air pollution, transport, noise and industrial pollution

Cover photo © Years of life lost (YLL) per 100 000 inhabitants attributable to exposure to PM2.5 in European countries (2016)

The withdrawal of the United Kingdom from the European Union did not affect the production of the report.
Data reported by the United Kingdom are included in all analyses and assessments contained herein, unless otherwise indicated.

Author(s)
Joana Soares (NILU), Jan Horálek (CHMI), Alberto González Ortiz (EEA), Cristina Guerreiro (NILU), Artur Gsella (EEA)

ETC/ATNI c/o NILU
ISBN 978-82-93752-11-0

European Topic Centre on Air pollution,
transport, noise and industrial pollution
c/o NILU – Norwegian Institute for Air Research
P.O. Box 100, NO-2027 Kjeller, Norway
Tel.: +47 63 89 80 00
Email: etc.atni@nilu.no
Web : https://www.eionet.europa.eu/etcs/etc-atni

Contents

Summary

Epidemiological studies have shown that air pollution is associated with cardiovascular and respiratory diseases, leading to increased sickness, hospital admissions, and premature death. Assessing the health effect attributed to air pollutants is critical to managing air pollution risks.

This report describes the methodology applied to assess health risks across Europe in 2016, as published in the latest European Environmental Agency's Air Quality in Europe report (EEA, 2019). The methodology applied is based on the work by de Leeuw and Horálek (2016) and described here in more detail, including the steps taken for the estimations, the datasets chosen for the calculations and their caveats, and the preparation of input data and gap-filling methodology for missing data. The goal of this report is also to present the health risks assessment across Europe in 2017, calculated following the same described methodology.

Mortality is the health outcome chosen to illustrate the health risk related to air pollution because it is an unambiguous endpoint, thus easy to measure. The mortality-related health endpoints chosen for the assessment are the number of premature deaths and years of life lost. The assessment estimates the health endpoints linked to exposure to fine particulate matter, ozone, and nitrogen dioxide concentration levels for 41 countries across Europe. The results show that the most significant health risks are estimated for the countries with the largest populations. However, in relative terms, when considering, e.g., years of life lost per 100 000 inhabitants, the largest relative risks are observed in central and eastern European countries, and the lowest are found for the northern and north-western parts of Europe.

Additionally to the assessment, two complementary analyses were undertaken: a sensitivity analysis on the presumed baseline concentration levels and a benefit analysis assuming that air quality guidelines for fine particulate matter recommended by the World Health Organization are attained. The sensitivity analysis estimates how much the results are affected when changing the concentration below which no health effects are expected (baseline concentrations). The analysis shows that the effect of changing baseline concentrations is substantial, especially for particulate matter, where currently, it is assumed that all levels of concentration affect human health. The benefit analysis shows that Europeans would benefit from attaining the World Health Organization's air quality guidelines for fine particulate matter, leading to a reduction of over 30 % of the premature deaths and years of life lost levels in 2017.

Acknowledgements

This report was prepared by the European Topic Centre for Air Pollution, Transport, Noise and Industry (ETC/ATNI) under task 1.1.2.1 (2019) “Air Quality Report”. The authors would like to thank the air quality data suppliers in the reporting countries for collecting and providing the data on which this report is based, and Frank de Leeuw (National Institute for Public Health and the Environment) for his assistance throughout this work.

1 Introduction

The exposure to ambient air pollution leads to adverse effects on human health and ecosystems. Epidemiological studies have shown that the exposure to pollutants such as fine particulate matter ($PM_{2.5}$), ozone (O_3) and nitrogen dioxide (NO_2) is associated with cardiovascular and respiratory diseases, leading to increased sickness, hospital admissions and premature death (Beelen et al., 2014). Thus, assessing the health effects attributed to air pollutants is critical to managing air pollution risks.

A health outcome is the result or consequence of exposure to air pollution in a given population. The health outcomes can be mortality or morbidity-related outcomes. Mortality measures the number of deaths in a particular population due to a specific or non-discriminated cause, while morbidity refers to having a disease or symptom of a disease under the same circumstances (and is expressed then as the incidence rate of a specific disease, hospital admissions, or work loss). As a health outcome, mortality is favoured because it is an unambiguous endpoint, thus easy to measure. Furthermore, a number of studies monetising the health effects due to air pollution (e.g. OECD, 2016) show that mortality outweighs the costs arising from the rate of illnesses related to air pollution.

Mortality due to air pollution can be quantified by combining air pollution concentrations, demographic data, and the relationship between the ambient concentrations and the health outcome. It can be expressed as health outcomes or endpoints such as the number of premature deaths and the years of life lost. The latter reflects the loss of life years associated with premature mortality and is often used as an indicator of the burden of disease by the World Health Organization, WHO (Murray and Lopez, 1996). The burden of disease can be seen as the difference between the current health status of a population and an ideal situation when there is no health outcome. To estimate the mortality endpoints, one needs first to quantify the population's relative risk when exposed to current concentration of air pollutants. This quantification considers (gridded) ambient air quality data, population density data, and pollutant-dependent concentration-response functions recommended by epidemiological studies. Finally, the estimation of mortality endpoints is based on the relationship between relative risk and demographic data. The demographic data includes mortality rate and life expectancy data for the targeted population.

This report presents the steps taken for estimating mortality endpoints published in the latest European Environmental Agency's (EEA) Air Quality in Europe report (EEA, 2019), and to assess the health risk due to exposure to $PM_{2.5}$, O_3, and NO_2 air concentration levels in 2017, based on the same methodology. The methodology applied for estimating mortality endpoints is built on the work by de Leeuw and Horálek (2016), with a few adjustments. The steps for the estimation are described in Section 2 and Section 3, where Section 2 describes the methodology, and Section 3 describes the datasets used for the calculations and their caveats, including the preparation of input data and gap-filling for missing data. Section 4 presents the health risk assessment for 2017 due to exposure to $PM_{2.5}$, O_3, and NO_2, and Section 5 shows the estimated health benefits of meeting the WHO air quality guideline (AQG) for annual mean $PM_{2.5}$, compared to the real situation in 2017. A sensitivity analysis of the concentration thresholds above which the health impacts are calculated is presented in Section 6. These thresholds are the concentration levels below which no health effects are expected. Section 7 addresses the uncertainties and caveats of the methodology and the data used for the health endpoints estimations.

2 Methodology

2.1 Assessing health risk due to air pollution

A health risk assessment requires information on the risk function (concentration-response function, CRF), the pollution concentrations for the exposed population, and the baseline frequency of the health outcome. The risk function relates concentration to risk of death or disease, and it is typically based on relative risk estimates provided by epidemiological studies. In epidemiological terms, the relative risk indicates the likelihood of an exposed group to experience a health outcome relative to a group that is not exposed. In practical terms, the relative risk is the change in the incidence of the health outcome per unit of concentration for those at risk. Thus, an RR of 1.00 implies that the risk is identical in the exposed and not exposed groups. If RR is greater than 1.00 then the risk is increased in the exposed group. The risk of exposure to air pollution in a population is typically estimated by an average concentration level. For European air pollution levels, the relative risk in a population whose exposure is estimated by an average concentration (RR_C) can be described as a log-linear function (Ostro, 2004) and specified as follows:

$$RR_C = \exp\left[\beta\ (C - C_0)\right] \qquad [1]$$

where, *C* is the concentration level the population is exposed to, C_0 the baseline concentration, and β is the concentration-response factor. C_0 can either be the background concentration (i.e., the level that would exist without any human-made pollution), a concentration below which no health effects are expected, or a counterfactual concentration level. β can be estimated based on a *CRF* recommended by epidemiological studies. Assuming the same log-linear approach behaviour, β can be estimated as follows:

$$\beta = \frac{\log(CRF)}{UC} \quad [2]$$

where *UC* is the unit of concentration. The value for the CRF depends on the pollutant and health outcome one wants to estimate. The epidemiological studies also quantify the variability of the CRF, by assessing random errors related to the study, providing confidence intervals (CIs) around a central value for the recommended CRF.

The contribution of a risk factor to a disease or a death can be estimated by means of population attributable fraction (PAF). PAF is defined as the proportional reduction in population disease or mortality that would occur if exposure to a risk factor were reduced to an alternative ideal exposure scenario. Assuming that the population is exposed to a single concentration level over the assessed period, PAF can be calculated from the relative risk as follows:

$$PAF = \frac{RR_C - 1}{RR_C} \qquad [3]$$

Finally, the health outcomes can be estimated by multiplying the PAF with a baseline incidence of the given health effect. Thus, the health outcome attributable to air pollution is estimated by:

$$health\ outcome = MR \cdot PAF \cdot Pop \qquad [4]$$

Where *MR* is the baseline incidence of the health effect expected for the population amount *Pop*.

2.2 Health endpoints

The health risk assessment presented in the Air Quality in Europe reports focuses on estimating PD and YLL as mortality-related health outcomes. PD are deaths that occur before a person reaches an expected age, thus considered to be preventable if their cause is eliminated. The so-called expected age is usually the life expectancy for a country typically stratified by sex and age. Based on Equation 4, the PD metric is estimated assuming the baseline incidence as the crude death rates by sex (s) and age (a) $CDR_{a,s}$:

$$PD = \sum_{a,s} CDR_{a,s} * PAF * Pop \qquad [5]$$

CDR is the number of deaths in a particular population due to a specific cause and is typically available from demographic datasets.

YLL is defined as the years of potential life lost due to premature death. It is an estimate of the average number of years that a person would have lived if the person had not died prematurely. YLL takes into account the age at which deaths occur and is greater for deaths at a younger age and lower for deaths at an older age (Murray and Lopez, 1996). It gives, therefore, more nuanced information than the number of PD alone. YLL is determined by relating PD with life expectancy (*LE*) by sex and age.

$$YLL = \sum_{a,s} PD \cdot LE_{a,s} \qquad [6]$$

LE is the average time a person is expected to live, based on the year of their birth, their current age and other demographic factors including sex. This statistical measure is typically available from demographic datasets.

3 Input data and preparatory steps for EEA´s health risk assessment

The health risk assessment for 41 countries across Europe presented here and in EEA (2019) are based on gridded data: ambient air concentrations and population density data. Thus, the estimation is done for each grid cell and then aggregated per country (or group of countries).

3.1 Ambient air concentrations

To estimate health endpoints due to exposure to air pollution, concentration maps with annual statistics of the relevant pollutant metric are produced on a 1*1 km^2 grid resolution for the whole Europe. The annual statistics are estimated using a mapping method ('Regression – Interpolation – Merging Mapping') that combines the monitoring data from rural and urban background stations for $PM_{2.5}$, O_3 and NO_2 with results from the EMEP chemical transport model and other supplementary data, such as altitude, meteorology, and population density (Horálek et al., 2016) using linear regression model followed by kriging of its residuals. For NO_2, and since 2017 maps also for $PM_{2.5}$, urban traffic station data was also included to take into account hotspots, since traffic is the most important source of NO_2 and an important source of PM. In this methodology, separate rural and urban background (and for NO_2 and $PM_{2.5}$ also urban traffic) map layers are created separately and subsequently merged into the final map. The readers are referred to ETC/ACM (2017a, 2017b, 2019) and ETC/ATNI (2020) for details on the methodology to obtain annual statistics on concentration maps. The maps, which are based on both monitoring and modelling data for the actual year, are available for several years, including 2016 and 2017, as used in Chapter 4. A caveat for the concentration maps is the exclusion of overseas territories such as Madeira, Azores, Canary Islands, French Guiana, Guadeloupe, Martinique, Mayotte and Réunion. In this report, the final merged maps in 1*1 km^2 grid resolution are used as input data. Potentially, separate map layers might be taken into account.

3.2 Population

The population density map used for estimating annual statistics referred to in Section 3.1 is based on the GEOSTAT 2011 dataset (Eurostat, 2014), and is mapped on the same grid resolution as the ambient air concentrations, facilitating the health outcomes estimation. To make use of the population density available, the GEOSTAT 2011 population data was scaled with the total population data available country-wise from Eurostat (Eurostat, 2019a), for 2016 and 2017. The data reflects the total population on the 31st of December of the indicated year reported by the National Statistical offices. The scaling of the population (scaled pop) was done, for years 2016 and 2017, by applying the following:

$$scaled\ pop_i = pop_i \times \frac{pop_{c\_Eurostat}}{pop_c} \qquad [7]$$

where pop_i is the population in the i^{th} grid cell for country *c* in the population density map (corresponding to 2011), pop_c is the total population for country *c* calculated based on the population density map (again corresponding to 2011), and $pop_{c\_Eurostat}$ is the total population reported to Eurostat for country *c* for years 2016 or 2017.

For sake of data completeness and compatibility between the GEOSTAT 2011 and the Eurostat population data, the following steps were taken:

1) The Eurostat data is available for all countries across Europe for 2016, but not available for Andorra and Monaco in 2017. Gap filling was done by extrapolating to 2017 the last 5 years of data available in the Eurostat database for both countries.

2) Since the concentration maps do not include overseas territories, population data for those territories need to be excluded from the original Eurostat data:
   - France (metropolitan) population, which excludes the overseas territories, was only reported up to 2013. After 2013, the total France population reported included the overseas territories. The data for France (metropolitan) population in 2016 and 2017 were obtained by extrapolating the last 5 years of data available for total France and France (metropolitan) population (2009-2013).
   - Population living in the Canary Islands, Spain, was removed from the national total population. The population living in both territories were obtained from the National Statistics office (INE-E, 2019).
   - Population living in Madeira and Azores, Portugal, was removed from the national total population. The population living in the three territories were obtained from the National Statistics office (INE-P, 2019).

3) The GEOSTAT 2011 Cyprus population data includes both Greek Cypriots and Turkish Cypriots. The Eurostat data includes only Greek Cypriots. Turkish Cypriot data (SPO, 2016) were added to the total presented in Eurostat.

The extrapolating referred above and onward was done following the equations below:

$$a = \bar{y} - b\,\bar{x} \quad [8]$$

$$b = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sum (x-\bar{x})} \quad [9]$$

where *a* is the population (or life expectancy in Section 3.3) to be predicted for a specific year, *y* are the population (or life expectancy in Section 3.3) values for the last 5 years that data is available for, x the corresponding years , and $\bar{x}$ and $\bar{y}$ the respective means.

3.3 Demographic data

Mortality data for premature deaths (see Equation 5) was obtained from WHO (WHO, 2019) database. WHO mortality data is described by year, sex, age (1-yr interval up to 4 years old, 5 years intervals between 5-95 years old, and 95+ years old) and cause of death. The data was compiled from the ICD10 Mortality Tabulation List, the latest tabulation existing for mortality data. The data is available from 1990's to 2017, depending on the countries. Country-wise data was compiled following the procedure described below:

1) Choose country codes 3080 (Cyprus), 3400 (Turkey), and all other codes with 4 digits starting with a 4, e.g. 4005 for Albania. The countries, and respective country code, for which data is available are described in Table 1. However, mortality data is missing for some European countries. In order to gap-fill the missing data, data from neighbouring countries with similar socio-economic characteristics was taken as a proxy. Table 3 shows the countries in need of gap-filling and the countries used as proxy.

2) Several lists of causes of death (condensed/detailed) from the revisions of the International Classification of Diseases are available. Codes 103 or 104 detailed lists were chosen for the study. Countries decide which list they use to describe their causes of death, either the detailed list of causes with a cause described with a 3-character code (103) or a 4-character code (104); Table 1, presents the list of causes of deaths by ICD revision adopted per country.

3) For the health outcomes, and according to the description of the CRFs, only natural deaths should be considered, thus some causes of deaths should be excluded: causes of death due to injury or poisoning, V01-Y89, and unknown and unspecified causes (R00-R99). Note that AAA, i.e. Total deaths all causes, should also be removed from the dataset, to avoid double counting.

4) In case the data is not available for 2016 or 2017, the data is extracted for the latest year available. Table 1 describes which year was available for the 2016 and 2017 estimations.

Table 1: List of country codes describing the European countries assessed in the WHO (2019) mortality data and respective ICD10 Mortality Tabulation List, in conjunction with the latest data available for 2016 and 2017 estimations

Country name	Country code	ICD10 Mortality Tabulation List	2016	2017
Austria	4010	104	2016	2017
Belgium	4020	104	2015	2015
Bosnia and Herzegovina	4025	103	2014	2014
Bulgaria	4030	104	2014	2014
Croatia	4038	104	2016	2016
Cyprus	3080	104	2016	2016
Czechia	4045	104	2016	2016
Denmark	4050	104	2015	2015
Estonia	4055	103	2016	2016
Finland	4070	103	2015	2015
France	4080	104	2015	2015
Germany	4085	104	2015	2015
Greece	4140	104	2015	2015
Hungary	4150	104	2016	2016
Iceland	4160	103	2016	2017
Ireland	4170	104	2015	2015
Italy	4180	104	2015	2015
Latvia	4186	104	2015	2015
Lithuania	4188	104	2016	2017
Luxembourg	4190	104	2015	2015
Malta	4200	104	2015	2015
Montenegro	4207	103	2009	2009
Netherlands	4210	104	2016	2016
North Macedonia	4195	103	2013	2013
Norway	4220	104	2016	2016
Poland	4230	104	2015	2015
Portugal	4240	104	2016	2016
Romania	4270	104	2016	2016
Serbia	4273	104	2015	2015
Slovakia	4274	104	2014	2014
Slovenia	4276	103	2015	2015

Country name	Country code	ICD10 Mortality Tabulation List	2016	2017
Spain	4280	104	2016	2016
Sweden	4290	104	2016	2016
Switzerland	4273	104	2015	2015
United Kingdom	4308	104	2015	2015

Life expectancy data is required for estimating YLL (see Equation 6). Life expectancy by age and sex is available from Eurostat database (Eurostat, 2019b); the data is available on a 1-year interval, from 0 to 85+ years old. In order to match WHO's mortality data age intervals, the life expectancy data needs to reflect the life expectancy of the 5-year interval average age, from 5 to 95+ years old. In order to estimate the life expectancy of the 5-year interval average age, the following steps were taken:

1) calculate the average age at death for each 5-year age interval based on the UN data on Abridged life tables by sex and age on country level (UN, 2019). The excel tables contain several data series for different periods and projection scenarios, described in three tabs. To be coherent with previous Air Quality in Europe reports, the data was taken from tab named 'ESTIMATES' and the period 2015-2020 was considered for the average number of years lived and the number of deaths. The data is available for the same age interval as WHO mortality data from 5 years old and two other intervals: 0 to 1 years old and 1 to 4 years old. The average age at death ($ageD_{i,s,c}$) for age interval *i*, sex *s* and country *c* was calculated by summing the lower limit of the age interval ($age_{i,s,c}$) and UN estimate for the average number of years lived ($AvgY_{i,s,c}$) at the correspondent age interval *i,* sex *s* and country *c* by applying the following:

$$ageD_{i,s,c} = AvgY_{i,s,c} + age_{i,s,c} \quad [10]$$

For interval 0 to 4 years old, Equation 10 was used to calculate the average age at death between 0 and 1 years old for sex *s* and country *c*. The average age at death for interval 0 to 4 years old ($ageD_{0-4}$) was then calculated as follows:

$$ageD_{0-4,s,c} = ageD_{0-1,s,c} * \left(\frac{nD_{0-1,s,c}}{nD_{0-1,s,c} + nD_{1-4,s,c}}\right) + \left(1 + ageD_{1-4,s,c}\right) * \left(\frac{ageD_{1-4,s,c}}{nD_{0-1,s,c} + nD_{1-4,s,c}}\right) \quad [11]$$

with $nD_{0-1,s,c}$ as the UN estimate for the number of deaths at age 0 to 1 years old for sex *s* and country *c*, and $nD_{1-4,s,c}$ as the UN estimate for the number of deaths for age interval from 1 to 4 years old for sex *s* and country *c*.

2) calculate the life expectancy corresponding to the average age of death for age interval *i*, for sex *s* and country *c* ($LEcal_{i,s,c}$) , applying the following formulation:

$$LEcal_{i,s,c} = LE_{ageB,s,c} + \left(LE_{ageB,s,c} - LE_{ageA,s,c}\right) * \left(ageD_{i,s,c} - age_{ageB,s,c}\right) \quad [12]$$

where $LE_{ageB,s,c}$ and $LE_{ageA,s,c}$ are the Eurostat life expectancy values for the 1-yr age intervals (i) for sex *s* and country *c* between the average age at death on the 5 year interval estimated via Equations 10 and 11, where $ageB$ and $ageA$ are the 1-year interval below and above the average age at death, respectively. Table 2 shows how to calculate Average age at death based on Dutch female population data (UN, 2019).

Table 2: Example on how to calculate average age of death for 0-4 interval and other 5-year age interval based on the 'Number of deaths' and 'Average number of years lived' for a specific sex, age and country.

Age ($age_{i,s,c}$)	Age interval	Number of deaths	Average number of years lived ($AvgY_{i,s,c}$)	Average age at death ($ageD_{i,s,c}$, Equation 10)
0	1	310	0.06	0.06
1	4	62	1.52	2.52
5	5	36	2.50	7.50
10	5	45	2.50	12.50
Age	**Age interval**			**Average age at death ($ageD_{0-4,s,c}$, Equation 11)**
0 ($ageD_{0-1,s,c}$)	1	310 ($nD_{0-1,s,c}$)	0.06	
1 ($ageD_{1-4,s,c}$)	4	62 ($nD_{1-4,s,c}$)	1.52	
0-4 ($ageD_{0-4,s,c}$)	5			0.47

3) For groups between 90-95 and 95+ years old, the data is obtained by extrapolating the values based on the last five 5-year interval for $LEcal_{i,s,c}$ (see Equation 8 and 9).

4) For countries lacking demographic data in 2016 and 2017, neighbouring countries with similar socio-economic characteristics were taken as a proxy. Table 3 shows the countries in need of gap-filling and the countries used as proxy.

Table 3: Countries in need of mortality data gap-fill and respective proxies

Country to gap-fill	Proxy
Lichtenstein	Austria
San Marino	Italy
Andorra **Monaco**	France
Cyprus	Greece
Albania **Bosnia and Herzegovina** **Montenegro** **North Macedonia** **Kosovo under UNSCR 1244/99**	Serbia

3.4 Concentration response functions

The CRFs recommended by the WHO in their HRAPIE project report (WHO, 2013) were applied in the cost-benefit analysis for the European Commission (Holland 2014), and have been applied since for health risk assessment estimated by the EEA. The HRAPIE recommendations group the effects according to the uncertainty related to the CRF and the availability of the baseline health data. A group is labelled with an A if enough data are available for quantification of the effects; a group is labelled with a B if there is more uncertainty when quantifying the same effects. Further, HRAPIE marked the pollutant-outcome pairs contributing to the total effect, i.e. it is assumed that their effects are additive, with an asterisk (*). All CRFs applied in this study describe the effect of long-term exposure on total all-cause (natural) mortality. The HRAPIE report also states that recommendations provided for CRFs are given as a relative risk (RR) for an increase of 10 µg/m^3, where it is assumed that the concentration changes (see Equation 1) are relatively low.

Table 4 shows the recommended RR for mortality with 95% confidence interval (CI), including the baseline concentration taken into consideration when calculating the health outcomes for each air pollutant. The baseline concentration (C_0) described in Equation 1 is also presented in Table 4 for $PM_{2.5}$ and NO_2 annual means; for O_3, SOMO35, the annual sum of daily maximum running 8-h average O_3 concentrations above 35 ppb across a whole year, is used instead of O_3 concentrations minus baseline concentration, thus in the calculation of RR_C using Equation 1, $(C - C_0)$ term is SOMO35 divided by the number of days in the year of the calculation.

Table 4: Risk ratios (RR) linking exposure to $PM_{2.5}$, NO_2 and O_3 and mortality, their associated 95% confidence interval (CI) and baseline concentrations (modified from WHO, 2013)

Pollutant	RR (95% CI) per 10 µg/m^3	Health outcome	Grouping of effects
$PM_{2.5}$	1.062 (1.040 – 1.083) C_0 = 0 µg/m^3	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	A*
O_3	1.0029 (1.0014 – 1.0043) C_0 = 35 ppb	All-cause (natural) mortality in all ages (ICD-10 codes A00-R99).	A*
NO_2	1.055 (1.031 - 1.08) C_0 = 20 µg/m^3	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	B*

Note that relative risk estimations due to exposure to ambient air concentration levels in 2016 and 2017 (Equation 1), take the central value of the confidence interval for the recommended CRFs into account. However, for estimating the uncertainties of the calculations related to the choice of CRF, minimum and maximum values of the confidence interval were also used and the results are presented in Section 7.

4 Health risk assessment in Europe for 2016 and 2017

The health risk assessment related to $PM_{2.5}$, NO_2, and O_3 for 2016 is presented in the Air Quality in Europe – 2019 Report (EEA, 2019) and for 2017 is presented in Tables 5 and 6 for 41 European countries. These tables show the population-weighted concentration, the estimated number of premature deaths (Table 4), and the number of YLL, and the YLL per 100 000 (Table 6) attributed to exposure to $PM_{2.5}$, NO_2 and O_3 concentration levels in 2017.

In the 41 countries listed, 423 000 PD are attributed to $PM_{2.5}$ exposure; 72 000 PD are attributed to NO_2; and 16 300 PD to O_3 exposure. In the EU-28, the PD attributed to $PM_{2.5}$, NO_2 and O_3 exposure are 385 000, 69 000, and 15 000, respectively. In the 41 countries assessed, 4 682 000 YLL are attributed to $PM_{2.5}$ exposure, 772 000 to NO_2 exposure, and 184 000 to O_3 exposure, translating into 871, 144, and 34 YLL per 100 000 inhabitants attributed to $PM_{2.5}$, NO_2, and O_3 exposure, respectively. In the EU-28, the YLL attributed to $PM_{2.5}$, NO_2 and O_3 exposure are 4 276 000, 740 000, and 171 000, respectively, translating into 846, 146 and 34 YLL per 100 000 inhabitants.

The largest health risks, PD and YLL, attributable to $PM_{2.5}$, are estimated for the countries with the largest populations (Germany, Italy, Poland, France, and the United Kingdom). However, in relative terms, when considering YLL per 100 000 inhabitants, the largest risks are observed in central and eastern European countries where the highest concentrations are also observed, i.e. Kosovo, Serbia, Bulgaria, Albania and North Macedonia. The lowest relative risks are found in the countries at the northern and north-western parts of Europe: Iceland, Norway, Sweden, Ireland and Finland. This typically reflects the lowest average population weighted concentrations.

For NO_2, the highest risks from exposure are seen in Italy, Germany, Spain, the United Kingdom and France. When considering YLL per 100 000 inhabitants, the highest rates are found in Greece, Monaco, Serbia, Italy, and Spain, and the lowest (< 1) are found in Estonia, Finland, Lithuania, Malta, Sweden, Iceland, Liechtenstein, and San Marino.

Regarding O_3, the countries with the largest risks are Italy, Germany, Spain, France and Poland, while the highest rates of YLL per 100 000 inhabitants are in Albania, Croatia, Montenegro, Slovenia, and Italy. The countries with less risk are Iceland, Ireland, Norway, the United Kingdom and Finland.

Table 5: Premature deaths attributable to $PM_{2.5}$, NO_2 and O_3 exposure in 41 European countries and the EU-28, 2017

		$PM_{2.5}$		**NO_2**		**O_3**	
Country	**Population (1 000)**	**Annual mean [a]**	**Premature deaths [b]**	**Annual mean [a]**	**Premature deaths [b]**	**SOMO35 [a]**	**Premature deaths [b]**
Austria	8 773	12.3	5 600	18.9	1 000	5311	330
Belgium	11 352	12.5	7 400	20.9	1 500	2553	210
Bulgaria	7 102	22.4	13 100	19.2	1 300	3938	330
Croatia	4 154	17.6	4 800	15.6	300	7110	270
Cyprus	1 194	15.7	660	19.6	100	6029	40
Czechia	10 579	17.1	9 900	15.2	260	4307	350
Denmark	5 749	8.5	2 500	8.8	30	1711	70
Estonia	1 316	5.4	460	6.3	< 1	1462	20

		$PM_{2.5}$		NO_2		O_3	
Country	**Population (1 000)**	**Annual mean ([a])**	**Premature deaths ([b])**	**Annual mean ([a])**	**Premature deaths ([b])**	**SOMO35 ([a])**	**Premature deaths ([b])**
Finland	5 503	4.4	1 300	7.6	< 1	1153	40
France	63 465	10.6	31 500	16.9	7 100	3809	1 600
Germany	82 522	11.8	60 500	19.4	10 300	3182	2 200
Greece	10 768	30.0	19 000	23.6	4 300	4858	450
Hungary	9 798	18.8	12 900	17.8	1 100	5010	480
Ireland	4 784	6.2	1 000	9.3	20	1418	30
Italy	60 589	17.0	59 800	22.1	15 700	7405	3 600
Latvia	1 950	9.5	1 400	11.1	30	1557	30
Lithuania	2 848	10.3	2 200	10.8	< 1	1417	40
Luxembourg	591	10.0	210	19.5	30	3001	10
Malta	460	11.8	220	16.0	< 1	6174	20
Netherlands	17 082	11.3	9 200	20.2	1 500	2281	260
Poland	37 973	21.4	44 800	14.9	1 500	3111	920
Portugal	9 749	9.1	5 300	16.2	770	3914	310
Romania	19 644	17.9	24 900	18.8	3 500	3885	760
Slovakia	5 435	18.8	5 100	14.7	40	4861	190
Slovenia	2 066	16.2	1 700	16.2	110	7035	100
Spain	44 286	12.0	26 000	21.6	9 500	5600	1 700
Sweden	9 995	5.0	2 500	7.7	< 1	1641	110
United Kingdom	65 844	9.3	31 100	19.9	8 800	1210	560
Albania	2 877	23.1	5 300	16.9	290	6898	220
Andorra	68	12.5	40	20.5	< 1	5182	< 1
Bosnia and Herzegovina	3 510	22.6	4 400	15.7	190	6967	190
Iceland	338	5.1	60	10.2	< 1	782	< 1
Kosovo	1 784	28.6	4 000	15.6	60	4930	100
Liechtenstein	38	9.4	20	18.2	< 1	5045	< 1
Monaco	38	13.2	20	26.8	10	8223	< 1
Montenegro	622	18.6	580	13.5	< 1	6787	30
North Macedonia	2 074	36.3	3 500	19.8	180	4248	60
Norway	5 258	5.2	1 200	10.4	80	1448	40
San Marino	33	14.2	30	14.5	< 1	7192	< 1
Serbia	7 040	28.2	15 500	20.6	1 800	4293	340
Switzerland	8 420	9.9	3 600	18.8	520	5281	270

		$PM_{2.5}$		NO_2		O_3	
Country	**Population (1 000)**	**Annual mean ([a])**	**Premature deaths ([b])**	**Annual mean ([a])**	**Premature deaths ([b])**	**SOMO35 ([a])**	**Premature deaths ([b])**
EU-28	505 571	13.3	385 000	16.0	69 000	3 748	15 000
Total	537 671	14.63	423 000	16.34	72 000	4 201	16 300

Notes: ([a]) The annual mean (in µg/m^3) and the SOMO35 (in µg/m^3.days), expressed as population-weighted concentration, is obtained according to the methodology described by ETC/ACM (2019a) and references herein and not only from monitoring stations. ([b]) Total and EU-28 PD are rounded to the nearest thousand (except for O_3, nearest hundred). The national totals are rounded to the nearest hundred or ten.

Table 6: Years of life lost (YLL) attributable to $PM_{2.5}$, NO_2 and O_3 exposure in 41 European countries and the EU-28, 2017

	$PM_{2.5}$		NO_2		O_3	
Country	**YLL[(a)]**	**YLL/10^5 inhab. [(b)]**	**YLL[(a)]**	**YLL/10^5 inhab. [(b)]**	**YLL[(a)]**	**YLL/10^5 inhab. [(b)]**
Austria	55 700	635	10 500	120	3 500	40
Belgium	81 200	715	16 500	145	2 400	21
Bulgaria	147 400	2 076	14 500	204	3 900	55
Croatia	50 500	1 216	3 200	77	3 000	72
Cyprus	6 500	544	990	83	370	31
Czechia	113 600	1 074	3 000	28	4 100	39
Denmark	27 500	478	320	6	790	14
Estonia	5 700	433	< 1	< 1	210	16
Finland	14 800	269	< 1	< 1	540	10
France	367 000	578	82 700	130	19 100	29
Germany	641 500	777	109 000	132	24 600	30
Greece	186 300	1 730	42 400	394	4 600	43
Hungary	152 600	1 558	13 600	139	5 900	60
Ireland	11 900	249	270	6	400	8
Italy	594 900	982	156 100	258	37 500	62
Latvia	17 400	892	420	22	410	21
Lithuania	25 500	895	10	< 1	500	17
Luxembourg	2 400	406	380	64	100	17
Malta	2 600	565	20	< 1	210	47
Netherlands	98 700	578	16 200	95	2 900	17
Poland	596 200	1 570	20 600	54	12 800	34
Portugal	56 800	583	8 300	85	3 500	36

	$PM_{2.5}$		NO_2		O_3	
Country	**YLL[(a)]**	**YLL/10^5 inhab.[(b)]**	**YLL[(a)]**	**YLL/10^5 inhab.[(b)]**	**YLL[(a)]**	**YLL/10^5 inhab.[(b)]**
Romania	298 200	1 518	41 600	212	9 600	49
Slovakia	65 100	1 198	530	10	2 500	46
Slovenia	21 100	1 021	1 400	68	1 300	63
Spain	286 000	646	104 700	236	19 000	43
Sweden	23 400	234	10	< 1	1 100	11
United Kingdom	325 000	494	92 300	140	6 200	9
Albania	55 100	1 915	3 100	108	2 100	73
Andorra	460	675	50	73	20	27
Bosnia and Herzegovina	49 500	1 410	2 200	63	2 000	57
Iceland	650	192	< 1	< 1	10	3
Kosovo	41 600	2 332	600	34	930	52
Liechtenstein	190	503	< 1	< 1	10	27
Monaco	270	709	130	341	20	52
Montenegro	7 500	1 205	30	5	420	68
North Macedonia	39 600	1 910	2 000	96	780	38
Norway	11 400	217	810	15	450	9
San Marino	280	843	< 1	< 1	20	61
Serbia	161 800	2 298	18 500	263	3 700	52
Switzerland	37 800	449	5 400	64	2 900	35
EU-28	4 276 000	846	740 000	146	171 000	34
Total	4 682 000	871	772 000	144	184 000	34

Note: [(a)] Total and EU-28 figures are rounded to the nearest thousand. National data are rounded to the nearest hundred or tenth. [(b)] Total and EU-28 values per 100 000 inhabitants are not rounded.

Comparing the estimations for 2017 with those for 2016 presented in EEA (2019), a slight increment can be seen for the PD and a higher increment for the YLL. This is due in part to the fact that life expectancy has increased for all countries much more in 2017 compared to 2016 than in 2016 compared to 2015.

5 Benefit analysis for $PM_{2.5}$

$PM_{2.5}$ is the pollutant with the highest health impact in terms of mortality, with the health risks of exposure at current $PM_{2.5}$ concentrations in 2017 presented in Section 4. This section presents the results of a hypothetical assessment of the potential health benefits of meeting the WHO AQG for $PM_{2.5}$ across Europe. For the current estimation, calculations of PD and YLL were made based on the assumption that all $PM_{2.5}$ concentrations for 2017 over 10 µg/m^3 are at 10 µg/m^3, while the concentrations below 10 µg/m^3 remain unchanged. The rest of the methodology was followed as explained in Sections 2 and 3.

The estimated benefit presents the expected minimum benefit of complying with the annual WHO AQG for $PM_{2.5}$ everywhere in Europe. This is so because the set of measures required to bring down concentrations above the WHO AQG would also further reduce concentrations elsewhere, including in some areas currently below 10 µg/m^3. With the methodology applied, these additional benefits are not considered, probably underestimating then the actual benefit of implementing the necessary set of measures to reach the $PM_{2.5}$ WHO AQG everywhere in Europe.

In the estimated scenario meeting the WHO AQG for $PM_{2.5}$ across Europe, PD and YLL in the EU-28 would decrease by 30 % and 31 %, respectively, while PD and YLL in the 41 European countries would decrease by 32 %, when compared with the current results for 2017 (Table 7). Consequently, it is estimated that the EU-28 and all the 41 European countries would have benefits of 115 000 and 135 000 fewer PD, respectively, when compared with the status in 2017. The benefits would be higher in those countries where concentrations are well above the WHO AQG for $PM_{2.5}$, compared to countries where concentrations are close to the WHO AQG for $PM_{2.5}$.

Table 7: Premature deaths and years of life lost attributable to $PM_{2.5}$ exposure in 41 European countries and the EU-28 in 2017, with and without attaining the WHO AQG of 10 µg/m^3 across Europe

		without attainment	**with attainment**
EU-28	Premature deaths	385 000	270 000
	Year of Life Lost	4 276 000	2 975 000
Total	Premature deaths	423 000	288 000
	Year of Life Lost	4 682 000	3 164 000

6 Sensitivity analysis of the health risk assessments to baseline concentrations

The recommendations from the HRAPIE report (WHO, 2013) indicate that the quantification of long-term effects of $PM_{2.5}$ should be estimated for all the concentration levels; for NO_2, annual levels above 20 µg/m^3, and for daily maximum running 8-h average O_3 concentrations above 35 ppb. The results using those recommendations are presented in Section 4. In order to assess how sensitive these estimations are to different baseline concentrations (C_0), additional calculations were undertaken following the same methodology as described in Sections 2 and 3, but with the following baseline concentrations: 2.5 µg/m^3 for $PM_{2.5}$ and 10 µg/m^3 for NO_2, and using SOMO10 (the annual sums of daily maximum running 8-h average O_3 concentrations above 10 ppb across a whole year) for O_3. The rationale for choosing these baseline concentrations is the following: a) 2.5 µg/m^3 for $PM_{2.5}$ is because the European $PM_{2.5}$ background concentration level is estimated to be, on average, 2.5 µg/m^3 (ETC/ACM, 2017a); b) Raaschou-Nielsen et al. (2012) showed an increase in all-cause mortality when NO_2 concentrations were lower than 20 µg/m^3, with 10 µg/m^3 being the lowest value observed affecting the study participants; c) the HRAPIE report (WHO, 2013) recommends to use SOMO10 as an alternative to the assessment for this pollutant.

Table 8 summarises the estimation of the health risks with the new baseline concentrations (for $PM_{2.5}$ C_0=2.5 µg/m^3, for NO_2 C_0=10 µg/m^3, for O_3 SOMO10). These values should be compared with the values in Tables 5 and 6. The number of PD and YLL attributable to $PM_{2.5}$ exposure when including the full range of concentration $PM_{2.5}$ (i.e. C_0=0 µg/m^3) is around 17 % higher than when C_0=2.5 µg/m^3 for both EU-28 and all 41 countries.

For NO_2, the estimations for both PD and YLL assuming C_0=20 µg/m^3 are at least 3.3 times lower than when assuming C_0=10 µg/m^3. Finally, for O_3, estimating health impacts based on SOMO10 leads to PD and YLL estimations almost 5 times higher than when based on SOMO35.

Table 8: Estimated number of premature deaths and years of life lost attributable to $PM_{2.5}$ (C_0=2.5 µg/m^3), NO_2 (C_0=10 µg/m^3) and O_3 (for SOMO10), reference year 2017

		$PM_{2.5}$ (C_0 = 2.5)	**NO_2 (C_0 = 10)**	**O_3 (SOMO10)**
EU-28	Premature deaths	318 000	236 000	71 000
	Years of life lost	3 530 000	2 448 000	818 000
Total	Premature deaths	351 000	256 000	77 000
	Years of life lost	3 890 000	2 595 000	872 000

7 Uncertainties and Caveats

Every single step of the process to asses health risks due to air pollution exposure is associated with uncertainties. These uncertainties are linked to those uncertainties of the input data used (e.g. concentrations, population, demographic and health data) and the assumptions and simplifications of the methodology.

The estimated ambient air concentration levels for population exposure and for health risk assessment are very important for the assessment outcome. ETC/ACM (2019) and ETC/ATNI (2020) describes the uncertainty related to the concentration maps made available for the health risk assessment. In this report, concentration maps in 1x1 km^2 resolution are used as an input. In order to take into account the pollution variability in finer scale, separate map layers (namely the traffic one) used in the mapping process (Section 3.1) might be taken into account. Ideally, the same spatial resolution as in the data for epidemiological studies should be used. However, spatial scale used in the epidemiological studies is not always clear (Maihau et al., 2017).

The population and demographic data has uncertainties inherent to statistical products and processes and data completeness depends on the availability of raw data transmitted by the National Statistical Offices (ESS, 2012). This assessment is based on data collected by WHO, UN and Eurostat. Some level of inconsistency between the datasets for the different countries may be expected, as individual countries may have different methodologies to collect and treat the data or may not have reported data. The data used for some countries are not for the estimation year but for the latest year available (see Table 1), adding to the uncertainty of the results. Data gap-filling (e.g. using data associated to a different year or from neighbouring countries) adds to the data uncertainty.

The choice of CRF and its generalisation to other regions than the ones where the epidemiological study was done is an important source of uncertainty (WHO, 2013). The CRFs chosen have associated CIs quantifying the error and the variability associated with the epidemiological study. To estimate the health risk assessment uncertainties related to the CRFs recommended, we estimated the health outcomes based on the maximum and minimum value of the CIs associated to the recommended CRFs described in Table 4. This calculation shows that the uncertainty associated with the recommended CRF is ±32 % for $PM_{2.5}$, ±42 % for NO_2 and ±50 % for O_3, for 2017. Furthermore, assuming the same baseline incidence of a given health effect across all the grid cells within a country is also a source of uncertainty.

Currently, the quantification of health risks are done individually for each air pollutant, but they exhibit some degree of correlation, positive or negative. WHO (2013) warns against adding the health risks estimated for different air pollutants without adjusting the used CRFs. For example, adding the risks of $PM_{2.5}$ and NO_2 to estimate a total health risk may lead to a significant double counting. Conversely, only assessing health risks due to exposure to an air pollutant at the time does not reflect the impact of the mixture of pollutants that coexist in ambient air.

8 References

Beelen, R., et al., 2014, *Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project*, The Lancet, 383,785-795.

de Leeuw F. and Horálek J., 2016, *Quantifying the health impacts of ambient air pollution: methodology and input data*, European Topic Centre on Air Pollution and Climate Change Mitigation. ETC/ACM Technical Paper 2016/5 (https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etcacm_tp_2016_5_aq_hia_methodology), accessed 21 November 2019.

EEA, 2019, *Air quality in Europe - 2019 report*, EEA Report No 10/2019, European Environment Agency (https://www.eea.europa.eu/publications/air-quality-in-europe-2019) accessed 21 November 2019.

ETC/ACM, 2017a, *European air quality maps for 2014 — PM_{10}, $PM_{2.5}$, ozone, NO_2 and NO_x spatial estimates and their uncertainties*, Technical Paper 2016/6, European Topic Centre on Air Pollution and Climate Change Mitigation.

ETC/ACM, 2017b, Inclusion of land cover and traffic data in NO_2 mapping methodology, Technical Paper 2016/12, European Topic Centre on Air Pollution and Climate Change Mitigation.

ETC/ACM, 2019, *European air quality maps for 2016 — PM_{10}, $PM_{2.5}$, ozone, NO_2 and NO_x spatial estimates and their uncertainties*, Eionet Report – ETC/ACM 2018/8, European Topic Centre on Air Pollution and Climate Change Mitigation.

ETC/ATNI, 2020, *European air quality maps for 2017 — PM_{10}, $PM_{2.5}$, ozone, NO_2 and NO_x spatial estimates and their uncertainties*, Eionet Report – ETC/ATNI 2019/9, European Topic Centre on Air Pollution, Transport, Noise and Industrial Pollution. *(In preparation.)*

European Statistical System (ESS), 2012, *Quality Assurance Framework of the European Statistical System* (https://ec.europa.eu/eurostat/documents/3859598/5923349/QAF_2012-EN.PDF/fcdf3c44-8ab8-41b8-9fd0-91bd1299e3ef?version=1.0) accessed 10 October 2019.

Eurostat, 2014, 'GEOSTAT 2011 grid dataset. Population distribution dataset' (http://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography) accessed 10 October 2019.

Eurostat, 2019a, *Population change - Demographic balance and crude rates at national level*, (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en) accessed 26 September 2019.

Eurostat, 2019b, *Life expectancy by age and sex* (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_mlexpec&lang=en) accessed 10 October 2019.

Horálek, J., Kurfürst, P., Benešová, N., de Smet, P., de Leeuw, F., 2016, *European air quality maps of PM and ozone for 2013*. ETC/ACM Technical Paper 2015/5, European Topic Centre on Air Pollution and Climate Change Mitigation.

INE-E, 2019, *Población por país de nacimiento, edad (grandes grupos de edad) y sexo*, Instituto Nacional de Estadística (https://www.ine.es/jaxi/Tabla.htm?path=/t20/e245/p04/provi/l0/&file=0ccaa004.px&L=0) accessed 10 October 2019.

INE-P, 2019, *Resident population (No.) by Place of residence (NUTS - 2013), Sex and Age group,* Instituto Nacional de Estatística (https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&contecto=pi&indOcorrCod=0008273&selTab=tab0) accessed 10 October 2019.

Maihau, B. , Lefebvre, W. , Walton, H., Dajnak, D., Janssen, S., Williams, M., Blyth, L., Beevers, S., 2017. *Improved Methodologies for NO2 Exposure Assessment in the EU*, Report no.: 2017/RMA/R/1250, VITO, Belgium, https://ec.europa.eu/environment/air/pdf/NO2%20exposure%20final%20report.pdf accessed 06 April 2020

Murray, C.J. and Lopez, A.D, 1996, *The Global burden of disease : a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020 : summary*, World Health Organization, World Bank & Harvard School of Public Health (https://apps.who.int/iris/handle/10665/41864) accessed 1 October 2019.

OECD, 2016, *The Economic Consequences of Outdoor Air Pollution*, OECD Publishing, Paris (https://doi.org/10.1787/9789264257474-en) accessed 20 June 2019.

Ostro, B., 2004, *Outdoor air pollution: Assessing the environmental burden of disease at national and local levels*, WHO Environmental Burden of Disease Series no. 5, Geneva, World Health Organization.

Raaschou-Nielsen, O., Andersen, Z.J., Jensen, S.S. et al., 2012, *Traffic air pollution and mortality from cardiovascular disease and all causes: a Danish cohort study*. Environ Health 11, 60 (2012). (https://doi.org/10.1186/1476-069X-11-60) accessed 28 June 2019

SPO, 2016, *Economic and Social Indicators, State Planning Organisation* (http://www.devplan.org/Ecosos/BOOK/SEG-2016.pdf) accessed 10.09.2019

UN, 2019, 'Abridged Life Tables – Female/Male' (https://population.un.org/wpp/Download/Standard/Mortality/) last update 28.08.2019, last accessed 14 October 2019.

WHO, 2013, *Health risks of air pollution in Europe – HRAPIE project Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*, World Health Organization, Regional Office for Europe, Copenhagen.

WHO, 2019, *Mortality raw data*, last updated 01 May 2019 (https://www.who.int/healthinfo/statistics/mortality_rawdata/en/) accessed 26 September 2019.

European Topic Centre on Air pollution,
transport, noise and industrial pollution
c/o NILU – Norwegian Institute for Air Research
P.O. Box 100, NO-2027 Kjeller, Norway
Tel.: +47 63 89 80 00
Email: etc.atni@nilu.no
Web : https://www.eionet.europa.eu/etcs/etc-atni

The European Topic Centre on Air pollution, transport, noise and industrial pollution (ETC/ATNI) is a consortium of European institutes under a framework partnership contract to the European Environment Agency.

European Environment Agency
European Topic Centre on Air pollution,
transport, noise and industrial pollution