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Monetisation of health impacts calculated in the environmental burden of disease

Exploration of alternative approaches

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Summary

This report explores different approaches for an economic valuation of the environmental burden of disease (EBD) due to ambient air pollution and calculates the associated health costs for the results quantified by the EEA's EBD for the year 2022 (ETC HE Report 2024/6). This study, as usual in the EEA's EBD, assesses prevalent cases, that is the number of existing and new cases of a health effect in the study year.

Health costs can be defined as being composed of direct costs (health care costs), indirect costs (productivity loss) and intangible costs (utility loss). Direct and indirect costs are often referred to as cost of illness (COI). Studies that value health impacts of air pollution and other stressors typically start from the quantification of the change in incidence of disease, i.e. in the number of new cases in a given period (often a year), which is monetised using estimates of the average health cost of illness over its duration.

Air pollutant impacts on health are calculated by EEA using Disability adjusted Life Years (DALY). DALY are composed of years of life lost (YLL, the mortality component) and of years lived with disability (YLD, the morbidity component).

The focus on change in DALY rather than change in incidence requires adaptation of methods previously used in studies assessing monetised health benefits or health damage, to value the outputs of a burden of disease analysis as provided in the EEA's EBD work on air pollution. Air pollutant impacts on mortality are valued separately from morbidity. While mortality is valued using either the value of a statistical life year (VOLY, for YLL) or the value of statistical life (VSL, for total number of deaths), covering utility loss only, direct and indirect costs (such as medical expenditure, productivity loss…) would ideally apply to the YLD component.

This exploratory work tests alternative approaches for generating economic values, from a simple approach, valuing DALY with the VOLY, thus capturing only the utility loss, to then explore alternative approaches for a more comprehensive valuation, such as including COI.

Therefore, for the monetisation of DALY, three approaches are applied

1. YLL and YLD are valued using VOLY
2. YLL is valued using VOLY, YLD using incidence-based COI data
3. YLL is valued using VOLY, YLD using prevalence-based COI data

Results are calculated for all mortality health endpoints of the 2024 EEA/EBD analysis (ETC HE Report 2024/6) and for all morbidity health endpoints for approaches 1 and 2. Approach 3 for valuing morbidity required intensive literature and data research as well as testing. Results are calculated for two health endpoints as proof of concept: stroke (attributed to NO_2 and $PM_{2.5}$) and lung cancer.

Attributable deaths (AD) calculated for all-cause (natural) and cause-specific mortality are monetised using the VSL. Years of life lost (YLL) quantified for all-cause and cause-specific mortality are monetised by the VOLY. The VSL and VOLY based estimates are alternatives and are not to be added.

The report uses as core for VOLY (and consistent VSL) values that align with the earlier EEA work on health effects of exposure to noise (ETC HE Report 2023/11). A sensitivity analysis uses VSL (and consistent VOLY) estimates based on the most recent meta-analysis by the OECD (2025) on valuation of mortality.

For the incidence-based valuation of YLD data sets based on two different country studies are proposed. The core analysis relies on a set of consistent incidence-based life-time costs for the different morbidity health endpoints that is based on a UK study (Walton et al., 2025). The second data set used in a sensitivity analysis relies on a French study (SPF, 2025). This highlights the importance of country specific assumptions and factors in valuation.

For the prevalence-based valuation of YLD two European multi-country studies were identified that proposed prevalence costs for stroke for 32 European countries (Luengo-Fernandez, 2020) and for lung cancer for 27 European countries (Luengo-Fernandez, 2013).

Monetisation is carried out at the country level for the EEA-38 plus Andorra, Monaco and San Marino (referred to herein as "EEA41" region), by pollutant and monetary indicator, without distinction for age or gender. Region-wide average unit cost values of VOLY, VSL and VYLD (value of Year Lived with Disability) for EU27 and EEA41 are used. Region-wide results are presented in the core text, country specific results in the annexes.

The core and sensitivity values for the valuation of AD and YLL are given in the table below.

Values of VOLY and VSL in €$_{2022}$ for EU27 and EEA41

Region	VOLY	VSL
Core values (based on (ETC HE Report 2023/11)		
EU27	88 300	3 404 700
EEA41	84 400	3 251 900
Sensitivity values (based on OECD, 2025)		
EU27	136 900	5 275 200
EEA41	130 700	5 038 500

Comparison of the estimates for all-cause mortality for EU27 and EEA41, respectively by pollutant and mortality indicator (AD, YLL) show that the results for the sensitivity estimate based on OECD (2025) are 55 % higher than the results for the core analysis estimate based on the ETC HE Report 2023/11, as was to be expected from difference in the two VSL and VOLY values.

The core VYLD estimates based on the three approaches are summarised in the table below.

Core values of YLD (mid estimate) in €$_{2022}$ for EU27 and EEA41

	Approach 1		Approach 2		Approach 3	
EU27	**YLD valued with VOLY (core)**		**YLD valued based on incidence study (core)**		**YLD valued based on prevalence studies**	
	EU27	**EEA41**	**EU27**	**EEA41**	**EU27**	**EEA41**
Asthma, children	88 300	84 400	155 800	148 800		
Asthma, adults	88 300	84 400	180 600	172 500		
Chronic obstructive pulmonary disease	88 300	84 400	192 400	183 800		
Diabetes Type 2	88 300	84 400	327 700	313 000		
Ischemic heart disease	88 300	84 400	708 400	676 600		
Lung cancer	88 300	84 400	525 300	501 700	212 600	203 000
Stroke	88 300	84 400	159 000	151 900	99 900	95 400

A comparison of morbidity valuations was performed for the different approaches to valuing YLD. When YLD is valued with VOLY, only the disutility component of morbidity is accounted for, whereas the cost of illness components (health care costs and productivity loss) of morbidity are neglected.

All heath cost results presented in this report are accorded to the following rules: no round-off for any number below 1000; round-off to the nearest 10 for any number below 20,000; otherwise round-off to the nearest 100.

For NO_2 related health impacts results were as expected. The economic value of total health burden (DALY) was lower for the valuation of YLD with VOLY than with cost of illness based on incidence cost studies (see table below).

Total burden of disease (DALY) costs from exposure to NO2 and PM2.5 in million €2022 by region under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022([1])

NO_2			$PM_{2.5}$			Source values	Chapter reference
Health cost - central	Health cost - lower CI	Health cost - upper CI	Health cost - central	Health cost - lower CI	Health cost - upper CI		
EU27							
41 900	17 550	65 400	212 700	90 300	320 700	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
65 000	27 200	101 400	329 800	140 000	497 200	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
69 400	31 900	107 500	275 100	116 300	416 900	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based	chapter 4.1
EEA41							
70 500	30 200	108 100	223 900	95 500	336 300	DALY value= VOLY from ETC HE 2023/11	chapter 3.1
109 200	46 700	167 400	346 700	147 800	520 800	DALY value= VOLY consistent with OECD, 2025	chapter 3.2
121 900	57 100	185 700	289 700	123 000	437 600	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based	chapter 4.1

CI, 95% confidence interval

This was different for $PM_{2.5}$. Monetised DALY results were highest when valuing YLD by the VOLY consistent with the VSL from OECD (2025). This appeared counter-intuitive on first sight, because the incidence-based unit costs for YLD are higher than the VOLY estimates. The reason for the different patterns between NO_2 and $PM_{2.5}$ is, however, related to how the costs per outcome (which combine number of incidents and their costs) are distinguished within each pollutant when applying a uniform cost per VYLD (VOLY) versus the differential costs per VYLD (incidence based VYLD)([2]).
Finally, the DALY results for stroke and lung cancer were compared for the different approaches to valuing YLD. Except for the valuation of YLD by the VOLY based on OECD (2025), the results proved to be relatively close across the different approaches. The estimate based on the VOLY from ETC HE 2023/11 was the lowest, as could be expected.

The purpose of this report being to explore approaches to valuing EBD, all results are to be considered as preliminary and subject to change in case that the approaches are refined and the values updated.

([1]) Results are presented for the EBD estimates for 2022 (ETC HE, 2024/6) corresponding to the scenario which is named "Baseline from WHO 2021 AQG" in that report.
([2]) For instance, consider diabetes (high cost per YLD) and stroke (half the cost per YLD compared to diabetes). For NO_2, the attributable YLD related to diabetes are twice as large as the YLD associated with stroke, whereas for $PM_{2.5}$, the number of attributable YLDs are the same for both health outcomes. Naturally, this will influence the relative change in the estimation of the total cost (sum across outcomes) of each pollutant when assuming a uniform cost per YLD versus a differential cost per YLD.

1 Introduction

The EEA annually publishes environmental burden of disease estimates of air pollution (EBD), quantifying health effects associated with ambient air pollution exposure of the European population to fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2) and tropospheric ozone (O_3). In these studies, prevalent cases, that is the number of existing and new cases of a health effect in the respective study year are assessed.

In the 2024 EBD analysis for the base year 2022 (ETC HE, 2024/6), the following health effects were considered.

- For all-cause mortality and for chronic obstructive pulmonary disease attributable to O_3
  - attributable deaths (AD) and years of life lost (YLL)
- For 6 cause-specific health endpoints attributable to $PM_{2.5}$ (diabetes mellitus, asthma in children, ischemic heart disease, stroke, chronic obstructive pulmonary disease, lung cancer); and for 3 cause-specific health endpoints attributable to NO_2 (diabetes mellitus, asthma in adults, stroke);
  - attributable deaths (AD) and years of life lost (YLL) as mortality outcomes
  - years lived with disability (YLD) as morbidity outcomes
  - disability-adjusted life years (DALYs, calculated as the sum of YLL and YLD) for mortality and morbidity

In 2025, EEA invited its European Topic Centre on Human health and Environment (ETC HE) to explore approaches for an economic valuation of the EBD and to calculate health costs for the EBD results quantified for the year 2022.

Health costs are often defined as being composed of direct costs (health care costs), indirect costs (productivity loss) and intangible costs (utility loss) (see for example Hunt et al., 2016, OECD, 2017; SPF, 2025). The sum of direct and indirect costs is often referred to as cost of illness (COI). Health cost studies provide information on these to varying degrees, with almost all providing data on direct costs, some providing also indirect costs, but few providing information on utility losses.

Studies that value health impacts of air pollution and other stressors typically start from the quantification of the change in incidence of disease, i.e. in the number of new cases in a given period (often a year), which is monetised using estimates of the average cost of illness over its duration. Air pollutant impacts on mortality are valued separately from morbidity, using either the value of a statistical life year (VOLY) or the value of statistical life (VSL).

VSL is an economic measure used to value reductions in mortality risk across a population. It represents the amount society is willing to pay to prevent one statistical death, based on aggregated willingness to pay (WTP) for small decreases in mortality risk. VSL is typically used in policymaking for broad measures impacting public safety, environmental protection, and health regulations. It offers a single, age-neutral statistical valuation of life, but it does not account for remaining life years or health status. VOLY measures the economic value of an additional year of life expectancy, representing how much people are willing to pay to extend their lifespan incrementally. This approach is particularly useful in health care and public health contexts where policies or interventions aim to improve health outcomes or extend life expectancy, rather than directly reduce mortality risk. VOLY allows for age and quality-of-life sensitivity, focusing on the value of each additional year rather than the entire life. This makes VOLY especially relevant in scenarios where extending life by smaller increments is the primary objective.

The focus on change in DALY rather than change in incidence requires adaptation of methods previously used in studies assessing monetised health benefits or health damage, to value the outputs of a burden of disease analysis as provided in the EEA's EBD work on air pollution.

DALYs are composed of years of life lost (YLL) and of years lived with disability (YLD). While the YLL component is frequently monetised using the VOLY covering utility loss only, direct and indirect costs (such as medical expenditure, productivity loss) would apply to the YLD component.

For this exploratory work, EEA wished to test alternative approaches, from a simple approach, valuing DALY by VOLY, thus capturing only the utility loss when monetising the prevalence based DALYs, to then explore alternative approaches for a more comprehensive valuation, such as including COI (see section 1.1). In this work, AD are valued using the VSL and YLLs using the VOLY.

1.1 Alternative approaches to valuation studied

It was decided to use a set of different approaches to value the EBD 2022 results. For the monetisation of DALY, three approaches are applied

1. YLL and YLD are valued using VOLY
2. YLL is valued using VOLY, YLD using incidence-based COI data (i.e. the COI part of the overall lifetime costs is used and disutility related to morbidity is also included).
3. YLL is valued using VOLY, YLD using prevalence-based COI data (i.e. the COI part of the overall prevalence costs is used and disutility related to morbidity is also included)

AD calculated for all-cause (natural) and cause-specific mortality are monetised using the VSL. Two options for the VSL value are calculated. YLL quantified for all-cause and cause-specific mortality are monetised by the VOLY. Two options are provided also for the value of a VOLY. In both cases, the first option aligns with the values in the ETC HE Report 2023/11, the second with those in OECD (2025).

Results are calculated for all mortality health endpoints of the 2024 EEA/EBD analysis and for all morbidity health endpoints for approaches 1 and 2.

Approach 3 to valuing morbidity required intensive literature and data research as well as testing. Results are calculated for two health endpoints as proof of concept. The two health endpoints chosen are stroke and lung cancer. Complementary values for the remaining health endpoints could be developed in later work.

Monetisation is carried out at the country level for the EEA-38 plus Andorra, Monaco and San Marino (referred to herein as “EEA41” region), by pollutant and monetary indicator, without distinction for age or gender. Region-wide average unit cost values (for VOLY, VSL and VYLD) for EU27 and EEA41 are used. Recommendations for when country-specific or regionally-averaged cost data are best used are discussed.

There are areas in this work where recommendations from economics are still under discussion. In such cases hypotheses were taken that can be revised in future work. This also holds for all results that are to be considered as preliminary and subject to change as approaches and values are refined.

All heath cost results presented in the tables of this report are accorded to the following rules: no round-off for any number below 1000; round-off to the nearest 10 for any number below 20,000; otherwise, round-off to the nearest 100.

1.2 Structure of the report

Chapter 2 provides results for the monetisation of estimated AD and YLL. The core analysis relies on VOLY and VSL that are consistent with the earlier EEA work on health effects of exposure to noise (ETC HE Report 2023/11). The sensitivity analysis uses VOLY and VSL estimates consistent with the most recent meta-analysis by the OECD (2025) on valuation of mortality.
Chapter 3 applies approach 1 to the valuation of DALY. Under this approach both DALY components, YLL and YLD, are valued by a VOLY. Results are provided for the VOLY consistent with other EEA work (ETC HE Report 2023/11) and, in the sensitive scenario, for VOLY used in OECD (2025).

Chapter 4 explores approach 2 and proposes a valuation of YLD based on incidence lifetime costs of illness. The chapter first provides methodological information before presenting the results based on one selected source study. Sensitivity of the estimates compared to an alternative data set is discussed.
Chapter 5 explores approach 3 and proposes a valuation of YLD based on prevalence-based cost of illness values for the health endpoints stroke and lung cancer. Again, methodological information is provided together with results of the calculation.
Chapter 6 compares the results in terms of DALY costs from the different approaches presented in the preceding chapters.
Chapter 7 summarises the analysis and presents discussions and options for future work.
For this exploratory work, all results are presented for the health effects quantified in the scenario "Baseline from WHO 2021 AQG" using the WHO (2021) air quality guidelines values as counterfactual concentrations.
In the core of the text, results are presented for the aggregate over EU27 and EEA41. For selected results, country specific variability is illustrated through maps and figures. Tables with country-specific results are provided in the annexes.

2 Monetisation of estimated attributable deaths and years of life lost

In this section, the results of monetising mortality as calculated in the EBD in terms of AD and YLL are presented. AD are monetised using the value of statistical life (VSL), YLL are monetised using the Value of a Life Year (VOLY). VSL and VOLY are proxies for society's willingness to pay (WTP) to reduce the risk of dying prematurely. They represent the disutility associated with premature death and are non-market costs. Note that the indicators AD and YLL are alternatives, and their results must not be added together.

A core and a sensitivity analysis are proposed. Results are presented for the EBD estimates for 2022 (ETC HE, 2024/6) corresponding to the Baseline from WHO 2021 AQG. This baseline assumes as counterfactual concentrations([3]) the air quality guidelines (AQGs) as published by WHO (2021) for annual mean exposure. These are 5 µg/m^3 for $PM_{2.5}$, 10 µg/m^3 for NO_2, and 60 µg/m^3 for O_3. These counterfactual concentrations do not represent no-effect thresholds (none having been identified) but instead concentrations above which impacts can be most reliably quantified. Results aggregated over EU27 and EEA41 are presented in the core text, country specific results are presented in the annexes.

2.1 Core analysis

The core analysis uses the estimate for a VOLY selected by the EEA for its work on noise (ETC HE, 2023/11) to monetise YLL. This provides an approach consistent with that stream of work by EEA. The EU27 VOLY estimate used in ETC HE 2023/11 is € 70,000 in 2016 prices.

In the present report, all results are expressed in € in 2022 prices. Standard economic analysis (OECD, 2025) requires adjustment for inflation between the initial (2016) and the target price year (2022). In the present work we have made the following choices: adjustment for inflation up to 2022, but adjustment for economic growth only up to 2019. The reason for this choice is that the impact of the COVID pandemic extended between 2020 and 2022. During this period economic growth (4.7% per annum) was high compared to the historical trends (2% per annum). We further apply an income elasticity of 1 in the adaptation to economic growth, consistent with the suggestion discussed in OECD (2025).

Adjusting the EU27 VOLY of €$_{2016}$ 70,000 for inflation using the Harmonised Index of Consumer Prices (HICP) by EUROSTAT ([4]) corresponds to €$_{2022}$ 83,000. The adjustment for economic growth up to 2019 relied on Real GDP per capita from EUROSTAT ([5]) and results in the value of €$_{2022}$ 88,300. Correcting for economic growth up to 2022 would have resulted in a 3.6% higher value.

The VOLY for EU27 was adapted to the EEA41 region by the ratio of the population weighted GDP in 2022 for EEA41 and the population weighted GDP in 2022 for EU27, both expressed in purchasing power parities (PPP), based on data from the World Development Indicators (WDI) ([6]). This was done to account for the lower average income in the larger region, since income is one of the factors affecting willingness to pay (WTP) for reductions in the risk of mortality. The resulting VOLY for EEA41 is €$_{2022}$ 84,400 (Table 1). The EEA41 figures are lower than the EU27 figures because on average population-weighted GDP/capita in the additional 14 countries is lower than in the EU.

For the monetisation of AD, a VSL consistent with this VOLY estimate had to be calculated. For this the VOLY for EU27 was multiplied by the mean remaining life expectancy for an average citizen (38.5 years): VSL= € 88,300* 38.5 = € 3.4 million in 2022 prices. The corresponding VSL for EEA41 is € 3.3 million (Table 1).

([3]) I.e., the concentration against which the estimated population exposure is compared and above which health effects are estimated.

([4]) HICP - annual data (average index and rate of change) [prc_hicp_aind], https://ec.europa.eu/eurostat/web/main/data/database

([5]) https://ec.europa.eu/eurostat/databrowser/view/tipsna40/default/table?lang=en

([6]) https://databank.worldbank.org/source/world-development-indicators; WDI was used because EUROSTAT did not provide values for all EEA41 countries

In the air pollution domain, there are more willingness-to-pay studies on VSL than on VOLY. It is hence more frequent to derive VOLY from VSL than the other way round. Economists generally recommend discounting the remaining life expectancy when deriving VOLY from VSL (OECD, 2012; OECD,2025). However, there is no consensus on the exact value the discount rate should take (e.g., Robinson, 2018; Ciarlantini et al., 2025). The present study takes a conservative option (biased to underestimation in the final results) by not discounting the remaining lifetime.

Table 1: Core values for VOLY and VSL in €$_{2022}$ for EU27 and EEA41 respectively, used in the analysis

€$_{2022}$	VOLY	VSL
EU27	88 300	3 404 700
EEA41	84 400	3 251 900

Table 2 and Table 3 present the estimated cost for mortality expressed in AD (as calculated in the ETC HE Report 2024/6) at the level of EU27 and EEA41, respectively. Estimates are for the central estimate and for the lower and higher confidence interval (CI) of the respective concentration-response functions.

Note that estimates for all-cause mortality must not be aggregated with estimates for cause-specific mortality as they provide different routes to the same quantity – the mortality burden of air pollution. The all-cause estimate is more complete than the sum of cause-specific mortality estimates and so, naturally, returns a higher result.
Furthermore, health damage calculated for the same health endpoint and population age groups should not be added for the pollutants $PM_{2.5}$ and NO_2, as available results from two-pollutant models indicate this would lead to overestimates of health damage (see for example Chen et al., 2024). Ideally, results would be adjusted to account for overlap between the pollutants, but debate on precisely how this should be done has yet to be concluded. Hereafter, results are therefore presented separately for all-cause and cause-specific mortality and by pollutant.
Finally, mortality associated with exposure to tropospheric O_3 is calculated for two metrics, SOMO35 and seasonal peak O_3. SOMO35 applies to short-term mortality, while seasonal peak O_3refers to long-term mortality. These results must not be added to avoid double counting.

Table 2 indicates that the central estimates for health damage from all-cause mortality would amount to € 812 billion for deaths attributable to $PM_{2.5}$ exposure and to € 162 billion in 2022 for deaths attributable to NO_2 in the EU27. For deaths attributable to O_3 exposure, the respective value is € 245 billion for peak $O_3$and € 95 billion for SOMO35([7]). The corresponding values for cause-specific mortality are € 713 billion to $PM_{2.5}$ exposure (and six outcomes), € 110 billion attributable to NO_2 (five outcomes) and € 25 billion to O_3 (only COPD).
The central estimate for all-cause mortality is equivalent to 5.08 % of GDP of EU27 for $PM_{2.5}$, 1.01% for NO_2, and 1.53% or 0.59% for O_3, peak and SOMO35 respectively.

([7]) It should be noted that the lower bound of the confidence interval (CI) of the concentration-response function used for all-cause mortality attributable to O_3in ETC HE Report 2024/6 is zero.

Table 2: Costs of AD in million €$_{2022}$ using VSL, EU27 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	EU27		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Mortality	**All-cause natural mortality**	**811 600**	**619 500**	**905 200**
		Asthma, children	10	0	14
		Chronic obstructive pulmonary disease	62 300	1 070	113 000
		Diabetes Mellitus	128 200	70 500	174 100
		Ischemic heart disease	248 100	134 300	352 400
		Lung cancer	90 500	34 700	140 600
		Stroke	184 300	76 600	278 400
		Total for $PM_{2.5}$ from cause-specific functions	**713 400**	**317 200**	**1 058 500**
NO_2	Mortality	**All-cause natural mortality**	**162 000**	**81 800**	**317 300**
		Asthma, adult	783	58	1 530
		Asthma, children	0	0	3
		Chronic obstructive pulmonary disease	28 200	12 130	43 000
		Diabetes Mellitus	42 300	22 300	60 200
		Stroke	38 900	6 640	69 600
		Total for NO_2 from cause-specific functions	**110 200**	**41 100**	**174 300**
O_3	Mortality (Peak)	**All-cause natural mortality**	**244 700**	**0**	**478 800**
		Chronic obstructive pulmonary disease	**25 300**	**24 200**	**27 000**
	Mortality (SOMO35)	**All-cause natural mortality**	**94 500**	**74 800**	**114 100**

Note: The VSL estimate used is €3.4 million (2022 prices, Table 1)

Table 3 presents the same results for the region EEA41. Here, the central estimates for health damage from all-cause mortality would amount to € 870 billion for deaths attributable to $PM_{2.5}$ exposure and to € 225 billion in 2022 for deaths attributable to NO_2. For deaths attributable to O_3 exposure, the respective value is € 265 billion for peak $O_3$and € 105 billion for SOMO35. The corresponding values for cause-specific mortality would be € 748 billion attributable to $PM_{2.5}$ exposure (six outcomes), € 159 billion to NO_2 (five outcomes) and € 28 billion to O_3 (only COPD).
In terms of GDP for the EEA41, the central estimate for all-cause mortality is equivalent to 4.73 % for $PM_{2.5}$, 1.22% for NO_2, and 1.44 % or 0.57% for O_3, peak and SOMO35 respectively.

Table 3: Costs of AD in million €$_{2022}$ using VSL, EEA41 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	All countries		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Mortality	**All-cause natural mortality**	**870 400**	**664 800**	**970 400**
		Asthma, children	10	0	13
		Chronic obstructive pulmonary disease	64 700	1 110	116 800
		Diabetes Mellitus	135 200	74 800	182 500
		Ischemic heart disease	256 500	139 100	363 600
		Lung cancer	95 100	36 600	147 400
		Stroke	196 700	82 100	296 000
		Total for $PM_{2.5}$ from cause-specific functions	**748 100**	**333 700**	**1 106 300**
NO_2	Mortality	**All-cause natural mortality**	**224 600**	**113 700**	**438 300**
		Asthma, adult	1 650	150	3 100
		Asthma, children	3	0	10
		Chronic obstructive pulmonary disease	43 200	18 970	64 800
		Diabetes Mellitus	60 500	32 500	84 500
		Stroke	53 400	9 210	94 600
		Total for NO_2 from cause-specific functions	**158 800**	**60 900**	**247 100**
O_3	Mortality (Peak)	**All-cause natural mortality**	**265 100**	**0**	**518 700**
		Chronic obstructive pulmonary disease	**27 900**	**26 700**	**29 800**
	Mortality (SOMO35)	**All-cause natural mortality**	**105 000**	**83 100**	**126 900**

Note: The VSL estimate used is €3.3 million (2022 prices, Table 1)

Figure 1 to Figure 3 illustrate how the economic cost from AD, expressed in €/capita, and associated with exposure to PM2.5, NO_2 and O_3, respectively, differ across the region (noting that different scales are used for each map). Tables corresponding to these figures are presented in annex 5 (Table 68 to Table 70).

Figure 1: Costs of AD attributable to $PM_{2.5}$ valued by VSL, in $€_{2022}$ per capita at country level – core analysis for Baseline from WHO 2021 AQG

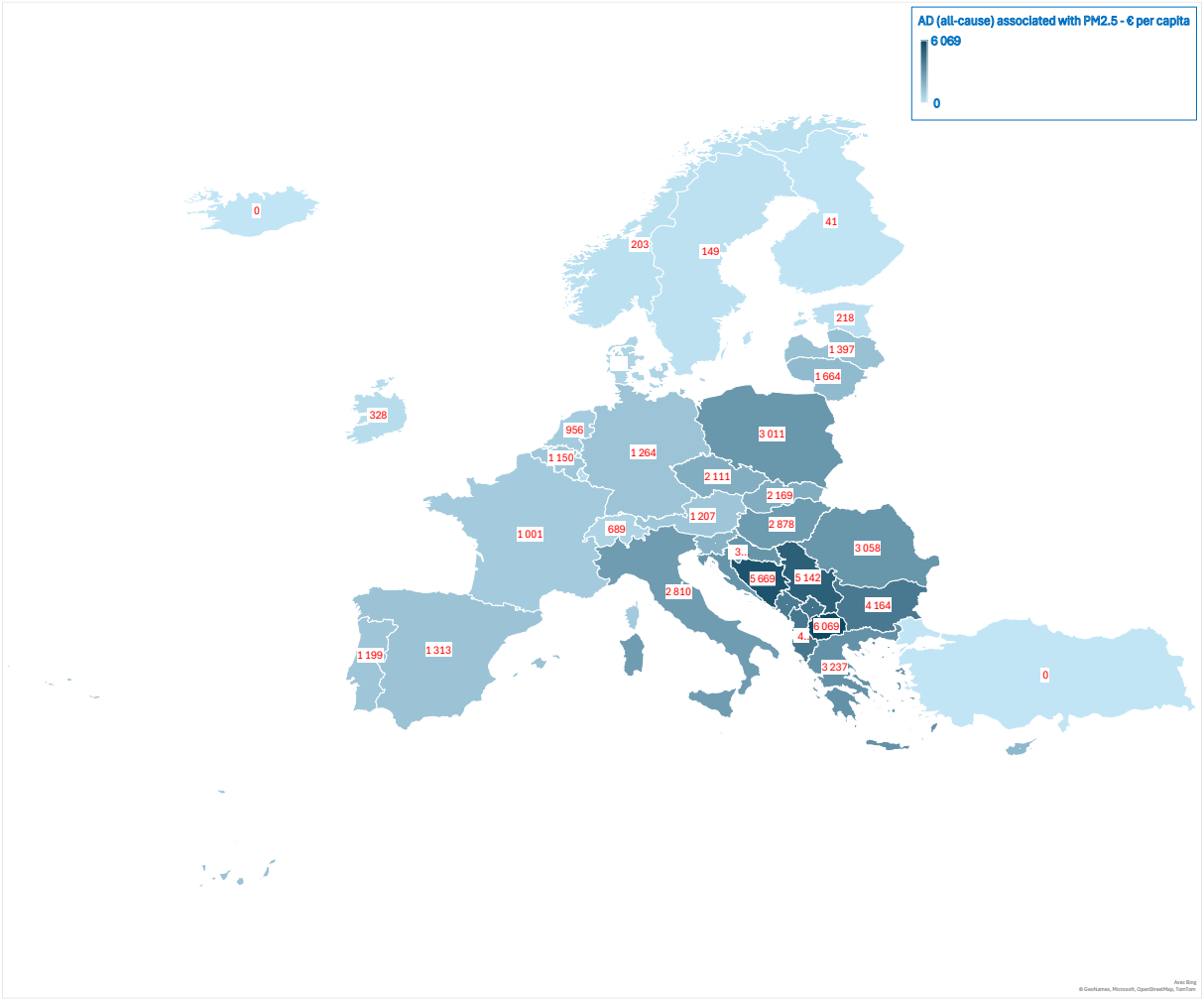

Figure 2: Costs of AD attributable to NO_2 valued by VSL, in €$_{2022}$ per capita at country level – core analysis for Baseline from WHO 2021 AQG

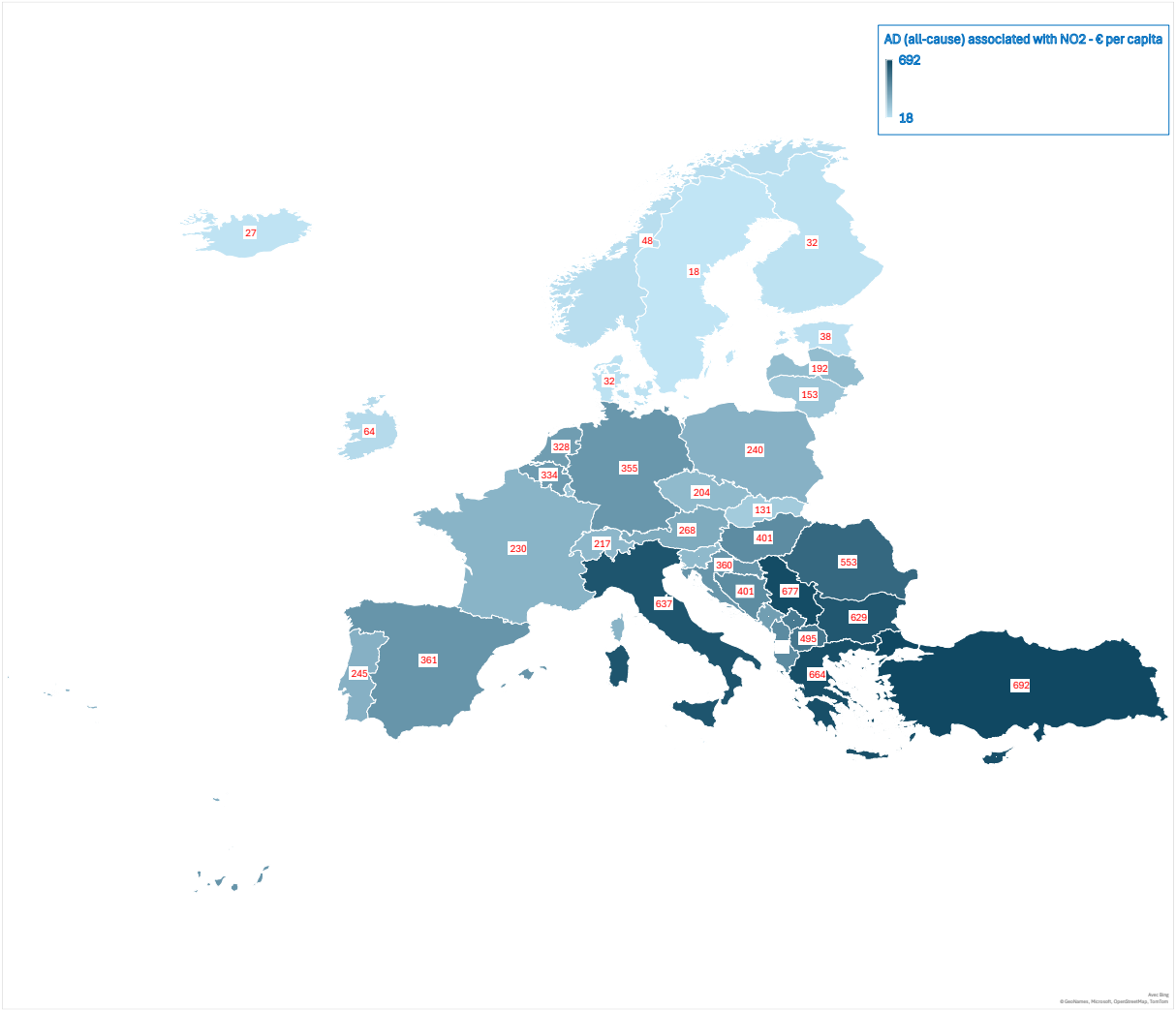

Figure 3: Costs of AD attributable to O_3 (SOMO35 metric) valued by VSL, in €$_{2022}$ per capita at country level – core analysis for Baseline from WHO 2021 AQG

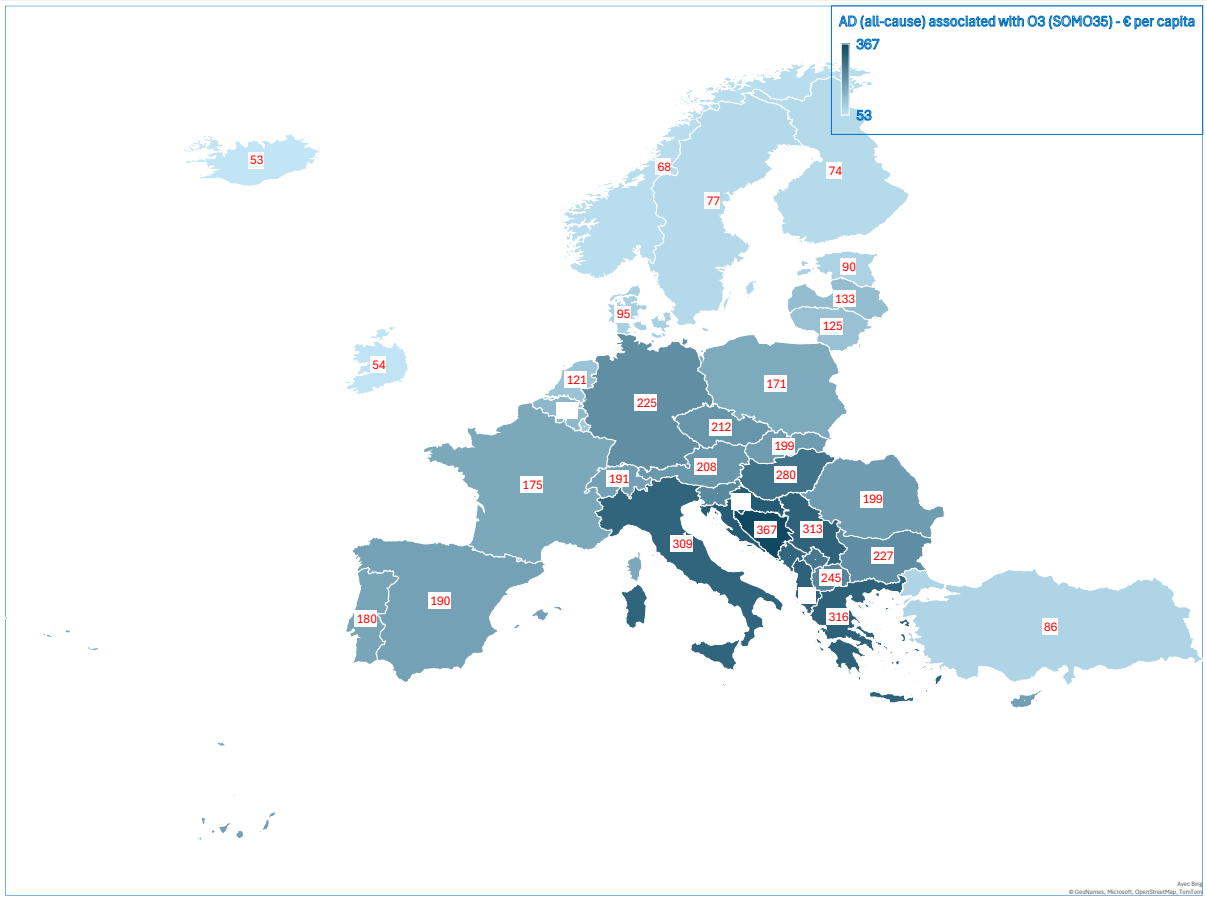

Table 4 and Table 5 present the same results for the alternative mortality indicator YLL for which the monetised results are lower than those for AD.

Here the central estimates for health damage from all-cause mortality in EU27 would amount to € 208 billion in 2022 for YLL attributable to $PM_{2.5}$ exposure and to € 41 billion for YLL attributable to NO_2 (Table 4). For YLL attributable to O_3 exposure, the respective values are € 63 billion (peak O_3) and € 25 billion (SOMO35). The corresponding values for cause-specific mortality would be € 178 billion to $PM_{2.5}$ exposure (six outcomes), € 25 billion attributable to NO_2 exposure (five outcomes), and € 6.5 billion to O_3 (only COPD).

For the YLL indicator, the highest percentage of health damage estimated and attributable to all-cause mortality from $PM_{2.5}$ does not exceed the equivalent of 1.3 % of GDP in EU27.

Table 4: Costs of YLL in million €$_{2022}$ using VOLY, EU27 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	EU27		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Mortality	All-cause natural mortality	207 700	158 500	231 600
		Asthma, children	36	13	56
		Chronic obstructive pulmonary disease	15 580	277	28 400
		Diabetes Mellitus	30 600	16 840	41 600
		Ischemic heart disease	57 900	31 300	82 300
		Lung cancer	33 700	12 930	52 400
		Stroke	40 000	16 620	60 400
		Total for $PM_{2.5}$ from cause-specific functions	177 800	78 000	265 100
NO_2	Mortality	All-cause natural mortality	40 700	20 600	79 700
		Asthma, adult	225	24	429
		Asthma, children	13	5	18
		Chronic obstructive pulmonary disease	7 030	3 020	10 730
		Diabetes Mellitus	9 870	5 200	14 030
		Stroke	8 280	1 420	14 820
		Total for NO_2 from cause-specific functions	25 400	9 670	40 000
O_3	Mortality (Peak)	All-cause natural mortality	62 500	0	122 300
		Chronic obstructive pulmonary disease	6 490	6 200	6 920
	Mortality (SOMO35)	All-cause natural mortality	24 800	19 620	30 000

Note: The VOLY estimate used is €88,300 (2022 prices, Table 1)

The results for EEA41 (Table 5) for the central estimates for health damage from all-cause mortality would amount to € 222 billion in 2022 for YLL attributable to $PM_{2.5}$ exposure and to € 61 billion for YLL attributable to NO_2 and to € 69 billion (peak) and € 28 billion (SOMO35) for O_3 exposure. The corresponding values for cause-specific mortality would be € 188 billion attributable to $PM_{2.5}$ exposure (six outcomes), € 40 billion to NO_2 exposure (five outcomes) and € 7.2 billion to O_3 (only COPD).
Again, the highest percentage of health damage estimated for mortality attributable to $PM_{2.5}$ does not exceed 1.2 % of GDP in EEA41.

Note that the mortality cost estimate for childhood asthma is higher when estimated in terms of VOLY than when estimated in terms of VSL. This should not be the case but is explained by the relative size of the results in terms of AD and YLL for childhood asthma downloaded from the EEA website and used here (see annex 7). This issue occurs in several places throughout this analysis.

Table 5: Costs of YLL in million €$_{2022}$ using VOLY, EEA41 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	All countries		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Mortality	All-cause natural mortality	222 400	169 800	247 900
		Asthma, children	40	14	61
		Chronic obstructive pulmonary disease	16 270	291	29 500
		Diabetes Mellitus	32 500	18 000	43 900
		Ischemic heart disease	60 300	32 700	85 500
		Lung cancer	35 500	13 670	55 100
		Stroke	43 100	18 000	64 900
		Total for $PM_{2.5}$ from cause-specific functions	187 800	82 700	278 900
NO_2	Mortality	All-cause natural mortality	60 800	30 800	118 500
		Asthma, adult	471	52	870
		Asthma, children	23	10	31
		Chronic obstructive pulmonary disease	11 230	4 930	16 820
		Diabetes Mellitus	15 730	8 500	21 900
		Stroke	12 670	2 200	22 400
		Total for NO_2 from cause-specific functions	40 100	15 700	62 000
O_3	Mortality (Peak)	All-cause natural mortality	68 600	0	134 300
		Chronic obstructive pulmonary disease	7 230	6 900	7 710
	Mortality (SOMO35)	All-cause natural mortality	28 400	22 500	34 400

Note: The VOLY estimate used is €84,400 (2022 prices, Table 1)

2.2 Sensitivity analysis

Guidance by OECD (2012) on the valuation of premature mortality was used in the last two assessments of industrial externalities (EEA, 2024a, b; ETC/ATNI, 2020/04) and also in air pollution policy studies for the European Commission (e.g. Klimont et al., 2025). OECD recently updated its meta-analysis "Mortality Risk Valuation in Policy Assessment" (OECD, 2025). This has led to an increase in the VSL estimate (and hence the VOLY estimate has also increased) which needs to be factored into analysis.

From this study, the population-weighted mean VSL for EU27 countries is US $ 8.4 million in 2022 prices. The confidence interval is US $7.0 – 9.8 million, but here the central value is used. The PPP-corrected exchange rate from OECD ([8]) between USD and euro (EU27) in 2022 is 0.63, leading to an estimate of € 5.275 million in 2022 prices. The corresponding scaled VOLY estimate is € 136,900 in 2022 prices. It relies on the same assumptions as described in section 2.1.

([8]) OECD Data Explorer • PPP detailed results, 2020 onwards

All sensitivity indicator values for VOLY and VSL are presented in Table 6.

Table 6: Sensitivity values for VOLY and VSL in €$_{2022}$ for EU27 and EEA41 respectively, used in the analysis

€$_{2022}$	VOLY	VSL
EU27	136 900	5 275 200
EEA41	130 700	5 038 500

Table 7 to Table 10 present the same results as Table 2 to Table 5 but using the sensitivity values for the mortality unit costs from Table 6.

Table 7: Costs of AD in million €$_{2022}$ using VSL, EU27 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	EU27		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	**Mortality**	All-cause natural mortality	1 257 500	959 900	1 402 500
		Asthma, children	16	0	21
		Chronic obstructive pulmonary disease	96 500	1 660	175 000
		Diabetes Mellitus	198 700	109 200	269 700
		Ischemic heart disease	384 500	208 100	546 100
		Lung cancer	140 200	53 800	217 800
		Stroke	285 500	118 700	431 300
		Total for $PM_{2.5}$ from cause-specific functions	1 105 300	491 400	1 640 000
NO_2	**Mortality**	All-cause natural mortality	250 900	126 800	491 700
		Asthma, adult	1 210	90	2 360
		Asthma, children	0	0	5
		Chronic obstructive pulmonary disease	43 700	18 790	66 600
		Diabetes Mellitus	65 600	34 500	93 200
		Stroke	60 300	10 290	107 800
		Total for NO_2 from cause-specific functions	170 800	63 700	270 000
O_3	**Mortality (Peak)**	All-cause natural mortality	379 100	0	741 800
		Chronic obstructive pulmonary disease	39 200	37 500	41 800
	Mortality (SOMO35)	All-cause natural mortality	146 400	115 800	176 800

Note: The VSL estimate used is €5.3 million (2022 prices, Table 6)

Table 7 presents the estimated cost for mortality expressed in AD at the level of EU27, for the central estimate and lower and higher confidence interval (CI) of the respective concentration-response functions.

The central estimates for health damage from all-cause mortality is now estimated at € 1.258 billion in 2022 for deaths attributable to $PM_{2.5}$ exposure and to € 251 billion for deaths attributable to NO_2. For deaths attributable to O_3 exposure, the respective values are € 379 billion (peak O_3) and € 146 billion (SOMO35). The corresponding values for cause-specific mortality are € 1,105 billion attributable to $PM_{2.5}$ exposure (six outcomes), € 171 billion to NO_2 exposure (five outcomes) and € 39 billion to O_3 (only COPD).
The central estimate for all-cause mortality is equivalent to 7.87 % of GDP of EU27 for $PM_{2.5}$, 1.57% for NO_2 and 2.37 % or 0.92 % for O_3, peak and SOMO35 respectively.

Table 8 presents the same results but aggregated at the larger region EEA41. Here, the central values for health damages from all-cause mortality are € 1.349 billion in 2022 for deaths attributable to $PM_{2.5}$ exposure and to € 348 billion for deaths attributable to NO_2. For deaths attributable to O_3 exposure, the respective values are € 411 billion (peak O_3) and € 163 billion (SOMO35). The corresponding values for cause-specific mortality are € 1.159 billion attributable to $PM_{2.5}$ exposure, € 246 billion to NO_2 exposure and € 43 billion to O_3.
In terms of percentage in GDP of EEA41 this is equivalent to 7.33 % of GDP of EEA41 for $PM_{2.5}$, 1.89 % for NO_2 and 2.23 % or 0.88 % for O_3, peak and SOMO35 respectively for all-cause mortality.

Maps with country-specific results are not shown, because the distribution of costs is similar to that shown in Figure 1 to Figure 3 for the core analysis.

Table 8: Costs of AD in million €$_{2022}$ using VSL, EEA41 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	All countries		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Mortality	All-cause natural mortality	1 348 600	1 030 000	1 503 600
		Asthma, children	15	0	20
		Chronic obstructive pulmonary disease	100 200	1 710	180 900
		Diabetes Mellitus	209 400	115 900	282 800
		Ischemic heart disease	397 400	215 500	563 300
		Lung cancer	147 400	56 700	228 400
		Stroke	304 700	127 300	458 700
		Total for $PM_{2.5}$ from cause-specific functions	1 159 100	517 000	1 714 100
NO_2	Mortality	All-cause natural mortality	347 900	176 100	679 100
		Asthma, adult	2 550	232	4 800
		Asthma, children	5	0	15
		Chronic obstructive pulmonary disease	67 000	29 400	100 400
		Diabetes Mellitus	93 800	50 400	131 000
		Stroke	82 700	14 270	146 600
		Total for NO_2 from cause-specific functions	246 100	94 300	382 800
O_3	Mortality (Peak)	All-cause natural mortality	410 700	0	803 700
		Chronic obstructive pulmonary disease	43 200	41 300	46 100
	Mortality (SOMO35)	All-cause natural mortality	162 700	128 700	196 500

Note: The VSL estimate used is €5.0 million (2022 prices)

Table 9 and Table 10 present the same results for the alternative mortality indicator YLL.

Table 9: Costs of YLL in million €$_{2022}$ using VOLY, EU27 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	EU27		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Mortality	All-cause natural mortality	322 000	245 800	359 100
		Asthma, children	56	20	87
		Chronic obstructive pulmonary disease	24 100	429	44 000
		Diabetes Mellitus	47 500	26 100	64 500
		Ischemic heart disease	89 800	48 600	127 500
		Lung cancer	52 300	20 100	81 300
		Stroke	62 000	25 800	93 700
		Total for $PM_{2.5}$ from cause-specific functions	275 700	120 900	411 100
NO_2	Mortality	All-cause natural mortality	63 100	31 900	123 600
		Asthma, adult	349	37	665
		Asthma, children	20	8	28
		Chronic obstructive pulmonary disease	10 890	4 680	16 630
		Diabetes Mellitus	15 300	8 060	21 800
		Stroke	12 840	2 200	23 000
		Total for NO_2 from cause-specific functions	39 400	14 990	62 000
O_3	Mortality (Peak)	All-cause natural mortality	96 900	0	189 500
		Chronic obstructive pulmonary disease	10 060	9 610	10 730
	Mortality (SOMO35)	All-cause natural mortality	38 400	30 400	46 400

Note: The VOLY estimate used is €136,900 (2022 prices, Table 6)

The central estimates for health damage from all-cause mortality in EU27 (Table 9) amount to €322 billion in 2022 for YLL attributable to $PM_{2.5}$ exposure and to €63 billion for YLL attributable to NO_2. For YLL attributable to O_3 exposure, the respective values are €97 billion (peak O_3) and €38 billion (SOMO35). The corresponding values for cause-specific mortality would be €276 billion attributable to $PM_{2.5}$ exposure (six outcomes), €39 billion to NO_2 exposure (five outcomes) and €10 billion to O_3 (only COPD).
Here, the all-cause mortality estimate for $PM_{2.5}$ exposure is equivalent to 2.0 % of GDP.

Table 10: Costs of YLL in million €$_{2022}$ using VOLY, EEA41 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	All countries		
			Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	**Mortality**	**All-cause natural mortality**	**344 300**	**263 000**	**383 900**
		Asthma, children	61	22	95
		Chronic obstructive pulmonary disease	25 200	450	45 700
		Diabetes Mellitus	50 300	27 900	68 000
		Ischemic heart disease	93 400	50 600	132 400
		Lung cancer	55 000	21 200	85 300
		Stroke	66 700	27 900	100 500
		Total for $PM_{2.5}$ from cause-specific functions	**290 800**	**128 000**	**431 900**
NO_2	**Mortality**	All-cause natural mortality	**94 100**	**47 600**	**183 500**
		Asthma, adult	729	80	1 350
		Asthma, children	36	15	48
		Chronic obstructive pulmonary disease	17 380	7 640	26 000
		Diabetes Mellitus	24 400	13 170	33 900
		Stroke	19 620	3 410	34 600
		Total for NO_2 from cause-specific functions	**62 100**	**24 300**	**96 000**
O_3	**Mortality (Peak)**	**All-cause natural mortality**	**106 300**	**0**	**208 000**
		Chronic obstructive pulmonary disease	**11 190**	**10 690**	**11 930**
	Mortality (SOMO35)	**All-cause natural mortality**	**44 000**	**34 900**	**53 200**

Note: The VOLY estimate used is €130,700 (2022 prices, Table 6)

The central estimates for health damage from all-cause mortality in EEA41 (Table 10) amount to € 344 billion in 2022 for YLL attributable to $PM_{2.5}$ exposure and to € 94 billion for YLL attributable to NO_2. For YLL attributable to O_3 exposure, the respective values are € 106 billion (peak O_3) and € 44 billion (SOMO35). The corresponding values for cause-specific mortality are € 291 billion attributable to $PM_{2.5}$ exposure (six outcomes), € 62 billion to NO_2 exposure (five outcomes) and € 11 billion to O_3 (only COPD).
Here, the all-cause mortality estimate for $PM_{2.5}$ exposure is equivalent to 1.87 % of GDP.

2.3 Comparison of the core and sensitivity results for VSL and VOLY for all-cause mortality

In this section the estimates for all-cause mortality for EU27 and EEA41, respectively are compared by pollutant and mortality indicator (AD, YLL). Table 11 to Table 14 refer to mortality associated with exposure to $PM_{2.5}$, Table 15 to Table 18 to mortality associated with exposure to NO_2, and Table 19 to Table 22 to mortality associated with exposure to O_3. For O_3, results for both metrics, seasonal peak $O_3$and SOMO35 are presented.

The results for the sensitivity estimate based on OECD (2025) are 55 % higher than the results for the core analysis estimate based on EEA (ETC HE Report 2023/11).

Mortality costs are approximately 270 % to 300 % higher when calculated in terms of AD and valued by VSL than when calculated in terms of YLL and valued by VOLY. With respect to this comparison, it should be recalled that unexpected results were identified in relation to the VOLY vs VSL results for childhood asthma, both for NO_2 and $PM_{2.5}$, with the mortality estimate being considerably higher when estimated in terms of VOLY than when estimated in terms of VSL. These results were explained by the relative size of the results in terms of AD and YLL for childhood asthma available downloaded from the EEA website (see annex 7)([9]).

Table 11: Costs of AD from exposure to $PM_{2.5}$ in million €2022 for EU27 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
811 600	619 500	905 200	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
1 257 500	959 900	1 402 500	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VSL estimate (consistent with EEA) used is €3.405 billion (table 1), the high VSL estimate (consistent with the new OECD estimate) is €5.275 billion (table 6, 2022 prices)

Table 12: Costs of AD from exposure to $PM_{2.5}$ in million €2022 for EEA41 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
870 400	664 800	970 400	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
1 348 600	1 030 000	1 503 600	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VSL estimate (consistent with EEA) used is €3.252 billion (table 1), the high VSL estimate (consistent with the new OECD estimate) is €5.039 billion (table 6,2022 prices)

Table 13: Costs of YLL from exposure to $PM_{2.5}$ in million €2022 for EU27 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
207 700	158 500	231 600	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
322 000	245 800	359 100	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VOLY estimate (consistent with EEA) used is €88,300 (table 1), the high VOLY estimate (consistent with the new OECD estimate) is €136,900 (table 6, 2022 prices)

([9]) A more general question is whether the same VOLY used for adults can be applied to valuing mortality in children or whether a lower VOLY should be used, given the higher remaining life expectancy, when assuming the same VSL applies to all ages. It can also be asked whether only VSL should be applied to mortality in children.

Table 14: Costs of YLL from exposure to $PM_{2.5}$ in million €2022 for EEA41 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
222 400	169 800	247 900	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
344 300	263 000	383 900	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VOLY estimate (consistent with EEA) used is €84,400 (table 1), the high VOLY estimate (consistent with the new OECD estimate) is €130,700 (table 6, 2022 prices)

Table 15: Costs of AD from exposure to NO_2 in million €2022 for EU27 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
162 000	81 800	317 300	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
250 900	126 800	491 700	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VSL estimate (consistent with EEA) used is €3.405 billion (table 1), the high VSL estimate (consistent with the new OECD estimate) is €5.275 billion (table 6, 2022 prices).

Table 16: Costs of AD from exposure to NO_2 in million €2022 for EEA41 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
224 600	113 700	438 300	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
347 900	176 100	679 100	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VSL estimate (consistent with EEA) used is €3.252 billion (table 1), the high VSL estimate (consistent with the new OECD estimate) is €5.039 billion (table 6, 2022 prices)

Table 17: Costs of YLL from exposure to NO_2 in million €2022 for EU27 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
40 700	20 600	79 700	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
63 100	31 900	123 600	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VOLY estimate (consistent with EEA) used is €88,300 (table 1), the high VOLY estimate (consistent with the new OECD estimate) is €136,900 (table 6, 2022 prices)

Table 18: Costs of YLL from exposure to NO_2 in million €2022 for EEA41 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
60 800	30 800	118 500	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
94 100	47 600	183 500	DALY value = VOLY consistent with OECD, 2025	chapter 2.2

Note: The low VOLY estimate (consistent with EEA) used is €84,400 (table 1), the high VOLY estimate (consistent with the new OECD estimate) is €130,700 (table 6, 2022 prices)

Table 19: Costs of AD from exposure to O_3 in million €2022 for EU27 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Metric	Source values	Chapter reference
244 700	0	478 800	Peak	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
94 500	74 800	114 100	SOMO35		
379 100	0	741 800	Peak	DALY value = VOLY consistent with OECD, 2025	chapter 2.2
146 400	115 800	176 800	SOMO35		

Note: The low VSL estimate (consistent with EEA) used is €3.405 billion (table 1), the high VSL estimate (consistent with the new OECD estimate) is €5.275 billion (table 6, 2022 prices)

Table 20: Costs of AD from exposure to O_3 in million €2022 for EEA41 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Source values	Chapter reference
265 100	0	518 700	Peak	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
105 000	83 100	126 900	SOMO35		
410 700	0	803 700	Peak	DALY value = VOLY consistent with OECD, 2025	chapter 2.2
162 700	128 700	196 500	SOMO35		

Note: The low VSL estimate (consistent with EEA) used is €3.252 billion (table 1), the high VSL estimate (consistent with the new OECD estimate) is €5.039 billion (table 6, 2022 prices)

Table 21: Costs of YLL from exposure to O_3 in million €2022 for EU27 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Metric	Source values	Chapter reference
62 500	0	122 300	Peak	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
24 800	19 620	30 000	SOMO35		
96 900	0	189 500	Peak	DALY value = VOLY consistent with OECD, 2025	chapter 2.2
38 400	30 400	46 400	SOMO35		

Note: The low VOLY estimate (consistent with EEA) used is €88,300 (table 1), the high VOLY estimate (consistent with the new OECD estimate) is €136,900 (table 6, 2022 prices)

Table 22: Costs of YLL from exposure to O_3 in million €2022 for EEA41 under core and sensitivity estimates, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Metric	Source values	Chapter reference
68 600	0	134 300	Peak	DALY value = VOLY from ETC HE 2023/11	chapter 2.1
28 400	22 500	34 400	SOMO35		
106 300	0	208 000	Peak	DALY value = VOLY consistent with OECD, 2025	chapter 2.2
44 000	34 900	53 200	SOMO35		

Note: The low VOLY estimate (consistent with EEA) used is €84,400 (table 1), the high VOLY estimate (consistent with the new OECD estimate) is €130,700 (table 6, 2022 prices)

3 Monetisation of DALY valuing YLL and YLD by VOLY

This section monetises total health burden, including mortality and morbidity, in terms of DALY. DALYs are used in the EBD assessments to estimate cause-specific mortality and morbidity effects of air pollution in a single quantitative indicator. DALY are composed of YLL and YLD. In this chapter, the first of three approaches is applied, valuing both YLL and YLD using the VOLY. This is a simplified approach, as only the utility loss related to health effects attributable to air pollution exposure is accounted for. Any market health costs associated to YLD, for medical exams or treatments or representing loss of productivity, are excluded from this valuation approach.
Monetised DALY results must not be added to monetised AD or YLL results from chapter 2, as this would imply a double counting of the mortality component which cannot be disentangled.

3.1 Core analysis

As in the preceding chapter, the core analysis relies on the VOLY estimate borrowed from the EEA noise work (ETC HE 2023/11) but updated to 2022 prices and adjusted for economic growth. For the EU27 the value amounts to € 88,300, for the EEA41 to € 84,400 (see Table 1).

The cost of the **total health burden** for EU27 expressed in DALY, aggregating the mortality and the morbidity component, by health endpoint is provided in Table 23 for the scenario Baseline from WHO 2021 AQG. For $PM_{2.5}$, health costs are highest for ischemic heart disease, followed by stroke, diabetes mellitus and lung cancer. The total for $PM_{2.5}$ is €213 billion equivalent to 1.33 % of GDP, for NO_2 it amounts to €42 billion equivalent to 0.26 % of GDP.

Table 23: Costs of the total burden of disease (DALY) in million €$_{2022}$ valued by VOLY, EU27 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Outcome	EU27		
		Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Asthma, children	3 610	1 320	5 520
	Chronic obstructive pulmonary disease	25 400	4 210	43 200
	Diabetes Mellitus	40 500	21 900	55 800
	Ischemic heart disease	59 600	32 000	85 000
	Lung cancer	34 100	13 080	53 000
	Stroke	49 600	17 700	78 200
	Total for $PM_{2.5}$	**212 700**	**90 300**	**320 700**
NO_2	Asthma, adult	3 140	342	5 980
	Asthma, children	1 090	457	1 470
	Chronic obstructive pulmonary disease	9 920	4 680	14 750
	Diabetes Mellitus	16 450	9 070	24 000
	Stroke	11 320	3 000	19 200
	Total for NO_2	**41 900**	**17 550**	**65 400**

Note: The VOLY estimate used is €88,300 (2022 prices)

The same results for EEA41 are presented in Table 24. The total for $PM_{2.5}$ is €224 billion equivalent to 1.22 % of GDP, for NO_2 it amounts to €71 billion equivalent to 0.38 % of GDP.

Table 24: Costs of the total burden of disease (DALY) in million €$_{2022}$ valued by VOLY, EEA41 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Outcome	All countries		
		Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Asthma, children	3 700	1 350	5 640
	Chronic obstructive pulmonary disease	26 400	4 350	44 700
	Diabetes Mellitus	42 800	23 300	58 700
	Ischemic heart disease	62 300	33 500	88 600
	Lung cancer	35 900	13 820	55 600
	Stroke	52 900	19 100	83 000
	Total for $PM_{2.5}$	**223 900**	**95 500**	**336 300**
NO_2	Asthma, adult	6 480	731	11 920
	Asthma, children	2 190	947	2 910
	Chronic obstructive pulmonary disease	17 100	8 350	24 900
	Diabetes Mellitus	28 100	15 840	40 300
	Stroke	16 660	4 290	28 100
	Total for NO_2	**70 500**	**30 200**	**108 100**

Note: The VOLY estimate used is €84,400 (2022 prices)

Figure 4 shows the distribution of the total monetised health burden (DALY) in €/capita, by country and pollutant. A table corresponding to this figure is presented in annex 5 (Table 71).

Figure 4: Costs of DALY in million €$_{2022}$ per capita valued by VOLY, by country – core analysis for Baseline from WHO 2021 AQG

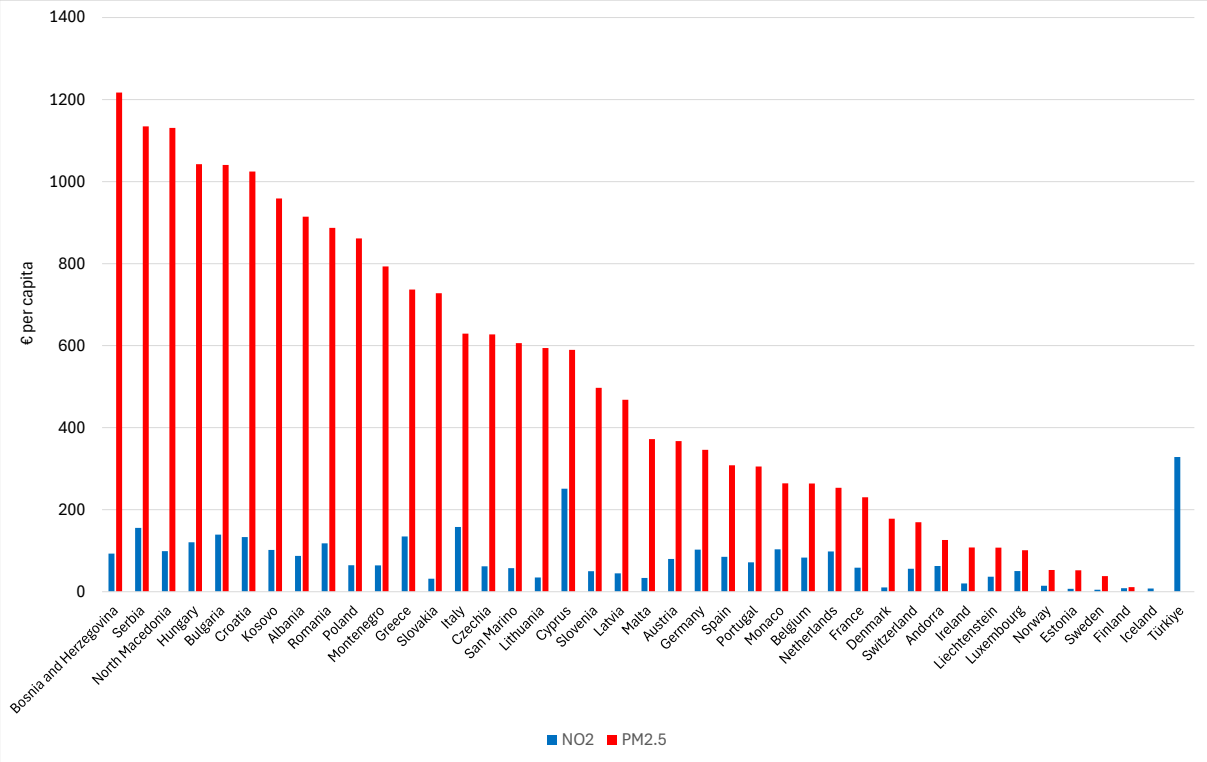

Table 25 and Table 26 present the costs of DALY for EU27 and EEA41, respectively, but decomposed into **mortality (YLL) and morbidity (YLD)** component for each health endpoint. This provides information on the relative importance of each component for specific health endpoints. Whereas for stroke, for example, mortality costs dominate the total cost, the mortality component is low for childhood asthma.

Table 25: Costs of YLL and YLD in million €$_{2022}$ by VOLY, EU27 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	Health Indicator	EU27		
				Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Morbidity	Asthma, childhood	YLD	3 580	1 310	5 460
		Chronic obstructive pulmonary disease		9 830	3 930	14 850
		Diabetes Mellitus		9 840	5 100	14 270
		Ischemic heart disease		1 720	708	2 700
		Lung cancer		337	143	534
		Stroke		9 580	1 070	17 740
	Mortality	Asthma, childhood	YLL	36	13	56
		Chronic obstructive pulmonary disease		15 580	277	28 400
		Diabetes Mellitus		30 600	16 840	41 600
		Ischemic heart disease		57 900	31 300	82 300
		Lung cancer		33 700	12 930	52 400
		Stroke		40 000	16 620	60 400
NO2	Morbidity	Asthma, adult	YLD	2 910	317	5 550
		Asthma, childhood		1 070	452	1 450
		Chronic obstructive pulmonary disease		2 890	1 650	4 020
		Diabetes Mellitus		6 580	3 870	9 950
		Stroke		3 030	1 580	4 380
	Mortality	Asthma, adult	YLL	225	24	429
		Asthma, childhood		13	5	18
		Chronic obstructive pulmonary disease		7 030	3 020	10 730
		Diabetes Mellitus		9 870	5 200	14 030
		Stroke		8 280	1 420	14 820

Note: The VOLY estimate used is €88,300 (2022 prices)

Table 26: Costs of YLL and YLD in million €$_{2022}$ by VOLY, EEA41 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	Health Indicator	All countries		
				Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Morbidity	Asthma, childhood	YLD	3 660	1 340	5 580
		Chronic obstructive pulmonary disease		10 100	4 060	15 220
		Diabetes Mellitus		10 250	5 310	14 850
		Ischemic heart disease		1 970	815	3 090
		Lung cancer		351	149	555
		Stroke		9 800	1 100	18 100
	Mortality	Asthma, childhood	YLL	40	14	61
		Chronic obstructive pulmonary disease		16 270	291	29 500
		Diabetes Mellitus		32 500	18 000	43 900
		Ischemic heart disease		60 300	32 700	85 500
		Lung cancer		35 500	13 670	55 100
		Stroke		43 100	18 000	64 900
NO2	Morbidity	Asthma, adult	YLD	6 000	678	11 050
		Asthma, childhood		2 160	936	2 880
		Chronic obstructive pulmonary disease		5 870	3 420	8 040
		Diabetes Mellitus		12 330	7 330	18 410
		Stroke		3 990	2 090	5 730
	Mortality	Asthma, adult	YLL	471	52	870
		Asthma, childhood		23	10	31
		Chronic obstructive pulmonary disease		11 230	4 930	16 820
		Diabetes Mellitus		15 730	8 500	21 900
		Stroke		12 670	2 200	22 400

Note: The VOLY estimate used is €84,400 in 2022 prices

3.2 Sensitivity analysis

As in the preceding chapter, the sensitivity analysis relies on the VOLY derived from the OECD (2025) estimate for VSL. Expressed in prices of 2022 the revised value is € 136,900 for EU27 and to 130,700 for EEA41 (Table 6).

Table 27 and Table 28 present the same results as Table 23 and Table 24 but using the higher VOLY unit cost estimate from OECD (2025).

Table 27 shows the costs of the total health burden for EU27 expressed in DALY for the scenario Baseline from WHO 2021 AQG. The total costs for $PM_{2.5}$ related health damage as expressed in DALY amounts to € 330 billion equivalent to 2.06 % of GDP, for NO_2 it amounts to € 65 billion equivalent to 0.41 % of GDP.

Table 27: Costs of the total burden of disease (DALY) valued by VOLY, EU27 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Outcome	EU27		
		Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Asthma, children	5 600	2 050	8 560
	Chronic obstructive pulmonary disease	39 400	6 530	67 000
	Diabetes Mellitus	62 700	34 000	86 600
	Ischemic heart disease	92 400	49 700	131 700
	Lung cancer	52 800	20 300	82 100
	Stroke	76 800	27 400	121 200
	Total for $PM_{2.5}$	**329 800**	**140 000**	**497 200**
NO_2	Asthma, adult	4 870	530	9 270
	Asthma, children	1 680	709	2 280
	Chronic obstructive pulmonary disease	15 380	7 250	22 900
	Diabetes Mellitus	25 500	14 070	37 200
	Stroke	17 550	4 650	29 800
	Total for NO_2	**65 000**	**27 200**	**101 400**

Note: The VOLY estimate used is €136,900 in 2022 prices

Table 28 shows the same results but for the total region, EEA41. In this aggregation, the total costs for $PM_{2.5}$ related health damage as expressed in DALY amounts to € 347 billion equivalent to 1.89 % of GDP, for NO_2 it amounts to € 109 billion equivalent to 0.59 % of GDP.

Table 28: Costs of the total burden of disease (DALY) valued by VOLY, EEA41 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Outcome	All countries		
		Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Asthma, children	5 720	2 100	8 730
	Chronic obstructive pulmonary disease	40 900	6 740	69 300
	Diabetes Mellitus	66 200	36 100	91 000
	Ischemic heart disease	96 400	51 900	137 200
	Lung cancer	55 600	21 400	86 200
	Stroke	81 900	29 600	128 500
	Total for $PM_{2.5}$	**346 700**	**147 800**	**520 800**
NO_2	Asthma, adult	10 030	1 130	18 460
	Asthma, children	3 390	1 470	4 510
	Chronic obstructive pulmonary disease	26 500	12 940	38 500
	Diabetes Mellitus	43 500	24 500	62 400
	Stroke	25 800	6 650	43 500
	Total for NO_2	**109 200**	**46 700**	**167 400**

Note: The VOLY estimate used is €130,700 (2022 prices)

Figure 5 shows the distribution of the total monetised health burden (DALY) in €/capita by country and pollutant when valuing VOLY based on OECD (2025). A table corresponding to this figure is presented in annex 5 (Table 72).

Figure 5: DALY in million €$_{2022}$ per capita valued by VOLY, by country – sensitivity analysis for Baseline from WHO 2021 AQG

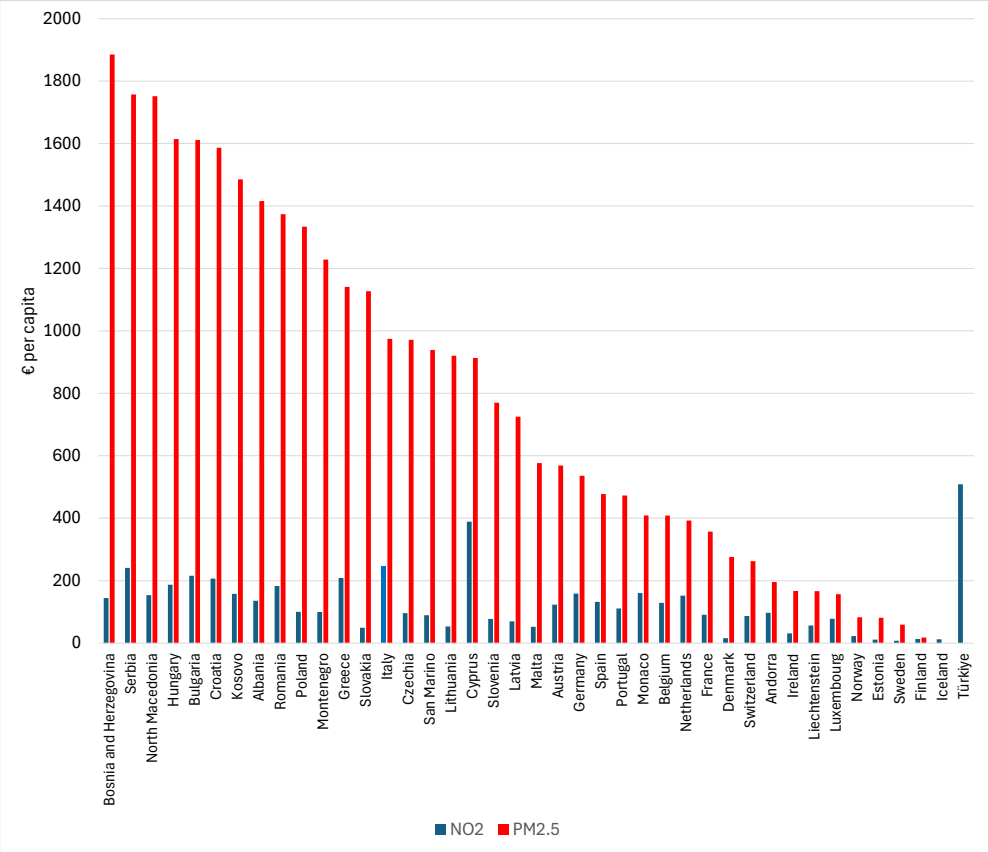

Table 29 and Table 30 present the same results as Table 25 and Table 26, disaggregating DALY into its components YLL and YLD, but using the higher VOLY unit cost estimate from OECD (2025).

Table 29: Costs of YLL and YLD in million €$_{2022}$ using VOLY, EU27 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	Health Indicator	EU27		
				Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Morbidity	Asthma, childhood	YLD	5 540	2 030	8 470
		Chronic obstructive pulmonary disease		15 240	6 100	23 000
		Diabetes Mellitus		15 260	7 900	22 100
		Ischemic heart disease		2 660	1 100	4 190
		Lung cancer		523	221	829
		Stroke		14 850	1 660	27 500
	Mortality	Asthma, childhood	YLL	56	20	87
		Chronic obstructive pulmonary disease		24 100	429	44 000
		Diabetes Mellitus		47 500	26 100	64 500
		Ischemic heart disease		89 800	48 600	127 500
		Lung cancer		52 300	20 100	81 300
		Stroke		62 000	25 800	93 700
NO2	Morbidity	Asthma, adult	YLD	4 520	492	8 600
		Asthma, childhood		1 660	700	2 250
		Chronic obstructive pulmonary disease		4 480	2 560	6 230
		Diabetes Mellitus		10 200	6 010	15 420
		Stroke		4 700	2 450	6 790
	Mortality	Asthma, adult	YLL	349	37	665
		Asthma, childhood		20	8	28
		Chronic obstructive pulmonary disease		10 890	4 680	16 630
		Diabetes Mellitus		15 300	8 060	21 800
		Stroke		12 840	2 200	23 000

Note: The VOLY estimate used is €136,900 (2022 prices)

Table 30: Costs of YLL and YLD in million €$_{2022}$ using VOLY, EEA41 – sensitivity analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	Health Indicator	All countries		
				Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Morbidity	Asthma, childhood	YLD	5 660	2 070	8 630
		Chronic obstructive pulmonary disease		15 650	6 280	23 600
		Diabetes Mellitus		15 880	8 230	23 000
		Ischemic heart disease		3 050	1 260	4 780
		Lung cancer		544	230	859
		Stroke		15 170	1 710	28 000
	Mortality	Asthma, childhood	YLL	61	22	95
		Chronic obstructive pulmonary disease		25 200	450	45 700
		Diabetes Mellitus		50 300	27 900	68 000
		Ischemic heart disease		93 400	50 600	132 400
		Lung cancer		55 000	21 200	85 300
		Stroke		66 700	27 900	100 500
NO2	Morbidity	Asthma, adult	YLD	9 300	1 050	17 110
		Asthma, childhood		3 350	1 450	4 460
		Chronic obstructive pulmonary disease		9 100	5 300	12 450
		Diabetes Mellitus		19 090	11 350	28 500
		Stroke		6 180	3 240	8 870
	Mortality	Asthma, adult	YLL	729	80	1 350
		Asthma, childhood		36	15	48
		Chronic obstructive pulmonary disease		17 380	7 640	26 000
		Diabetes Mellitus		24 400	13 170	33 900
		Stroke		19 620	3 410	34 600

Note: The VOLY estimate used is €130,700 (2022 prices)

4 Monetisation of DALY valuing YLL by VOLY and YLD by incidence lifetime cost of illness

This chapter describes the methods and results of the second approach presented to valuing YLD. The difference compared to chapter 3 consists of the valuation of the years lived with disability by an annualised lifetime per incident. More precisely we use the COI part of the overall lifetime costs and also include disutility related to morbidity. The YLL is still valued using VOLY.

YLD are monetised by a value based on health cost estimates developed for health impact analyses (as for example used in the EEA/ETC externalities work and developed for the EC Clean Air Outlooks and updated in the EU research project VALESOR ([10]) and the WHO EMAPEC study ([11]). These apply to health effects quantified in terms of incidence (new annual cases) and therefore cover lifetime costs.

A possibility to make them applicable to a prevalence-based EBD analysis (that requires monetisation of all cases, existing and new, in a given year), is to calculate an annualised present value of the lifetime cost. Ideally, to annualise lifetime costs, the average length of the disease and its average evolution (how costs vary over the lifetime of the disease) would need to be considered, to correctly discount future costs to a present year. These characteristics tend to be very different for different health endpoints. A further uncertainty in this approach would relate to the distribution of episodes of varying degrees of severity in the year of analysis (2022 in our case), especially whether it could be expected to average out so that the use of an annualised lifetime cost is appropriate.

The following equation was used to calculate the cost of a YLD from lifetime costs per incident case.

$$Cost\ per\ YLD_{incidence} = VYLD_{incidence} = \frac{1}{DW} \times \left(\frac{Lifetime\ cost\ per\ incident\ case}{Disease\ duration}\right)$$

Where

DW: disability weight

Under steady state conditions, the assumption can be made that $VYLD_{incidence}$ is equal to $VYLD_{prevalence}$. The EEA EBD report also uses the steady state assumption in its calculations (see annex 6). The annualised lifetime costs are used as proxy for the cost per prevalent case. A comparison of approaches is provided in section 6.2 for two specific outcomes.

4.1 Core analysis

We adapt a consistent set of incidence-based morbidity costs from Walton et al. (2025), a UK study that was one of the case studies used for the EMAPEC report from WHO-Europe. It has the advantage of being recent and to include all health cost components in a consistent manner for the different health endpoints. The study assesses a set of incidence-based lifetime unit costs per health impact based on recent UK literature and assessments. The disutility part of the morbidity costs is valued through quality adjusted life years (QALY). A quality-adjusted life year is a generic measure of disease burden, including both the quality and the quantity of life lived. One quality-adjusted life year (QALY)

([10]) VALESOR (Valuation of health stressors), https://valesor.eu
([11]) EMAPEC, Estimating the morbidity from air pollution and its economic costs, https://www.who.int/activities/estimating-the-morbidity-from-air-pollution-and-its-economic-costs

is equal to 1 year of life in perfect health. In Walton et al. (2025), a QALY is valued at £ 70,000 in 2022 prices.
Assumptions about duration of illness are taken from Ricardo (2023). The disability weights used are an unweighted average over all ages from the EEA EBD analysis, and the initial values are taken from the Global Burden of Disease data base.

Table 31 presents the initial unit cost data from Walton et al. (2025) in British pounds in 2022 prices.

Table 31: Incidence based unit lifetime health costs per health endpoint, in UK £ in 2022 prices

Health endpoint	Mid value			Low value			High value		
	Direct cost	Indirect cost	Disutility	Direct cost	Indirect cost	Disutility	Direct cost	Indirect cost	Disutility
Asthma, children	7 700	18 000	210 000	6 300	11 000	150 000	9 400	25 000	260 000
Asthma, adults	5 500	18 000	150 000	4 400	11 000	110 000	6 600	25 000	180 000
Chronic obstructive pulmonary disease	18 000	10 000	52 000	15 000	6 000	39 000	22 000	14 000	65 000
Diabetes Type 2	17 000	16 000	220 000	14 000	9 200	170 000	21 000	22 000	280 000
Ischemic heart disease	9 800	1 900	140 000	8 000	1 100	100 000	12 000	2 700	170 000
Lung cancer	34 000	110 000	40 000	28 000	66 000	30 000	42 000	160 000	49 000
Stroke	220 000	13 000	210 000	190 000	7 600	160 000	260 000	19 000	260 000

Source: Walton et al. (2025)

These initial values were converted to €$_{2022}$ using purchasing power parity (PPP) based exchange rates from the OECD ([12]). They were further adapted to EU27 using for

- direct health costs: the ratio of health expenditure per capita between EU27 and the UK from the World Development Indicators (WDI) ([13]) to account for differences between the UK and the other countries in the health system
- indirect health costs: the ratio of GDP per capita in PPP between EU27 and the UK from WDI
- disutility: the ratio of GDP per capita in PPP between EU27 and the UK from WDI

The YLD costs were then calculated from these incidence lifetime costs. The YLD unit costs per health endpoint are presented in Table 32, together with the selected disease duration and disability weights (DW). DWs were calculated as simple average over the age and sex specific values present in the EEA database. ([14])

Table 32: Incidence-based YLD unit cost values per health endpoint, in €$_{2022}$, for EU27

Health endpoint	Disease duration	Disability weight	Cost per YLD		
			Mid	Low	High
Asthma, children	36,2	0,038	155 800	110 500	194 600
Asthma, adult	23,6	0,037	180 600	130 500	220 300
Chronic obstructive pulmonary disease	8,9	0,042	192 400	144 000	243 000
Diabetes mellitus	9,1	0,078	327 700	250 100	418 400
Ischemic heart disease	9,5	0,021	708 400	509 100	862 400
Lung cancer	1,8	0,176	525 300	352 700	717 700
Stroke	14,8	0,166	159 000	127 900	193 700

The values applicable to EEA41 were calculated by multiplying the values estimated for EU27 by the ratio of GDP in 2022 expressed in PPP for EEA41 to EU27 (see Table 33).

Table 33: Incidence-based YLD unit cost values per health endpoint, in €$_{2022}$, for EEA41

Health endpoint	Disease duration	Disability weight	Cost per YLD		
			Mid	Low	High
Asthma, children	36,2	0,038	148 800	105 600	185 900
Asthma, adult	23,6	0,037	172 500	124 700	210 400
Chronic obstructive pulmonary disease	8,9	0,042	183 800	137 500	232 100
Diabetes mellitus	9,1	0,078	313 000	238 900	399 600
Ischemic heart disease	9,5	0,021	676 600	486 200	823 700
Lung cancer	1,8	0,176	501 700	336 900	685 500
Stroke	14,8	0,166	151 900	122 200	185 000

The following results are calculated based on the mid-value, only.

([12]) PPP detailed results, 2020 onwards
([13]) Global Health Expenditure database, World Health Organization (WHO), uri: http://apps.who.int/nha/database
([14]) Note that especially for IHD, but also for COPD and diabetes mellitus these DWs appear low compared to age and sex weighted disability weights calculated for EU27 based on GBD 2023 data.

The costs of the **total health burden** expressed in DALY, aggregating the mortality and the morbidity component, by health endpoint is provided in Table 34 and Table 35 for the scenario Baseline from WHO 2021 AQG, respectively for EU27 and EEA41.

Table 34: Costs of the total burden of disease (DALY) valuing YLL by VOLY and YLD by incidence lifetime cost of illness in million €$_{2022}$, EU27 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Outcome	EU27		
		Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Asthma, children	6 340	2 320	9 700
	Chronic obstructive pulmonary disease	37 000	8 840	60 700
	Diabetes Mellitus	67 100	35 700	94 500
	Ischemic heart disease	71 700	37 000	103 900
	Lung cancer	35 700	13 780	55 600
	Stroke	57 200	18 560	92 400
	Total for $PM_{2.5}$	**275 100**	**116 300**	**416 900**
NO_2	Asthma, adult	6 190	673	11 780
	Asthma, children	1 910	802	2 580
	Chronic obstructive pulmonary disease	13 320	6 620	19 480
	Diabetes Mellitus	34 300	19 570	50 900
	Stroke	13 750	4 260	22 700
	Total for NO_2	**69 400**	**31 900**	**107 500**

Note: The VOLY estimate used is €88,300 (2022 prices)

Using the incidence based-unit cost values for YLD, the total health burden for $PM_{2.5}$, expressed in DALY, amounts to € 275 billion equivalent to 1.72% of GDP in EU27 (Table 34). For NO_2 the respective values are € 69 billion equivalent to 0.43% of GDP.

For EEA41 (Table 35), the incidence based-unit cost values for YLD imply a total health burden for $PM_{2.5}$, expressed in DALY, of € 290 billion (equivalent to 1.58% of GDP). For NO_2 the respective values are € 122 billion (equivalent to 0.66 % of GDP).

Table 35: Costs of the total burden of disease (DALY) valuing YLL by VOLY and YLD by incidence lifetime cost of illness in in million €$_{2022}$, EEA41 – core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Outcome	All countries		
		Impact result - central	Impact result - lower CI	Impact result - upper CI
$PM_{2.5}$	Asthma, children	6 480	2 370	9 890
	Chronic obstructive pulmonary disease	38 300	9 120	62 600
	Diabetes Mellitus	70 500	37 700	99 000
	Ischemic heart disease	76 100	39 200	110 200
	Lung cancer	37 600	14 560	58 400
	Stroke	60 700	19 980	97 400
	Total for $PM_{2.5}$	**289 700**	**123 000**	**437 600**
NO_2	Asthma, adult	12 750	1 440	23 500
	Asthma, children	3 840	1 660	5 110
	Chronic obstructive pulmonary disease	24 000	12 380	34 300
	Diabetes Mellitus	61 400	35 700	90 100
	Stroke	19 850	5 960	32 700
	Total for NO_2	**121 900**	**57 100**	**185 700**

Note: The VOLY estimate used is €84,400 (2022 prices)

Figure 6 shows the distribution of the total monetised health burden (DALY) in €/capita, by country and pollutant when YLD is monetised by the incidence-based unit cost core set. A table showing the exact numbers of this figure is presented in annex 5 (Table 73).

Figure 6: Costs of DALY in million €$_{2022}$ per capita, valuing YLL by VOLY and YLD by incidence lifetime cost of illness, by country – core analysis for Baseline from WHO 2021 AQG

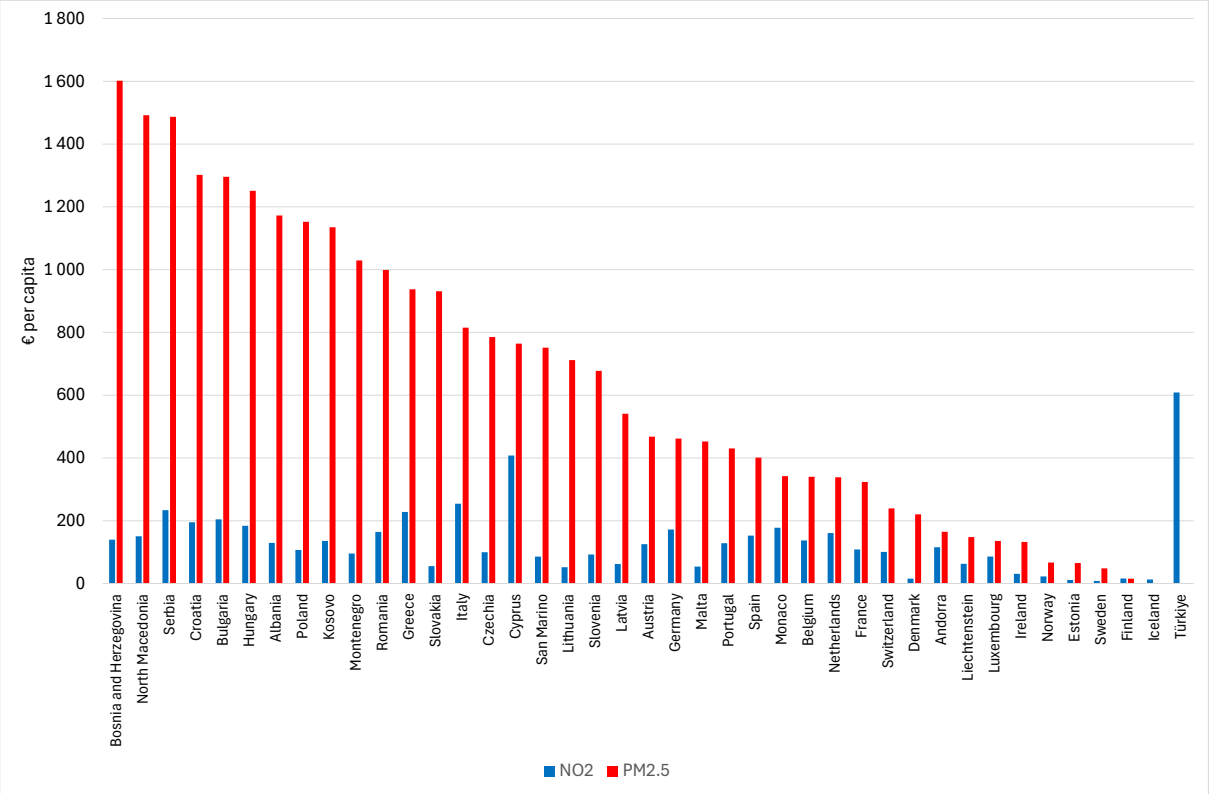

Table 36 and Table 37 present, respectively for EU27 and EEA41, the same results but decomposed in the **mortality (YLL) and morbidity (YLD)** component of the respective health endpoints.

Table 36: Costs of YLL by VOLY and YLD by incidence lifetime cost of illness in million €$_{2022}$ for EU27– core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	Health Indicator	EU27		
				Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Morbidity	Asthma, childhood	YLD	6 310	2 300	9 640
		Chronic obstructive pulmonary disease		21 400	8 570	32 400
		Diabetes Mellitus		36 500	18 910	53 000
		Ischemic heart disease		13 780	5 680	21 700
		Lung cancer		2 010	848	3 180
		Stroke		17 240	1 930	31 900
	Mortality	Asthma, childhood	YLL	36	13	56
		Chronic obstructive pulmonary disease		15 580	277	28 400
		Diabetes Mellitus		30 600	16 840	41 600
		Ischemic heart disease		57 900	31 300	82 300
		Lung cancer		33 700	12 930	52 400
		Stroke		40 000	16 620	60 400
NO2	Morbidity	Asthma, adult	YLD	5 960	649	11 350
		Asthma, childhood		1 890	797	2 560
		Chronic obstructive pulmonary disease		6 300	3 600	8 750
		Diabetes Mellitus		24 400	14 380	36 900
		Stroke		5 460	2 840	7 890
	Mortality	Asthma, adult	YLL	225	24	429
		Asthma, childhood		13	5	18
		Chronic obstructive pulmonary disease		7 030	3 020	10 730
		Diabetes Mellitus		9 870	5 200	14 030
		Stroke		8 280	1 420	14 820

Note: The VOLY estimate used is €88,300 (2022 prices)

Table 37: Costs of YLL by VOLY and YLD by incidence lifetime cost of illness in million €$_{2022}$ for EEA41– core analysis for Baseline from WHO 2021 AQG

Air Pollutant	Category	Outcome	Health Indicator	All countries		
				Impact result - central	Impact result - lower CI	Impact result - upper CI
PM2.5	Morbidity	Asthma, childhood	YLD	6 440	2 360	9 830
		Chronic obstructive pulmonary disease		22 000	8 830	33 100
		Diabetes Mellitus		38 000	19 700	55 100
		Ischemic heart disease		15 790	6 530	24 800
		Lung cancer		2 090	884	3 300
		Stroke		17 630	1 980	32 600
	Mortality	Asthma, childhood	YLL	40	14	61
		Chronic obstructive pulmonary disease		16 270	291	29 500
		Diabetes Mellitus		32 500	18 000	43 900
		Ischemic heart disease		60 300	32 700	85 500
		Lung cancer		35 500	13 670	55 100
		Stroke		43 100	18 000	64 900
NO2	Morbidity	Asthma, adult	YLD	12 270	1 390	22 600
		Asthma, childhood		3 810	1 650	5 080
		Chronic obstructive pulmonary disease		12 790	7 450	17 500
		Diabetes Mellitus		45 700	27 200	68 300
		Stroke		7 180	3 760	10 310
	Mortality	Asthma, adult	YLL	471	52	870
		Asthma, childhood		23	10	31
		Chronic obstructive pulmonary disease		11 230	4 930	16 820
		Diabetes Mellitus		15 730	8 500	21 900
		Stroke		12 670	2 200	22 400

Note: The VOLY estimate used is €84,400 (2022 prices)

4.2 An alternative data set

In this section an alternative set of incidence-based VYLD-prevalence adjusted unit costs per health endpoint is presented and compared to the core data set.

In 2025, SPF (Santé Publique France) published a valuation study of morbidity effects of ambient air pollution. The economic unit values used were developed within the French case study for EMAPEC. Table 38 shows the values estimated for France in € for 2018. The direct and indirect costs are based on a bibliographic study and detailed analysis of data for France. The disutility component was calculated based on a QALY (quality adjusted life year), valuing one QALY at € 45,000 (in 2018 prices).

Table 38: Incidence based unit lifetime health costs per health endpoint for France in € in 2018 prices

	Direct cost	Indirect cost	Disutility
Asthma, children	35 000	32 000	41 000
Asthma, adults	21 000	30 000	27 000
Chronic obstructive pulmonary disease	62 000	12 000	125 000
Diabetes Type 2	52 000	6 000	37 000
Ischemic heart disease (*)	23 000	2 000	30 000
Lung cancer	54 000	8 800	42 000
Stroke	77 000	15 000	33 000

(*) AMI - Acute myocardial infarction (i.e. heart attacks)

These were adjusted consistently with the adjustment of the UK data set in chapter 4.1. All health unit costs were converted to 2022 prices using the EUROSTAT HICP, furthermore, direct health costs were adjusted by the ratio of health expenditure per capita in EU27 in 2022 to the health expenditure per capita in France in 2018. Productivity loss and disutility were adjusted by the ratio of GDP per capita expressed in PPP for EU27 in 2019 (to avoid the covid years) and that for France in 2018. The YLD costs for EU27 were then calculated from these incidence lifetime costs using information on disease duration and the DWs. Conversion to an EEA41 average value relies again on the ratio of GDP (PPP) in EEA41 and that of EU27 in 2022.
Table 39 indicates the resulting unit cost values for the regions EU27 and EEA41, together with the assumed disease duration according to SPF (2025). The disability weights are again calculated as simple average over the age and sex specific values present in the EEA database.

Table 39: Incidence-based YLD unit cost values per health endpoint, in €$_{2022}$, for EU27 and EEA41 - sensitivity 1

Health endpoint	Disease duration	Disability weight	Cost per YLD	
			EU27	EEA41
Asthma, children	36.2	0.038	95 200	90 900
Asthma, adults	23.6	0.037	107 900	103 100
Chronic obstructive pulmonary disease	12.0	0.042	480 900	459 300
Diabetes Type 2	12.0	0.078	126 400	120 700
Ischemic heart disease (*)	10.0	0.021	328 000	313 200
Lung cancer	2.2	0.176	334 300	319 300
Stroke	7.0	0.166	133 900	127 900

(*) AMI - Acute myocardial infarction (i.e. heart attacks)

Table 40 shows the incidence-based lifetime costs by cost component after their conversion to € in 2022 prices for the EU27 region for the two data sets, based on the UK study used in the core analysis and based on the French study presented in this section.
A tendency of higher disutility costs in the UK study (except for COPD) is consistent with the higher value assumed in that study for a QALY compared to that assumed in the French study.
Other differences stem from detailed assumptions in each study. For example, in the UK study, adult asthma covers all adults from age 19, in the French study the population is restricted to the age group

from 18 to 39 years. COPD in the UK study is more closely defined as chronic bronchitis. Treatment of specific diseases may also vary between countries.

Table 40: Incidence based lifetime cost by component in €$_{2022}$ for EU27 based on the UK and the French study

EU27, €2022	Based on Walton et al. (2025)				Based on SPF (2025)			
	Direct cost	Indirect cost	Disutility	Total	Direct cost	Indirect cost	Disutility	Total
Asthma, children	4 670	11 930	139 200	155 800	32 000	27 700	35 500	95 200
Asthma, adults	5 250	18 790	156 600	180 600	30 300	40 900	36 800	107 900
Chronic obstructive pulmonary disease	40 400	24 500	127 500	192 400	155 700	28 500	296 700	480 900
Diabetes Type 2	20 200	20 800	286 600	327 700	70 900	7 730	47 700	126 400
Ischemic heart disease (*)	42 100	8 920	657 400	708 400	141 700	11 640	174 600	328 000
Lung cancer	90 200	319 100	116 000	525 300	177 000	27 300	130 100	334 300
Stroke	75 400	4 870	78 700	159 000	84 300	15 510	34 100	133 900

Table 41 shows the aggregated mid-values for YLD for EU27 in €2022 based on the UK and the French study. Differences between the two studies here are additionally explained by different assumptions about the duration of disease. Assumptions about disease duration are identical in both studies for asthma and close for ischemic heart disease and lung cancer. For COPD and diabetes mellitus the assumed disease duration is higher in the French study, for stroke the assumed duration in the UK study is twice that assumed for France (see Table 32 and Table 39). Differences in the estimated YLD values are the most important for COPD, diabetes and ischemic heart disease.

Table 41: Aggregated mid-values for YLD cost per case of illness (incidence-based approach) for EU27 in €2022 based on the UK and the French study

Health endpoint	VYLD based on Walton et al. (2025)	VYLD based on SPF (2025)
Asthma, children	155 800	95 200
Asthma, adults	180 600	107 900
Chronic obstructive pulmonary disease	192 400	480 900
Diabetes Type 2	327 700	126 400
Ischemic heart disease (AMI)	708 400	328 000
Lung cancer	525 300	334 300
Stroke	159 000	133 900

5 Monetisation of DALY valuing YLL by VOLY and YLD by prevalence cost of illness

In this chapter the third approach to valuing YLD and its results are presented. The difference compared to chapter 4 consists of the valuation of the years lived in disability by an annual cost developed to monetise prevalence. As in the previous chapter, we use the COI part of the overall lifetime costs and also include morbidity related disutility. The mortality component of the DALY (YLL) continues being valued using VOLY.

Using unit costs based on health cost estimates developed for prevalence cost analyses (EBD) avoids the hypotheses used in chapter 4 to adapt an incidence-based lifetime cost into a YLD usable for prevalence. Unlike incidence-based health costs, prevalence-based health costs represent the costs of the mix of illness states of existing and new cases in a given year.

5.1 Stroke

The prevalence cost for stroke is based on Luengo-Fernandez, et al. (2020). The study assesses direct and indirect health costs (COI) across 32 European countries. Direct costs include primary, outpatient, emergency and hospital care, as well as medications and social care. Productivity loss covers losses related to morbidity and to informal care. We excluded productivity losses related to mortality as their inclusion may lead to a double count with the YLL valuation. The application of a consistent approach to collecting health costs in many European countries and the fact that the study appeared rather complete in the health cost items covered, was a reason for its selection. Since disutility is not accounted for in Luengo-Fernandez, et al. (2020), it had to be added.

Table 42 indicates the direct (health care) and indirect (productivity loss) health costs as provided in Luengo-Fernandez, et al. (2020).

Table 42: Prevalence based health costs for stroke in 32 European countries, in million € in 2017 prices

Direct cost	Indirect cost	Total COI
31 340	22 031	53 371

Source: Luengo-Fernandez, et al. (2020)

In a simplified approach, the cost initially expressed in 2017 prices was corrected for inflation and converted to 2022 prices based on the EU27 average consumer price indices from EUROSTAT ([15]). Direct health costs were furthermore adapted by the increase in health expenditure in the European Union between 2017 and 2022 from WDI ([16]). This appeared important as the authors noted that health costs for stroke tended to increase over time. Additionally, productivity loss was adapted for economic growth using real GDP per capita from EUROSTAT. Again, we corrected for economic growth up to 2019 because of, as explained above, the exceptionally high growth in the covid period. Division of the prevalence cost by prevalent cases in 2017 gives the costs per prevalent case per year. Division by the disability weight for stroke (again calculated as an unweighted average over all ages from the EEA EBD analysis, with the initial values extracted from the Global Burden of Disease data base) yields the cost per $YLD_{prevalence}$. It amounts to € 53 thousand per case in $€_{2022}$ (Table 42). To this an estimate for disutility was added, taken from Walton et al. (2025). These authors estimate that disutility accounts for 47% of total health costs for stroke. The resulting $YLD_{prevalence}$ including disutility is hence close to €100,000 per case in $€_{2022}$ for EU27 (Table 43). The corresponding value for EEA41 was

([15]) https://ec.europa.eu/eurostat/databrowser/view/tec00027__custom_8273662/default/table?lang=en
([16]) Global Health Expenditure database, World Health Organization (WHO), uri: http://apps.who.int/nha/database

estimated by multiplying the value for EU27 by the ratio of GDP in purchasing power parity of EEA41 to EU27.

The equation used to calculate the cost of a YLD from costs per prevalent case is the following:

$$Cost\ per\ YLD_{prevalence} = VYLD_{prevalence}\ \frac{1}{DW} \times (Annual\ cost\ per\ prevalent\ case)$$

The calculation is further explained in annex 6.

Adaptation for inflation and growth rate resulted in the total COI of € 78,517 million in 2022 prices. Division by the prevalent cases in 2017 (8.999 million) resulted in a cost per prevalent case of € 8,725. Division by the disability weight for stroke (0.166) yielded the cost per $VYLD_{prevalence}$ for COI of € 52,555. Including finally disutility results in the total $VYLD_{prevalence}$ of €99,992 for EU27 and, after adaption for the ratio of GDP (PPP) in EEA41 and EU27, of € 95,438 for EEA41 (Table 43).

Table 43: $VYLD_{prevalence}$ for stroke in EU27 and EEA41 in €$_{2022}$

	EU27	EEA41
$VYLD_{prevalence}$ for stroke	99 900	95 400

Table 44 provides the prevalence-cost based estimate of DALY, with the YLL component based on ETC HE (2023/11), and the YLD component based on Luengo-Fernandez et al. (2020).

The costs of DALY results are slightly lower, but in the same order of magnitude as the result for the incidence-based valuation approach for stroke presented in Table 34. This is so because the mortality cost estimate for YLL (which is identical in these two tables) dominates the overall DALY result.
The DALY results are lower than those valuing both YLL and YLD by the high VOLY based on OECD (2025) in Table 27.

Table 44: Costs of total burden of disease (DALY), YLL valued by VOLY and YLD valued by prevalence cost of illness for stroke in million €2022 in EU27, Baseline from WHO 2021 AQG, 2022

Air Pollutant	Category	Health Indicator	EU27		
			Damage cost - central	Damage cost - lower CI	Damage cost - upper CI
$PM_{2.5}$	Mortality	YLL	40 000	16 620	60 400
	Morbidity	YLD	10 840	1 220	20 100
	Total burden of disease	**DALY**	**50 800**	**17 840**	**80 500**
NO_2	Mortality	YLL	8 280	1 420	14 820
	Morbidity	YLD	3 430	1 780	4 960
	Total burden of disease	**DALY**	**11 720**	**3 200**	**19 780**

Note: The VOLY estimate used is €88,300 (2022 prices)

The VYLD results are for $PM_{2.5}$ (central value) €10,837 million and for NO_2 (central value) €3,433 million. The results are lower than the respective values in Table 36 for the incidence-based values (for $PM_{2.5}$ €17,240 million and for NO_2 €5,460 million). Note however, that the incidence based VYLD estimate is derived from a UK study, whereas the prevalence based VYLD estimate from a study covering 32 European countries.

Table 45 shows the same results in terms of DALY, YLL and YLD, using for the latter prevalence cost of illness, for the EEA41 region.

Table 45: Costs of total burden of disease (DALY), YLL valued by VOLY and YLD valued by prevalence cost of illness for stroke in million €2022 in EEA41, Baseline from WHO 2021 AQG, 2022

Air Pollutant	Category	Health Indicator	EEA41		
			Damage cost - central	Damage cost - lower CI	Damage cost - upper CI
$PM_{2.5}$	Mortality	YLL	43 100	18 000	64 900
	Morbidity	YLD	11 080	1 250	20 500
	Total burden of disease	**DALY**	**54 200**	**19 250**	**85 300**
NO_2	Mortality	YLL	12 670	2 200	22 400
	Morbidity	YLD	4 510	2 360	6 480
	Total burden of disease	**DALY**	**17 180**	**4 560**	**28 900**

Note: The VOLY estimate used is € 84,400 (2022 prices)

5.2 Lung cancer

The prevalence cost for lung cancer is based on another study by Luengo-Fernandez (2013). This study covers 27 European countries and includes direct health costs (primary, outpatient, inpatient, accident and emergency care, medications) and indirect health costs (productivity losses related to morbidity and informal care). The study is for the year 2009 and costs are expressed in € of 2009. Adaptations from the initial cost data to the $VYLD_{prevalence}$ used in this report are consistent with those applied to the data for stroke (chapter 5.1).

Table 46 indicates the direct (health care) and indirect (productivity loss) health costs as provided in Luengo-Fernandez, et al. (2013).

Table 46: Prevalence based health costs for lung cancer in 27 European countries, in million € in 2009 prices

Direct cost	Indirect cost	Total COI
4 227	4 630	8 857

Source: Luengo-Fernandez, et al. (2013)

Adaptation for inflation and growth rate resulted in the total COI of € 15,930 million in 2022 prices. Division by the prevalent cases in 2009 (542,898) resulted in a cost per prevalent case of € 29,342. Division by the disability weight for lung cancer (0.176) yielded the cost per $VYLD_{prevalence}$ for COI of

€ 166,346. Including finally disutility results in the total $VYLD_{prevalence}$ of € 212,553 for EU27 and, after adaption for the ratio of GDP (PPP) in EEA41 and EU27, of € 203,015 for EEA41 (Table 47).

Table 47: $VYLD_{prevalence}$ for lung cancer in EU27 and EEA41 in $€_{2022}$

	EU27	EEA41
$VYLD_{prevalence}$ for lung cancer	212 600	203 000

Table 48 provides the prevalence-cost based estimate of DALY for EU27, with the YLL component based on ETC HE (2023/11), and the YLD component based on Luengo-Fernandez et al. (2013).

Table 48: Costs of total burden of disease (DALY), YLL valued by VOLY and YLD valued by prevalence cost of illness for lung cancer in million €2022 in EU27, Baseline from WHO 2021 AQG, 2022

Air Pollutant	Category	Health Indicator	EU27		
			Damage cost - central	Damage cost - lower CI	Damage cost - upper CI
$PM_{2.5}$	Mortality	YLL	33 700	12 930	52 400
	Morbidity	YLD	812	343	1 290
	Total burden of disease	**DALY**	**34 500**	**13 280**	**53 700**

Note: The VOLY estimate used is €88,300 (2022 prices)

The DALY result of € 34,537 is very similar to the result for the incidence-based valuation approach for lung cancer presented in Table 34 (€ 35,700). This is so because the mortality cost estimate for YLL is identical in these two tables and the mortality component in DALY accounts for a major part of the total burden of disease of lung cancer.
The DALY result for lung cancer using the prevalence-based approach for VYLD is lower than the one valuing both YLL and YLD by the high VOLY based on OECD (2025) in Table 27.

Table 49 presents the DALY, YLL and YLD results following the prevalence-based monetisation of YLD for the region EEA41.

Table 49: Costs of total burden of disease (DALY), YLL valued by VOLY and YLD valued by prevalence cost of illness for lung cancer in million €2022 in EEA41, Baseline from WHO 2021 AQG, 2022

Air Pollutant	Category	Health Indicator	EEA41		
			Damage cost - central	Damage cost - lower CI	Damage cost - upper CI
$PM_{2.5}$	Mortality	YLL	35 500	13 670	55 100
	Morbidity	YLD	845	358	1 330
	Total burden of disease	**DALY**	**36 400**	**14 030**	**56 400**

Note: The VOLY estimate used is €84,400 (2022 prices)

6 Comparison of DALY costs results for different approaches of valuing YLD

6.1 Total burden of disease cost per pollutant aggregated over all health endpoints

Table 50 and Table 51 show the different estimates of total burden of disease (DALY) costs for NO_2 and for EU27 and EEA41, respectively.

Table 50: Total burden of disease (DALY) costs from exposure to NO_2 in million €$_{2022}$ for EU27 under different valuation approaches for VYLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
41 900	17 550	65 400	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
65 000	27 200	101 400	DALY value= VOLY consistent with OECD, 2025	chapter 3.2
69 400	31 900	107 500	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (Walton et al., 2025)	chapter 4.1
59 900	27 500	91 100	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	

Note: The low VOLY estimate (EEA) used is €88,300, the high VOLY estimate (OECD) is €136,900 (2022 prices)

When YLD are valued by VOLY, only the disutility component of morbidity is accounted for, whereas the cost of illness components (health care costs and productivity loss) of morbidity are neglected. As could be expected, total health burden (DALY) associated with NO_2 is lower for the valuation of YLD with VOLY than with incidence-based disutility and cost of illness based on incidence cost studies. The difference between the results using the two alternative incidence cost data sets (Walton et al., 2025; SPF, 2025) is limited. This is even more so for $PM_{2.5}$, see below.

Table 51: Total burden of disease (DALY) costs from exposure to NO_2 in million €$_{2022}$ for EEA41 under different valuation approaches for VYLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
70 500	30 200	108 100	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
109 200	46 700	167 400	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
121 900	57 100	185 700	DALY value YLL = VOLY from ETC HE 2023/11, VYLD incidence based (Walton et al., 2025)	chapter 4.1
105 400	49 800	157 300	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	

Note: The low VOLY estimate (EEA) used is €84,400, the high VOLY estimate (OECD) is €130,700 (2022 prices)

Figure 7 shows the results, expressed in €/capita, in graphical form by country. A table showing the exact numbers of this figure is presented in annex 5 (Table 74).

Figure 7: Costs of DALY from exposure to NO_2 in million €$_{2022}$ per capita, by country under different valuation approaches for YLD - Baseline from WHO 2021 AQG, 2022

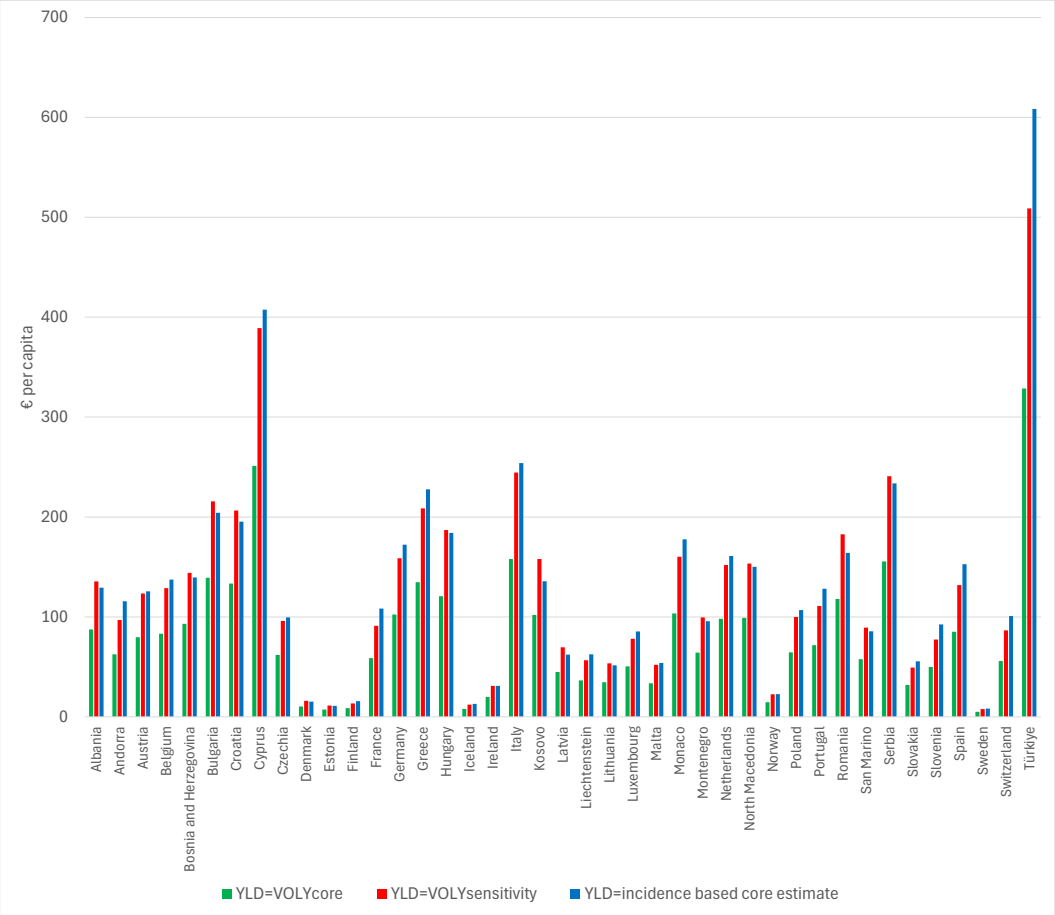

Table 52 and Table 53 show the different estimates of total burden of disease (DALY) for $PM_{2.5}$ and for EU27 and EEA41, respectively.

Table 52: Total burden of disease (DALY) costs from exposure to $PM_{2.5}$ in million €2022 for EU27 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
212 700	90 300	320 700	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
329 800	140 000	497 200	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
275 100	116 300	416 900	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
271 500	112 900	411 300	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	

Note: The low VOLY estimate (EEA) used is €88,300, the high VOLY estimate (OECD) is €136,900 (2022 prices)

Table 53: Total burden of disease (DALY) costs from exposure to $PM_{2.5}$ in million €2022 for EEA41 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
223 900	95 500	336 300	DALY = VOLY from ETC HE 2023/11	chapter 3.1
346 700	147 800	520 800	DALY = VOLY consistent with OECD, 2025	chapter 3.2
289 700	123 000	437 600	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
284 800	119 000	430 000	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	

Note: The low VOLY estimate (EEA) used is €84,400, the high VOLY estimate (OECD) is €130,700, both in prices of 2022

For $PM_{2.5}$, however, DALY values are highest when valuing YLD by the VOLY consistent with the VSL from OECD (2025). This appears counter-intuitive on first sight, because the incidence-based unit costs for VYLD are higher than the VOLY estimates.
The reason for the different patterns between NO_2 (Table 50 and Table 51) and $PM_{2.5}$ (Table 52 and Table 53) is related to how the costs per outcome (which combine number of incidents and their costs) are distinguished within each pollutant when applying a uniform cost per VYLD (Chapter 3) versus the differential costs per VYLD (Chapter 4). For instance, consider diabetes (high cost per YLD) and stroke (half the cost per YLD compared to diabetes). For NO_2, the attributable YLDs related to diabetes are twice as large as the YLDs associated with stroke, whereas for $PM_{2.5}$, the number of attributable YLDs are the same for both health outcomes. Naturally, this will influence the relative change in the estimation of the total cost (sum across outcomes) of each pollutant when assuming a uniform cost per YLD versus a differential cost per YLD.

Figure 8 shows the results expressed in €/capita in graphical form by country. A table showing the exact numbers of this figure is presented in annex 5 (Table 75).

Figure 8: Costs of DALY from exposure to $PM_{2.5}$ in million €$_{2022}$ per capita by country under different valuation approaches for YLD - Baseline from WHO 2021 AQG, 2022

6.2 Total burden of disease costs per pollutant for stroke and lung cancer

In the following tables the DALY associated costs for stroke and lung cancer are compared for the different approaches to valuing YLD. The tables are organised by health endpoint, pollutant and region. Table 54 and Table 55 show the different DALY associated costs for stroke from exposure to NO_2, respectively for EU27 and EEA41.

Table 54: DALY costs for stroke from exposure to NO_2 in million €2022 for EU27 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
11 320	3 000	19 200	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
17 550	4 650	29 800	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
13 750	4 260	22 700	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
12 880	3 810	21 500	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	
11 720	3 200	19 780	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD prevalence based from European study	Chapter 5

Note: The low VOLY estimate (EEA) used is €88,300, the high VOLY estimate (OECD) is €136,900 (2022 prices)

Except for the valuation of YLD by the high VOLY based on OECD (2025), the results are relatively close across the different approaches. The estimate based on the low VOLY is the lowest, as could be expected. The incidence-based estimates are however slightly higher than the prevalence-based estimate. Again, the former are based on one study for the UK and one for France, the latter on a study for Europe.

Table 55: DALY costs for stroke from exposure to NO_2 in million €2022 for EEA41 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
16 660	4 290	28 100	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
25 800	6 650	43 500	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
19 850	5 960	32 700	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
18 720	5 370	31 100	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	
17 180	4 560	28 900	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD prevalence based from European study	Chapter 5

Note: The low VOLY estimate (EEA) used is €84,400, the high VOLY estimate (OECD) is €130,700 (2022 prices)

Table 56 and Table 57 show the different DALY results for stroke from exposure to $PM_{2.5}$, respectively for EU27 and EEA41.

Table 56: DALY costs for stroke from exposure to $PM_{2.5}$ in million €2022 for EU27 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
49 600	17 700	78 200	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
76 800	27 400	121 200	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
57 200	18 560	92 400	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
54 500	18 250	87 300	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	
50 800	17 840	80 500	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD prevalence based from European study	Chapter 5

Note: The low VOLY estimate (EEA) used is €88,300, the high VOLY estimate (OECD) is €136,900 (2022 prices)

The different results for stroke from exposure to $PM_{2.5}$ show the same pattern as those for stroke from exposure to NO_2.

Table 57: DALY costs for stroke from exposure to $PM_{2.5}$ in million €2022 for EEA41 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
52 900	19 100	83 000	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
81 900	29 600	128 500	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
60 700	19 980	97 400	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
57 900	19 670	92 300	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	
54 200	19 250	85 300	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD prevalence based from European study	Chapter 5

Note: The low VOLY estimate (EEA) used is €84,400, the high VOLY estimate (OECD) is €130,700 (2022 prices)

Table 58 and Table 59 show the different DALY results for lung cancer from exposure to $PM_{2.5}$, respectively for EU27 and EEA41.

Also, for lung cancer, DALY for which the YLD component is valued by the low VOLY result in the lowest health burden cost. Those based on the high VOLY lead to the highest estimate. The estimates using incidence- and prevalence-based COI are very close for this health endpoint.

Table 58: DALY costs for lung cancer from exposure to $PM_{2.5}$ in million €2022 for EU27 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
34 100	13 080	53 000	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
52 800	20 300	82 100	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
35 700	13 780	55 600	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
35 000	13 470	54 500	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	
34 500	13 280	53 700	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD prevalence based from European study	Chapter 5

Note: The low VOLY estimate (EEA) used is €88,300, the high VOLY estimate (OECD) is €136,900 (2022 prices)

Table 59: DALY costs for lung cancer from exposure to $PM_{2.5}$ in million €2022 for EEA41 under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

Health cost - central	Health cost - lower CI	Health cost - upper CI	Source values	Chapter reference
35 900	13 820	55 600	DALY value = VOLY from ETC HE 2023/11	chapter 3.1
55 600	21 400	86 200	DALY value = VOLY consistent with OECD, 2025	chapter 3.2
37 600	14 560	58 400	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based from UK study (Walton et al., 2025)	chapter 4.1
36 900	14 240	57 200	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD incidence based (SPF, 2025)	
36 400	14 030	56 400	DALY value: YLL = VOLY from ETC HE 2023/11, VYLD prevalence based from European study	Chapter 5

Note: The low VOLY estimate (EEA) used is €84,400, the high VOLY estimate (OECD) is €130,700 (2022 prices)

7 Discussion and conclusions

This report explored different approaches for an economic valuation of the environmental burden of disease (EBD) of air pollution and calculated the associated economic costs for the results quantified by the EEA's EBD for the year 2022 (ETC HE Report 2024/6).

Given the exploratory nature of the report, all results are to be considered as preliminary and subject to change as approaches and values are refined. This also holds for options taken in areas where there is not complete agreement amongst economists. Conservative options were for example taken with respect to the extrapolation of unit costs by economic growth avoiding covid years, or the choice to not discount the remaining lifetime of an average citizen when estimating VOLY aligned with a given VSL (and vice versa).

The report suggested two sets of VOLY and VSL that could be used for the monetisation of results in terms of YLL and AD, respectively. For the core analysis, the value of a VOLY consistent with the earlier EEA work on health effects of exposure to noise (ETC HE Report 2023/11) was used. A VSL consistent with this VOLY was estimated. For a sensitivity analysis, the most recent meta-analysis by the OECD (2025) on valuation of mortality was suggested as data source for the VSL value, for which a consistent VOLY was estimated.

Next to AD and YLL, the EEA EBD quantifies health effects in terms of DALY. DALYs are composed of YLL (mortality component) and of YLD (morbidity component).

Costs of health impacts can be defined as being composed of direct costs (health treatment costs), indirect costs (productivity loss) and intangible costs (utility loss). Direct and indirect costs are often referred to as cost of illness (COI). Studies that value health impacts of air pollution and other stressors typically start from the quantification of the change in incidence of disease, which is monetised using estimates of the average health cost of illness over its duration. The focus on change in DALY rather than change in incidence requires adaptation of methods previously used in studies assessing monetised health benefits or health damage, to value the outputs of a burden of disease analysis as provided in the EEA's EBD work on air pollution.

While the YLL component is frequently monetised using the VOLY, covering utility loss only, direct and indirect costs (such as medical expenditure, productivity loss…) would ideally apply to the VYLD component.

This exploratory work tested three approaches for valuing YLD, from a simple approach, valuing both DALY components by VOLY, thus capturing only the utility loss when monetising the prevalence based DALYs, to then explore alternative approaches for a more comprehensive valuation, such as including COI. For the monetisation of DALY, three approaches were applied

1. YLL and YLD are valued using VOLY
2. YLL is valued using VOLY, YLD using incidence-based COI data
3. YLL is valued using VOLY, YLD using prevalence-based COI data

Results were calculated for all mortality health endpoints of the 2024 EEA/EBD analysis and for all morbidity health endpoints for approaches 1 and 2. Approach 3 to valuing morbidity required intensive literature and data research as well as testing. Results were calculated for two health endpoints as proof of concept: stroke and lung cancer.

AD calculated for all-cause (natural) and cause-specific mortality are monetised using the VSL. YLL quantified for all-cause and cause-specific mortality are monetised by the VOLY.

For this valuation of mortality, the report uses as core values for VOLY (and consistent VSL) values that are consistent with the earlier EEA work on health effects of exposure to noise (ETC HE Report 2023/11). The sensitivity analysis uses VSL (and consistent VOLY) estimates based on the most recent meta-analysis by the OECD (2025) on valuation of mortality.

For the incidence-based valuation of YLD two data sets are investigated. The core analysis relies on a set of consistent incidence-based life-time costs for the different morbidity health endpoints that is based on a UK study (Walton et al., 2025). The second data set used in a sensitivity analysis relies on a French study (SPF, 2025).

For the prevalence-based valuation of YLD two European multi-country studies were identified that proposed prevalence costs for stroke for 32 European countries (Luengo-Fernandez, 2020) and for lung cancer for 27 European countries (Luengo-Fernandez, 2013).

Monetisation was carried out at the country level for the EEA41 region, by pollutant and monetary indicator, without distinction for age or gender. Region wide average unit cost values (for VOLY, VSL and VYLD) for EU27 and EEA41 are used.

The core and sensitivity values for the valuation of AD and YLL are summarised in Table 60.

Table 60: Values for VOLY and VSL in €$_{2022}$ for EU27 and EEA41

€$_{2022}$	VOLY	VSL
Core values (based on (ETC HE Report 2023/11)		
EU27	88 300	3 404 700
EEA41	84 400	3 251 900
Sensitivity values (based on OECD, 2005)		
EU27	136 900	5 275 200
EEA41	130 700	5 038 500

Comparison of the estimates for all-cause mortality for EU27 and EEA41, respectively by pollutant and mortality indicator (AD, YLL) showed that the results for the sensitivity estimate based on OECD (2025) are 55 % higher than the results for the core analysis estimate based on the ETC HE Report 2023/11.

The core VYLD estimates based on the three approaches explored are summarised in Table 61.

Table 61: Core values for VYLD (mid estimate) in €$_{2022}$ for EU27 and EEA41

EU27, €2022	VYLD based on VOLY (core)		VYLD based on incidence study (core)		VYLD based on prevalence study	
	EU27	EEA41	EU27	EEA41	EU27	EEA41
Asthma, children	88 300	84 400	155 800	148 800		
Asthma, adults	88 300	84 400	180 600	172 500		
Chronic obstructive pulmonary disease	88 300	84 400	192 400	183 800		
Diabetes Type 2	88 300	84 400	327 700	313 000		
Ischemic heart disease	88 300	84 400	708 400	676 600		
Lung cancer	88 300	84 400	525 300	501 700	212 600	203 000
Stroke	88 300	84 400	159 000	151 900	99 900	95 400

A comparison of DALY results was performed for the different approaches to valuing YLD. When YLD are valued by VOLY, only the disutility component of morbidity is accounted for, whereas the cost of

illness components (health care costs and productivity loss) of morbidity are neglected. For NO_2 related health impacts results were as expected (Table 62). Total health burden was lower for the valuation of YLD with VOLY than with incidence-based disutility and cost of illness based on incidence cost studies. This was different for $PM_{2.5}$. Monetised DALY results were highest when valuing YLD by the VOLY consistent with the VSL from OECD (2025). This appeared counter-intuitive on first sight, because the incidence-based unit costs for YLD are higher than the VOLY estimates. The reason for the different patterns between NO_2 and $PM_{2.5}$ is, however, related to how the costs per outcome (which combine number of incidents and their costs) are distinguished within each pollutant when applying a uniform cost per YLD (VOLY) versus the differential costs per YLD (incidence based VYLD). The differences in DALY results based on either of the two incidence-based data sets (core: Walton et al., 2025, sensitivity: SPF, 2025) were very similar, especially for lung cancer and stroke, and for the sum over all health endpoints associated to $PM_{2.5}$ exposure.

Table 62: Total burden of disease (DALY) costs from exposure to NO_2 and $PM_{2.5}$ in million €2022 by region under different valuation approaches for YLD, Baseline from WHO 2021 AQG, 2022

NO_2			$PM_{2.5}$			Source values	Chapter reference
Health cost - central	Health cost - lower CI	Health cost - upper CI	Health cost - central	Health cost - lower CI	Health cost - upper CI		
EU27							
41 900	17 550	65 400	212 700	90 300	320 700	DALY = VOLY from ETC HE 2023/11	chapter 3.1
65 000	27 200	101 400	329 800	140 000	497 200	DALY = VOLY consistent with OECD, 2025	chapter 3.2
69 400	31 900	107 500	275 100	116 300	416 900	DALY: YLL = VOLY from ETC HE 2023/11, VYLD incidence based	chapter 4.1
EEA41							
70 500	30 200	108 100	223 900	95 500	336 300	DALY = VOLY from ETC HE 2023/11	chapter 3.1
109 200	46 700	167 400	346 700	147 800	520 800	DALY = VOLY consistent with OECD, 2025	chapter 3.2
121 900	57 100	185 700	289 700	123 000	437 600	DALY: YLL = VOLY from ETC HE 2023/11, VYLD incidence based	chapter 4.1

Finally, the DALY results for stroke and lung cancer were compared for the different approaches to valuing YLD. Except for the valuation of YLD by the high VOLY based on OECD (2025), the results proved to be relatively close across the different approaches. The estimate based on the low VOLY was the lowest, as could be expected.

The studies selected for the prevalence-based approach to valuing YLD applied consistent approaches to assessing the costs of prevalence in various European countries (32 countries for stroke and 27 for lung cancer). Furthermore, the studies covered the main health cost components. For these reasons they were considered as an interesting basis to valuing prevalence of health effects in the European region as calculated in the EEA EBD. As a disadvantage they are rather old, in particular the lung cancer study. Using prevalence-based studies to monetise prevalence would be most natural. It requires fewer assumptions in the calculation of a VYLD than are required for incidence-based studies. However, more analysis is needed to assess whether such multi-country studies can be found for the other health endpoints assessed in the EEA EBD.

No such multi-country studies could be identified for the incidence-based approach to valuing YLD. Incidence-based studies were thus selected based on other criteria. These were the coverage of the complete set of health endpoints assessed in the EBD, and a publication year as recent as possible. Two alternative sets of incidence-based VYLDs were thus suggested. The first is based on the incidence life-time cost set developed for the UK in Walton et al. (2025), the second is based on the incidence life-time cost set developed for France (SPF, 2025).
A comparison of the two, once adjusted to average values for EU27 and EEA41, showed rather strong differences for some of the health endpoints. Some of these can be explained by obvious differences in assumptions applied in the two background studies, such as different values for a QALY used to estimate the disutility cost component of each health endpoint. Others are likely to stem from detailed assumptions in each study (such as possibly different age groups, the inclusion of different treatment options, or differences in the exact definition of the health endpoint). Differences between the health systems of the two countries may also play a role. More detailed analyses would be necessary to identify all explanations, and which assumptions would best apply to a European average.

For this exploratory work, all results were presented for the health effects quantified in the scenario "Baseline from WHO 2021 AQG" setting as counterfactual concentrations the WHO (2021) air quality guidelines values. In future work, results could be provided for all scenarios studied in the EBD.

The work demonstrates the feasibility of valuation using data from a number of sources. Further evaluation of these sources is needed to identify the figures most suitable for use at EU and EEA levels. This would naturally simplify the presentation of results compared to the rather long collections of tables presented here. It is important to recognise the exploratory nature of the assessment provided in this report.

Finally, monetisation was carried out at the country level for the EEA41 region but applying average region wide unit cost values (for VOLY, VSL and VYLD) for EU27 and EEA41 to all countries. When analyses concern a common policy across multiple countries (e.g. across the EU, or across UNECE Member States) it is common practice to use a value averaged across the countries that are covered by the analysis. It appears good practice also to use in a European EBD. When carrying out analysis within a single country, variation in values between countries, e.g. with respect to wage rates (for productivity) or wealth (for disutility) should be recognised. Such country specific estimates could be provided in future work.

Which approach to valuation of YLD should be favoured depends on priorities. Including COI into the valuation is preferable over including only disutility (YLL), as this would tend towards an underestimate of health costs. It should, however, be noted that there is a risk that mortality disutility values might partially include COI. OECD (2025) caution the reader about this possibility but still recommend adding COI to VSL.
For the prevalence-based EBDs it would be best to use prevalence-based health costs. However, if the aim is to be consistent with other work for the European Commission monetizing health effects of air pollution, the incidence-based values, adapted as described in this report, could be preferred. Also, incidence-based cost data are more easily available. Developing a full set of unit health cost data for the EEA EBD for ambient air pollution might be less resource intensive than setting up the full set based on prevalence cost studies.

Possible future work on the monetisation of EBD will have to be adjusted to the evolving health effects considered in the EEA EBD. In the latest update of the EBD (ETC HE Report 2025/8), dementia was included as an additional health endpoint. 'Dementia' covers a range of conditions that have significant impact on cognitive abilities (memory, language, executive function, maintaining attention, social cognition and visuospatial abilities). The most common form of dementia is Alzheimer's disease,

caused by the accumulation of abnormal proteins in the brain. This is followed by vascular dementia linked to reduced blood flow to the brain and dementia with Lewy bodies, which, like Alzheimer's, is caused by abnormal protein build-up in the brain. The leading form of early-onset dementia (before age 65) is frontotemporal dementia (affecting the frontal and temporal lobes of the brain) though this accounts for only around 2% of all cases. Dementia is recognised as a cause of death but given the age of people suffering from the condition it is difficult to assess the reliability of data given that individuals are likely to be suffering a number of health conditions (e.g. respiratory, cardiovascular) alongside their dementia. Estimates of the duration of dementia are in the region of 8-10 years. However, over this period the condition develops from being relatively minor with people continuing to live independent lives, to severe with individuals left with very limited cognition and fully dependent on others for care. In view of the age of those affected, many sufferers may die before they reach this stage. Given these issues, the attribution of a specific disability weight to the condition is complex. Whilst it would be useful to continue to research the issue, it was considered premature to conclude on this in the context of the current report. In this context, note that the ETC HE Report 2025/8 used the concentration-response function from Forastiere et al. (2024) of 1.46 (1.20 - 1.78). A revised function based on Best Rogowski et al. (2025), mentioned in the recent HRAPIE 2 (WHO, 2025), suggests a significantly lower relative risk for PM2.5 (1.17, 95% CI: 1.10–1.25) that would reduce the burden of dementia by 56%, i.e. to levels half as large as COPD.

List of abbreviations

Abbreviation	Name	Reference
AD	Attributable Death	
AMI	Acute myocardial infarction (heart attack)	
AQG	Air Quality Guidelines (from WHO)	
CI	Confidence Interval	
COI	Cost of Illness	
COPD	Chronic Obstructive Pulmonary Disease	
DALY	Disability adjusted Life Year	
DW	Disability weight	
EBD	Environmental Burden of Disease	
EEA	European Environment Agency	www.eea.europa.eu
EMAPEC	Estimating the morbidity from air pollution and its economic costs, WHO project	https://www.who.int/activities/estimating-the-morbidity-from-air-pollution-and-its-economic-costs
ETC HE	European Topic Centre on Human Health and the Environment	
GDP	Gross Domestic Product	
HADEA	European health and digital executive agency	
HICP	Harmonised Index of Consumer Prices	
NO_2	Nitrogen dioxide	
O_3	Ozone	
OECD	Organisation for Economic Cooperation and Development	https://www.oecd.org/
$PM_{2.5}$	Particulate matter with an aerodynamic diameter less than 2.5 microns	
PPP	Purchasing Power Parity	
QALY	Quality Adjusted Life Year	
SOMO35	Sum of means over 35ppb (measure of O_3 concentration)	
VALESOR	Valuation of health stressors, EU research project	https://valesor.eu
VOLY	Value of a statistical Life Year	
VSL	Value of Statistical Life	
VYLD	Value of Years Lived with Disability	
WDI	World Development Indicators, World Bank data bank	https://databank.worldbank.org/source/world-development-indicators
WHO	World Health Organisation	https://www.who.int/home
WTP	Willingness To Pay	
YLD	Years Lived with Disability	
YLL	Years of Life Lost	

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Annex 1 Specific results – AD valued by low VSL, YLL and YLD valued by low VOLY

Core values for VOLY and VSL in €$_{2022}$, respectively, for EEA41 are € 84,400 and € 3.252 million (see chapter 2.1).

Table 63: Country specific results by aggregated indicator and pollutant, in €$_{2022}$ million for EEA41 – VOLY/VSL core

Air Pollutant	NO_2					O_3						$PM_{2.5}$				
Category	morbidity	mortality, all-cause		mortality, cause-specific		mortality, all-cause, peak		mortality, cause-specific, peak		mortality, all-cause, SOMO35		morbidity	mortality, all-cause		mortality, cause-specific	
Outcome	YLD	AD	YLL	AD	YLL	AD	YLL	AD	YLL	AD	YLL	YLD	AD	YLL	AD	YLL
Albania	65	1 130	305	767	179	2 280	620	159	41	872	243	550	11 860	3 200	8 870	2 240
Andorra	3	20	5	7	2	26	7	0	0	10	3	5	42	12	16	8
Austria	256	2 410	590	1 900	459	4 790	1 180	644	179	1 860	473	995	10 840	2 650	11 130	2 760
Belgium	380	3 870	1 000	2 170	585	4 590	1 190	680	208	1 670	452	1 140	13 350	3 450	8 730	2 540
Bosnia and Herzegovina	89	1 390	340	989	233	3 070	757	224	56	1 260	321	938	19 630	4 820	14 660	3 660
Bulgaria	257	4 080	1 010	2 990	645	3 040	760	117	30	1 470	377	1 440	27 000	6 700	25 600	5 890
Croatia	141	1 380	322	1 760	374	3 230	756	341	75	1 270	306	889	12 000	2 800	14 980	3 400
Cyprus	112	826	205	891	203	410	103	42	10	237	61	210	2 180	539	2 270	616
Czechia	213	2 140	572	1 780	439	6 050	1 620	663	188	2 220	611	1 550	22 200	5 910	23 800	5 760
Denmark	19	182	48	150	41	1 720	455	433	116	556	152	326	3 850	1 010	3 180	881
Estonia	3	42	12	20	6	413	109	20	6	117	31	20	289	76	241	61
Finland	24	176	43	81	24	1 410	346	120	35	403	101	23	228	56	189	51
France	2 050	15 140	4 070	7 080	1 830	29 300	7 920	1 860	528	11 510	3 270	7 200	66 000	17 730	38 700	11 420
Germany	3 620	29 600	7 370	19 850	4 910	50 300	12 610	6 640	1 920	18 730	4 830	9 870	105 200	26 200	93 100	23 200
Greece	535	6 940	1 580	4 150	873	7 230	1 650	650	123	3 290	772	2 360	33 800	7 700	26 700	6 600
Hungary	357	3 840	1 050	2 930	803	7 080	1 940	963	296	2 690	753	1 830	27 700	7 540	34 700	8 900
Iceland	1	7	2	0	1	68	19	13	3	16	5	0	0	0	0	0
Ireland	40	325	97	228	62	839	251	166	45	273	86	155	1 680	499	1 600	476
Italy	3 370	37 600	8 560	30 200	5 950	44 000	10 040	5 160	948	18 210	4 250	13 550	165 800	37 700	140 600	30 800
Kosovo	35	849	229	280	145	1 020	279	36	19	478	133	221	7 800	2 100	2 930	1 550

Air Pollutant	NO_2					O_3						$PM_{2.5}$				
Category	morbidity	mortality, all-cause		mortality, cause-specific		mortality, all-cause, peak		mortality, cause-specific, peak		mortality, all-cause, SOMO35		morbidity	mortality, all-cause		mortality, cause-specific	
Outcome	YLD	AD	YLL	AD	YLL	AD	YLL	AD	YLL	AD	YLL	YLD	AD	YLL	AD	YLL
Latvia	19	354	95	283	65	748	200	23	7	241	66	141	2 610	694	3 560	812
Liechtenstein	1	7	2	3	1	16	5	3	0	7	2	2	23	7	23	3
Lithuania	32	423	109	283	64	1 070	276	46	12	345	91	332	4 670	1 200	6 970	1 470
Luxembourg	15	101	30	59	17	192	56	26	9	68	21	27	241	70	159	50
Malta	5	49	14	39	12	208	59	23	6	104	30	42	550	154	592	176
Monaco	2	13	4	0	2	23	6	0	0	10	3	5	42	12	16	8
Montenegro	11	195	51	101	28	455	118	23	7	185	50	101	2 530	649	1 510	425
Netherlands	720	5 760	1 520	3 750	1 010	6 020	1 590	972	285	2 120	583	1 650	16 820	4 430	12 220	3 540
North Macedonia	53	901	217	507	129	832	202	49	13	449	112	438	11 140	2 680	6 640	1 790
Norway	31	257	63	182	48	1 240	304	283	74	367	94	101	1 100	267	881	239
Poland	938	8 850	2 590	5 250	1 440	17 860	5 260	901	255	6 320	1 910	8 480	111 100	32 500	99 200	26 400
Portugal	327	2 430	615	1 740	385	4 800	1 220	358	80	1 780	465	1 250	11 900	3 010	8 970	2 330
Romania	497	10 530	2 820	7 430	1 750	9 910	2 670	702	189	3 780	1 060	2 580	58 200	15 590	65 000	15 670
San Marino	1	7	2	0	1	20	5	0	1	7	2	7	81	21	62	17
Serbia	294	4 590	1 130	3 260	764	5 190	1 280	403	100	2 120	538	1 710	34 900	8 570	26 900	6 700
Slovakia	77	706	205	341	96	2 840	829	127	41	1 070	327	878	11 780	3 410	13 370	3 390
Slovenia	53	433	117	228	52	1 170	319	59	16	491	134	384	4 150	1 120	3 100	836
Spain	1 680	16 360	4 220	9 570	2 190	22 100	5 710	2 110	516	8 600	2 290	5 350	59 600	15 350	41 400	11 570
Sweden	21	182	45	120	31	2 450	606	319	83	790	203	144	1 550	383	1 300	334
Switzerland	247	1 900	481	956	241	4 160	1 060	442	127	1 660	444	682	6 010	1 520	4 230	1 120
Türkiye	13 770	58 600	19 030	46 500	14 060	12 950	4 260	2 100	583	7 310	2 790	0	0	0	0	0

Annex 2 Country specific results – AD valued by high VSL, YLL and YLD valued by high VOLY

Sensitivity values for VOLY and VSL in €$_{2022}$, respectively, for EEA41 are € 130,700 and € 5.039 million (see chapter 2.2).

Table 64: Country specific results by aggregated indicator and pollutant, in €$_{2022}$ million for EEA41 – VOLY/VSL sensitivity

Air Pollutant	NO_2					O_3						$PM_{2.5}$				
Category	morbidity	mortality, all-cause		mortality, cause-specific		mortality, all-cause, peak		mortality, cause-specific, peak		mortality, all-cause, SOMO35		morbidity	mortality, all-cause		mortality, cause-specific	
Outcome	YLD	AD	YLL	AD	YLL	AD	OLL	AD	YLL	AD	YLL	YLD	AD	YLL	AD	YLL
Albania	101	1 750	472	1 190	277	3 540	960	247	63	1 350	376	851	18 380	4 960	13 750	3 480
Andorra	4	30	8	10	4	40	11	0	1	15	4	7	66	18	25	12
Austria	397	3 730	913	2 940	711	7 420	1 830	998	278	2 890	732	1 540	16 790	4 110	17 250	4 280
Belgium	589	6 000	1 550	3 370	906	7 110	1 850	1 050	323	2 590	699	1 760	20 700	5 350	13 520	3 930
Bosnia and Herzegovina	138	2 150	527	1 530	361	4 760	1 170	348	87	1 960	498	1 450	30 400	7 460	22 700	5 670
Bulgaria	398	6 320	1 570	4 630	999	4 720	1 180	181	46	2 270	583	2 220	41 800	10 370	39 600	9 120
Croatia	218	2 140	499	2 730	579	5 000	1 170	529	116	1 970	473	1 380	18 590	4 330	23 200	5 260
Cyprus	174	1 280	317	1 380	315	635	159	66	15	368	94	325	3 370	835	3 520	954
Czechia	329	3 320	885	2 750	680	9 370	2 510	1 030	292	3 450	946	2 400	34 400	9 160	36 900	8 910
Denmark	30	282	75	232	64	2 670	705	670	179	862	236	505	5 960	1 570	4 930	1 370
Estonia	5	66	18	30	10	640	169	30	9	181	48	30	448	117	373	95
Finland	37	272	67	126	37	2 180	535	186	55	625	157	35	353	87	292	79
France	3 170	23 500	6 300	10 970	2 840	45 400	12 270	2 880	818	17 840	5 060	11 150	102 200	27 500	60 000	17 680
Germany	5 610	45 800	11 410	30 700	7 600	78 000	19 520	10 290	2 970	29 000	7 470	15 280	162 900	40 600	144 200	36 000
Greece	829	10 750	2 440	6 430	1 350	11 210	2 560	1 010	190	5 100	1 200	3 650	52 400	11 920	41 400	10 230
Hungary	552	5 950	1 620	4 540	1 240	10 960	3 000	1 490	458	4 160	1 170	2 830	42 800	11 670	53 700	13 780
Iceland	2	10	4	0	2	106	29	20	5	25	8	0	0	0	0	0
Ireland	63	504	151	353	96	1 300	389	257	70	423	133	240	2 600	773	2 470	737
Italy	5 230	58 300	13 260	46 800	9 210	68 100	15 550	8 000	1 470	28 200	6 580	21 000	257 000	58 400	217 900	47 700
Kosovo	55	1 320	355	433	225	1 590	431	55	30	741	207	342	12 080	3 260	4 540	2 410

Air Pollutant	NO_2					O_3						$PM_{2.5}$				
Category	morbidity	mortality, all-cause		mortality, cause-specific		mortality, all-cause, peak		mortality, cause-specific, peak		mortality, all-cause, SOMO35		morbidity	mortality, all-cause		mortality, cause-specific	
Outcome	YLD	AD	YLL	AD	YLL	AD	OLL	AD	YLL	AD	YLL	YLD	AD	YLL	AD	YLL
Latvia	30	549	147	438	100	1 160	310	35	11	373	102	219	4 050	1 070	5 510	1 260
Liechtenstein	1	10	3	5	1	25	7	5	1	10	3	4	35	10	35	4
Lithuania	50	655	168	438	100	1 660	428	71	18	534	141	515	7 230	1 850	10 790	2 280
Luxembourg	23	156	46	91	27	297	86	40	13	106	33	41	373	108	247	78
Malta	8	76	22	60	18	322	91	35	10	161	46	65	852	238	917	272
Monaco	3	20	7	0	3	35	10	0	1	15	5	7	66	19	25	12
Montenegro	17	302	78	156	44	705	183	35	11	287	77	157	3 910	1 010	2 340	659
Netherlands	1 120	8 930	2 350	5 810	1 560	9 320	2 460	1 510	442	3 290	902	2 550	26 100	6 850	18 930	5 470
North Macedonia	82	1 400	336	786	199	1 290	312	76	21	695	174	679	17 260	4 150	10 280	2 770
Norway	47	398	97	282	74	1 920	471	438	115	569	145	157	1 700	413	1 370	371
Poland	1 450	13 700	4 000	8 130	2 230	27 700	8 140	1 400	395	9 780	2 960	13 140	172 100	50 300	153 700	40 900
Portugal	507	3 760	952	2 690	596	7 440	1 890	554	125	2 760	720	1 930	18 440	4 670	13 900	3 600
Romania	770	16 310	4 370	11 510	2 710	15 350	4 130	1 090	292	5 850	1 630	3 990	90 200	24 100	100 700	24 300
San Marino	1	10	3	0	2	30	8	0	1	10	3	10	126	32	96	27
Serbia	455	7 110	1 740	5 040	1 180	8 040	1 980	625	155	3 290	834	2 650	54 100	13 270	41 600	10 380
Slovakia	119	1 090	317	529	149	4 400	1 280	197	63	1 660	507	1 360	18 250	5 290	20 700	5 240
Slovenia	82	670	182	353	81	1 820	493	91	24	761	207	595	6 430	1 740	4 810	1 290
Spain	2 590	25 400	6 530	14 820	3 390	34 200	8 850	3 280	800	13 330	3 540	8 290	92 300	23 800	64 200	17 910
Sweden	33	282	70	186	48	3 790	939	494	128	1 220	314	223	2 410	593	2 020	517
Switzerland	383	2 940	746	1 480	373	6 440	1 640	685	197	2 580	688	1 060	9 320	2 360	6 560	1 730
Türkiye	21 300	90 800	29 500	72 000	21 800	20 100	6 600	3 260	902	11 320	4 320	0	0	0	0	0

Annex 3 Country specific results – AD valued by low VSL, YLL by low value and YLD by incidence-based unit cost

Core values for VOLY and VSL in $€_{2022}$, respectively, for EEA41 are € 84,400 and € 3.252 million (see chapter 4.1).
Incidence-based unit costs for $YLD_{prevalence}$ are recalled in Table 65.

Table 65: Incidence-based YLD mid unit cost values per health endpoint, in $€_{2022}$, for EEA41

Health endpoint	Cost per YLD
	Mid
Asthma, children	148 800
Asthma, adult	172 500
Chronic obstructive pulmonary disease	183 800
Diabetes mellitus	313 000
Ischemic heart disease	676 600
Lung cancer	501 700
Stroke	151 900

Table 66: Country specific results by aggregated indicator and pollutant, in €$_{2022}$ million for EEA41 – VOLY/VSL core and incidence based YLD

Air Pollutant	NO_2					O_3						$PM_{2.5}$				
Category	morbidity	mortality, all-cause		mortality, cause-specific		mortality, all-cause, peak		mortality, cause-specific, peak		mortality, all-cause, SOMO35		morbidity	mortality, all-cause		mortality, cause-specific	
Outcome	YLD	AD	YLL	AD	YLL	AD	YLL	AD	YLL	AD	YLL	YLD	AD	YLL	AD	YLL
Albania	182	1 130	305	767	179	2 280	620	159	41	872	243	1 030	11 860	3 200	8 870	2 240
Andorra	7	20	5	7	2	26	7	0	0	10	3	6	42	12	16	8
Austria	668	2 410	590	1 900	459	4 790	1 180	644	179	1 860	473	1 440	10 840	2 650	11 130	2 760
Belgium	1 010	3 870	1 000	2 170	585	4 590	1 190	680	208	1 670	452	1 410	13 350	3 450	8 730	2 540
Bosnia and Herzegovina	250	1 390	340	989	233	3 070	757	224	56	1 260	321	1 890	19 630	4 820	14 660	3 660
Bulgaria	679	4 080	1 010	2 990	645	3 040	760	117	30	1 470	377	2 510	27 000	6 700	25 600	5 890
Croatia	381	1 380	322	1 760	374	3 230	756	341	75	1 270	306	1 630	12 000	2 800	14 980	3 400
Cyprus	309	826	205	891	203	410	103	42	10	237	61	344	2 180	539	2 270	616
Czechia	608	2 140	572	1 780	439	6 050	1 620	663	188	2 220	611	2 500	22 200	5 910	23 800	5 760
Denmark	48	182	48	150	41	1 720	455	433	116	556	152	412	3 850	1 010	3 180	881
Estonia	8	42	12	20	6	413	109	20	6	117	31	26	289	76	241	61
Finland	64	176	43	81	24	1 410	346	120	35	403	101	34	228	56	189	51
France	5 310	15 140	4 070	7 080	1 830	29 300	7 920	1 860	528	11 510	3 270	9 890	66 000	17 730	38 700	11 420
Germany	9 430	29 600	7 370	19 850	4 910	50 300	12 610	6 640	1 920	18 730	4 830	15 200	105 200	26 200	93 100	23 200
Greece	1 510	6 940	1 580	4 150	873	7 230	1 650	650	123	3 290	772	3 190	33 800	7 700	26 700	6 600
Hungary	966	3 840	1 050	2 930	803	7 080	1 940	963	296	2 690	753	3 120	27 700	7 540	34 700	8 900
Iceland	3	7	2	0	1	68	19	13	3	16	5	0	0	0	0	0
Ireland	97	325	97	228	62	839	251	166	45	273	86	206	1 680	499	1 600	476
Italy	9 050	37 600	8 560	30 200	5 950	44 000	10 040	5 160	948	18 210	4 250	17 320	165 800	37 700	140 600	30 800
Kosovo	95	849	229	280	145	1 020	279	36	19	478	133	459	7 800	2 100	2 930	1 550
Latvia	52	354	95	283	65	748	200	23	7	241	66	202	2 610	694	3 560	812

Air Pollutant	NO_2					O_3						$PM_{2.5}$				
Category	morbidity	mortality, all-cause		mortality, cause-specific		mortality, all-cause, peak		mortality, cause-specific, peak		mortality, all-cause, SOMO35		morbidity	mortality, all-cause		mortality, cause-specific	
Outcome	YLD	AD	YLL	AD	YLL	AD	YLL	AD	YLL	AD	YLL	YLD	AD	YLL	AD	YLL
Liechtenstein	2	7	2	3	1	16	5	3	0	7	2	3	23	7	23	3
Lithuania	80	423	109	283	64	1 070	276	46	12	345	91	523	4 670	1 200	6 970	1 470
Luxembourg	38	101	30	59	17	192	56	26	9	68	21	37	241	70	159	50
Malta	16	49	14	39	12	208	59	23	6	104	30	60	550	154	592	176
Monaco	5	13	4	0	2	23	6	0	0	10	3	6	42	12	16	8
Montenegro	31	195	51	101	28	455	118	23	7	185	50	210	2 530	649	1 510	425
Netherlands	1 820	5 760	1 520	3 750	1 010	6 020	1 590	972	285	2 120	583	2 420	16 820	4 430	12 220	3 540
North Macedonia	147	901	217	507	129	832	202	49	13	449	112	953	11 140	2 680	6 640	1 790
Norway	75	257	63	182	48	1 240	304	283	74	367	94	124	1 100	267	881	239
Poland	2 500	8 850	2 590	5 250	1 440	17 860	5 260	901	255	6 320	1 910	16 080	111 100	32 500	99 200	26 400
Portugal	888	2 430	615	1 740	385	4 800	1 220	358	80	1 780	465	1 950	11 900	3 010	8 970	2 330
Romania	1 380	10 530	2 820	7 430	1 750	9 910	2 670	702	189	3 780	1 060	3 340	58 200	15 590	65 000	15 670
San Marino	1	7	2	0	1	20	5	0	1	7	2	8	81	21	62	17
Serbia	825	4 590	1 130	3 260	764	5 190	1 280	403	100	2 120	538	3 400	34 900	8 570	26 900	6 700
Slovakia	206	706	205	341	96	2 840	829	127	41	1 070	327	1 670	11 780	3 410	13 370	3 390
Slovenia	142	433	117	228	52	1 170	319	59	16	491	134	592	4 150	1 120	3 100	836
Spain	4 740	16 360	4 220	9 570	2 190	22 100	5 710	2 110	516	8 600	2 290	6 620	59 600	15 350	41 400	11 570
Sweden	55	182	45	120	31	2 450	606	319	83	790	203	168	1 550	383	1 300	334
Switzerland	640	1 900	481	956	241	4 160	1 060	442	127	1 660	444	974	6 010	1 520	4 230	1 120
Türkiye	37 400	58 600	19 030	46 500	14 060	12 950	4 260	2 100	583	7 310	2 790	0	0	0	0	0

Annex 4 Country specific results – AD valued by low VSL, YLL by low value and YLD by prevalence-based unit cost

Core values for VOLY and VSL in €$_{2022}$, respectively, for EEA41 are € 84,400 and € 3.252 million (see chapter 5).
Prevalence-based unit costs for $VYLD_{prevalence}$ are € 203,000 for lung cancer and € 95,400 for stroke.

Table 67: Country specific results by aggregated indicator and pollutant, in €$_{2022}$ million for EEA41 – VOLY/VSL core and incidence based YLD for stroke and lung cancer

Air Pollutant	**NO_2**			**$PM_{2.5}$**					
Category	**morbidity**	**mortality, cause-specific**		**morbidity**		**mortality, cause-specific**			
Outcome	**YLD**	**AD**	**YLL**	**YLD**		**AD**		**YLL**	
Health Indicator	Stroke	Stroke	Stroke	Lung cancer	Stroke	Lung cancer	Stroke	Lung cancer	Stroke
Albania	12	315	68	6	79	1 030	2 880	424	619
Andorra	0	3	1	0	0	3	7	2	2
Austria	61	410	88	11	175	1 260	1 690	490	363
Belgium	43	709	164	17	94	1 770	2 250	690	521
Bosnia and Herzegovina	17	400	89	15	143	1 870	4 720	659	1 050
Bulgaria	95	2 290	465	14	391	1 600	13 450	560	2 730
Croatia	40	361	74	12	212	1 530	2 770	524	568
Cyprus	24	156	35	2	40	257	371	97	83
Czechia	40	426	98	18	258	2 330	3 940	793	901
Denmark	4	33	8	5	57	576	634	200	151
Estonia	1	7	2	0	2	23	52	8	13
Finland	5	39	9	0	4	23	46	8	11
France	299	2 480	581	86	836	8 020	10 050	3 450	2 350
Germany	831	5 260	1 160	104	1 880	11 570	17 350	4 340	3 810
Greece	141	1 890	354	33	431	3 990	8 220	1 420	1 540
Hungary	89	989	239	33	400	3 930	6 400	1 390	1 550
Iceland	0	0	0	0	0	0	0	0	0

Air Pollutant	NO_2			$PM_{2.5}$					
Category	morbidity	mortality, cause-specific		morbidity		mortality, cause-specific			
Outcome	YLD	AD	YLL	YLD		AD		YLL	
Ireland	6	52	14	3	19	247	254	96	67
Italy	699	9 650	1 790	160	1 910	18 240	37 600	6 380	6 970
Kosovo	5	114	56	4	31	400	907	271	444
Latvia	3	192	38	1	15	198	1 310	62	256
Liechtenstein	0	0	0	0	0	3	3	0	0
Lithuania	10	185	37	3	73	319	1 890	106	378
Luxembourg	2	16	4	0	3	26	39	12	10
Malta	0	7	2	0	2	62	91	23	23
Monaco	0	0	1	0	0	3	7	2	2
Montenegro	2	42	11	2	15	205	472	78	119
Netherlands	152	1 100	247	26	282	2 660	2 970	1 020	668
North Macedonia	10	202	49	6	70	950	2 070	342	500
Norway	5	39	9	1	14	140	163	50	37
Poland	211	2 180	564	117	1 620	12 950	23 900	4 720	6 190
Portugal	68	644	138	10	210	1 090	2 910	443	625
Romania	134	4 800	1 040	40	462	4 590	23 800	1 670	5 150
San Marino	0	0	0	0	1	7	16	3	4
Serbia	56	1 320	295	28	259	3 390	8 600	1 190	1 920
Slovakia	23	189	48	9	233	1 040	2 820	365	705
Slovenia	12	124	25	5	69	537	1 060	208	212
Spain	282	2 940	689	63	657	7 450	9 870	3 110	2 320
Sweden	3	33	7	1	18	153	263	52	58
Switzerland	58	289	63	7	117	712	845	282	184
Türkiye	1 070	13 520	4 110	0	0	0	0	0	0

Annex 5 Numerical results for graphical presentations

Table 68: Costs of AD attributable to NO_2 valued by VSL, in $€_{2022}$ per capita at country level – core analysis for Baseline from WHO 2021 AQG

Country	AD (all-cause) associated with NO_2 - € per capita
Albania	405
Andorra	251
Austria	268
Belgium	334
Bosnia and Herzegovina	401
Bulgaria	629
Croatia	360
Cyprus	661
Czechia	204
Denmark	32
Estonia	38
Finland	32
France	230
Germany	355
Greece	664
Hungary	401
Iceland	27
Ireland	64
Italy	637
Kosovo	479
Latvia	192
Liechtenstein	254
Lithuania	153
Luxembourg	170
Malta	96
Monaco	522
Montenegro	324
Netherlands	328
North Macedonia	495
Norway	48
Poland	240
Portugal	245
Romania	553
San Marino	297
Serbia	677
Slovak Republic	131
Slovenia	209
Spain	361
Sweden	18
Switzerland	217
Türkiye	692

Table 69: Costs of AD attributable to O_3 (SOMO35 metric) valued by VSL, in €$_{2022}$ per capita at country level – core analysis for Baseline from WHO 2021 AQG

Country	AD (all-cause) associated with O_3 (SOMO35) - € per capita
Albania	315
Andorra	126
Austria	208
Belgium	145
Bosnia and Herzegovina	367
Bulgaria	227
Croatia	329
Cyprus	191
Czechia	212
Denmark	95
Estonia	90
Finland	74
France	175
Germany	225
Greece	316
Hungary	280
Iceland	53
Ireland	54
Italy	309
Kosovo	271
Latvia	133
Liechtenstein	254
Lithuania	125
Luxembourg	108
Malta	211
Monaco	261
Montenegro	308
Netherlands	121
North Macedonia	245
Norway	68
Poland	171
Portugal	180
Romania	199
San Marino	297
Serbia	313
Slovak Republic	199
Slovenia	237
Spain	190
Sweden	77
Switzerland	191
Türkiye	86

Table 70: Costs of AD attributable to $PM_{2.5}$ valued by VSL, in €$_{2022}$ per capita at country level – core analysis for Baseline from WHO 2021 AQG

Country	AD (all-cause) associated with $PM_{2.5}$ - € per capita
Albania	4 246
Andorra	629
Austria	1 207
Belgium	1 150
Bosnia and Herzegovina	5 669
Bulgaria	4 164
Croatia	3 107
Cyprus	1 735
Czechia	2 111
Denmark	656
Estonia	218
Finland	41
France	1 001
Germany	1 264
Greece	3 237
Hungary	2 878
Iceland	0
Ireland	328
Italy	2 810
Kosovo	4 397
Latvia	1 397
Liechtenstein	763
Lithuania	1 664
Luxembourg	387
Malta	1 057
Monaco	1 304
Montenegro	4 096
Netherlands	956
North Macedonia	6 069
Norway	203
Poland	3 011
Portugal	1 199
Romania	3 058
San Marino	2 671
Serbia	5 142
Slovak Republic	2 169
Slovenia	1 974
Spain	1 313
Sweden	149
Switzerland	689
Türkiye	0

Table 71: DALY in million €$_{2022}$ per capita valued by VOLY, by country – core analysis for Baseline from WHO 2021 AQG

Country	NO_2	$PM_{2.5}$
Albania	87	914
Andorra	63	126
Austria	80	367
Belgium	83	264
Bosnia and Herzegovina	93	1 220
Bulgaria	139	1 040
Croatia	133	1 030
Cyprus	251	590
Czechia	62	627
Denmark	10	178
Estonia	7	52
Finland	9	11
France	59	230
Germany	102	346
Greece	135	737
Hungary	121	1 040
Iceland	8	0
Ireland	20	108
Italy	158	629
Kosovo	102	959
Latvia	45	468
Liechtenstein	37	107
Lithuania	35	594
Luxembourg	50	101
Malta	34	372
Monaco	103	264
Montenegro	64	793
Netherlands	98	253
North Macedonia	99	1 130
Norway	15	53
Poland	64	861
Portugal	72	305
Romania	118	887
San Marino	58	606
Serbia	156	1 140
Slovakia	32	728
Slovenia	50	497
Spain	85	308
Sweden	5	38
Switzerland	56	169
Türkiye	329	0

Table 72: DALY in million €$_{2022}$ per capita valued by VOLY, by country – sensitivity analysis for Baseline from WHO 2021 AQG

Country	NO_2	$PM_{2.5}$
Albania	135	1 420
Andorra	97	196
Austria	123	569
Belgium	129	408
Bosnia and Herzegovina	144	1 890
Bulgaria	216	1 610
Croatia	207	1 590
Cyprus	389	913
Czechia	96	971
Denmark	16	276
Estonia	11	81
Finland	13	18
France	91	357
Germany	159	536
Greece	209	1 140
Hungary	187	1 610
Iceland	12	0
Ireland	31	167
Italy	244	975
Kosovo	158	1 490
Latvia	70	725
Liechtenstein	57	166
Lithuania	54	920
Luxembourg	78	157
Malta	52	576
Monaco	160	409
Montenegro	99	1 230
Netherlands	152	393
North Macedonia	153	1 750
Norway	23	82
Poland	100	1 330
Portugal	111	473
Romania	183	1 370
San Marino	89	939
Serbia	241	1 760
Slovakia	49	1 130
Slovenia	77	770
Spain	132	477
Sweden	8	59
Switzerland	87	262
Türkiye	509	0

Table 73: DALY in million €$_{2022}$ per capita, valuing YLL by VOLY and YLD by incidence lifetime cost of illness, by country – core analysis for Baseline from WHO 2021 AQG

Country	NO_2	$PM_{2.5}$
Albania	129	1 170
Andorra	116	165
Austria	126	468
Belgium	137	340
Bosnia and Herzegovina	139	1 600
Bulgaria	204	1 300
Croatia	195	1 300
Cyprus	408	764
Czechia	100	785
Denmark	15	221
Estonia	11	65
Finland	16	15
France	108	323
Germany	172	462
Greece	228	937
Hungary	184	1 250
Iceland	13	0
Ireland	31	132
Italy	254	815
Kosovo	136	1 140
Latvia	62	541
Liechtenstein	63	148
Lithuania	52	712
Luxembourg	85	135
Malta	54	453
Monaco	178	342
Montenegro	96	1 030
Netherlands	161	339
North Macedonia	150	1 490
Norway	23	67
Poland	107	1 150
Portugal	128	431
Romania	164	999
San Marino	86	751
Serbia	234	1 490
Slovakia	56	931
Slovenia	92	677
Spain	153	401
Sweden	8	48
Switzerland	101	239
Türkiye	608	0

Table 74: Costs of DALY from exposure to NO_2 in million €$_{2022}$ per capita, by country under different valuation approaches for YLD - Baseline from WHO 2021 AQG, 2022

Country	VYLD=VOLY$_{core}$	VYLD=VOLY$_{sensitivity}$	VYLD=incidence-based core estimate
Albania	87	135	129
Andorra	63	97	116
Austria	80	123	126
Belgium	83	129	137
Bosnia and Herzegovina	93	144	139
Bulgaria	139	216	204
Croatia	133	207	195
Cyprus	251	389	408
Czechia	62	96	100
Denmark	10	16	15
Estonia	7	11	11
Finland	9	13	16
France	59	91	108
Germany	102	159	172
Greece	135	209	228
Hungary	121	187	184
Iceland	8	12	13
Ireland	20	31	31
Italy	158	244	254
Kosovo	102	158	136
Latvia	45	70	62
Liechtenstein	37	57	63
Lithuania	35	54	52
Luxembourg	50	78	85
Malta	34	52	54
Monaco	103	160	178
Montenegro	64	99	96
Netherlands	98	152	161
North Macedonia	99	153	150
Norway	15	23	23
Poland	64	100	107
Portugal	72	111	128
Romania	118	183	164
San Marino	58	89	86
Serbia	156	241	234
Slovakia	32	49	56
Slovenia	50	77	92
Spain	85	132	153
Sweden	5	8	8
Switzerland	56	87	101
Türkiye	329	509	608

Table 75: Costs of DALY from exposure to $PM_{2.5}$ in million €$_{2022}$ per capita by country under different valuation approaches for YLD - Baseline from WHO 2021 AQG, 2022

Country	VYLD=VOLY$_{core}$	VYLD=VOLY$_{sensitivity}$	VYLD=incidence-based core estimate
Albania	914	1 420	1 170
Andorra	126	196	165
Austria	367	569	468
Belgium	264	408	340
Bosnia and Herzegovina	1 220	1 890	1 600
Bulgaria	1 040	1 610	1 300
Croatia	1 030	1 590	1 300
Cyprus	590	913	764
Czechia	627	971	785
Denmark	178	276	221
Estonia	52	81	65
Finland	11	18	15
France	230	357	323
Germany	346	536	462
Greece	737	1 140	937
Hungary	1 040	1 610	1 250
Iceland	0	0	0
Ireland	108	167	132
Italy	629	975	815
Kosovo	959	1 490	1 140
Latvia	468	725	541
Liechtenstein	107	166	148
Lithuania	594	920	712
Luxembourg	101	157	135
Malta	372	576	453
Monaco	264	409	342
Montenegro	793	1 230	1 030
Netherlands	253	393	339
North Macedonia	1 130	1 750	1 490
Norway	53	82	67
Poland	861	1 330	1 150
Portugal	305	473	431
Romania	887	1 370	999
San Marino	606	939	751
Serbia	1 140	1 760	1 490
Slovakia	728	1 130	931
Slovenia	497	770	677
Spain	308	477	401
Sweden	38	59	48
Switzerland	169	262	239
Türkiye	0	0	0

Annex 6 Cost of Morbidity

INCIDENT-BASED ANALYSIS

Attributable Fraction, AF

$$AF = \left(1 - \frac{1}{RR\,(z, c_f)}\right) \tag{1}$$

RR, incidence-based relative risk; z, exposure (µg/m^3); c_f, counterfactual scenario

Environmental Burden of Disease, EBD

$$\binom{Attributable}{cases} = AF \cdot \binom{Incident}{rate} \cdot \binom{Population}{at\ risk} \tag{2}$$

$Incident\ rate$, number of newly diagnosed occurrences of a disease (e.g. annual new cases per 10^5 persons).

The morbidity cost is

$$\binom{Morbidity}{cost}_{incident} = \binom{Attributable}{cases} \cdot \binom{Lifetime\ cost\ per}{Incident\ case} \tag{3}$$

The lifetime cost includes COI (direct medical and non-medical costs) and disutility (e.g. valued using QALY). The annual cost is adjusted for changes in economic growth, and for increases in health care expenses, including cost increases due to inflation, greater demand for health care services (resource utilisation), upgrades in quality-of-service delivery, investments in medical equipment, and adoption of novel treatment options. Future economic costs are discounted to present value. This is an incident-based analysis.

As a proxy for the lifetime cost, one could use the cost per prevalent case, i.e.

$$\binom{Lifetime\ cost\ per}{Incident\ case} \approx \binom{Disease}{duration} \cdot \binom{Cost\ per}{prevalent\ case} \tag{4}$$

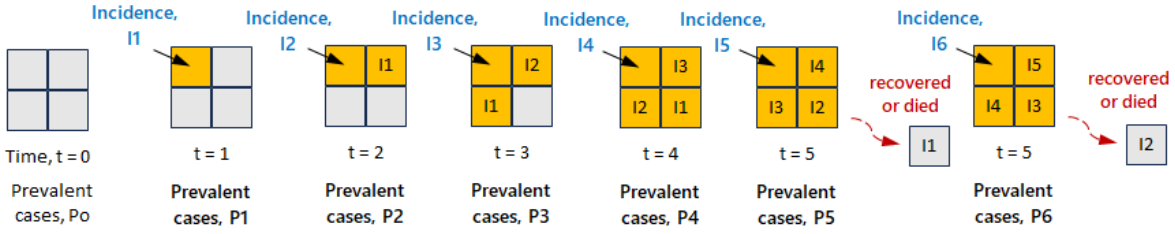
For a given year, the cost per prevalent case is calculated as the total economic value of health care costs (medical and non-medical expenditures summed across all stages of illness), opportunity costs (including work-loss days, permanent disability and informal care), and welfare costs divided by the total number of prevalent cases. Eq. (4) generally provides a conservative lifetime cost estimate since it does not account for economic growth or increases in health care expenditures due to disease progression and rising demand for services. These increases in costs, however, are partially offset because of discounting.

As illustrated in the figure below, under steady state conditions, the ratio of prevalent cases and incidence (frequency of occurrence of new events of a disease) is equal to the duration of disease. This is a simplification of the dynamic relationship between population-disease-risk. Thus,

$$\binom{Morbidity}{cost}_{incident} = AF \cdot \binom{Prevalent}{cases} \cdot \binom{Cost\ per}{prevalent\ case} \tag{5}$$

For a non-steady state scenario, (3) must be used (with (4) if necessary).

Consider a population at steady state subject to invariant risk factors and no interaction between risk factors (i.e. no competing risks). The duration of the disease (time from diagnosis to recovery or death), L, is 4.



$$P_4 = \sum_{k=1}^{4} \Delta t_k \times I_k = 4 \cdot I_4 \; since \; I_1 = I_2 = I_3 = I_4$$

$$P_4 = 4 \cdot I_4 = L \times I_4 \qquad P_6 = P_5 = P_4$$

PREVALENT-BASED ANALYSIS

The economic burden of disease (BoD) for a given year is the product of the number of prevalent cases (total number of occurrences of a disease among the population) and the cost per prevalent case. (6)

$$\begin{pmatrix} Morbidity \\ cost \end{pmatrix}_{prevalent} = \begin{pmatrix} Prevalent \\ cases \end{pmatrix} \cdot \begin{pmatrix} Cost\ per \\ prevalent\ case \end{pmatrix}$$

YEARS LIVED WITH DISABILITY, YLD

$$YLD_{incident} = d_W \cdot \begin{pmatrix} Disease \\ duration \end{pmatrix} \cdot \begin{pmatrix} Attributable \\ cases \end{pmatrix} \tag{7}$$

d_W, disability weight (value varies between 0 and 1, with 1 corresponding to death)

In a steady state population, $prevalent\ cases = (disease\ duration) \times incidence$, thus

$$YLD_{incident} = AF \cdot d_W \cdot \begin{pmatrix} Prevalent \\ cases \end{pmatrix} \tag{8}$$

and

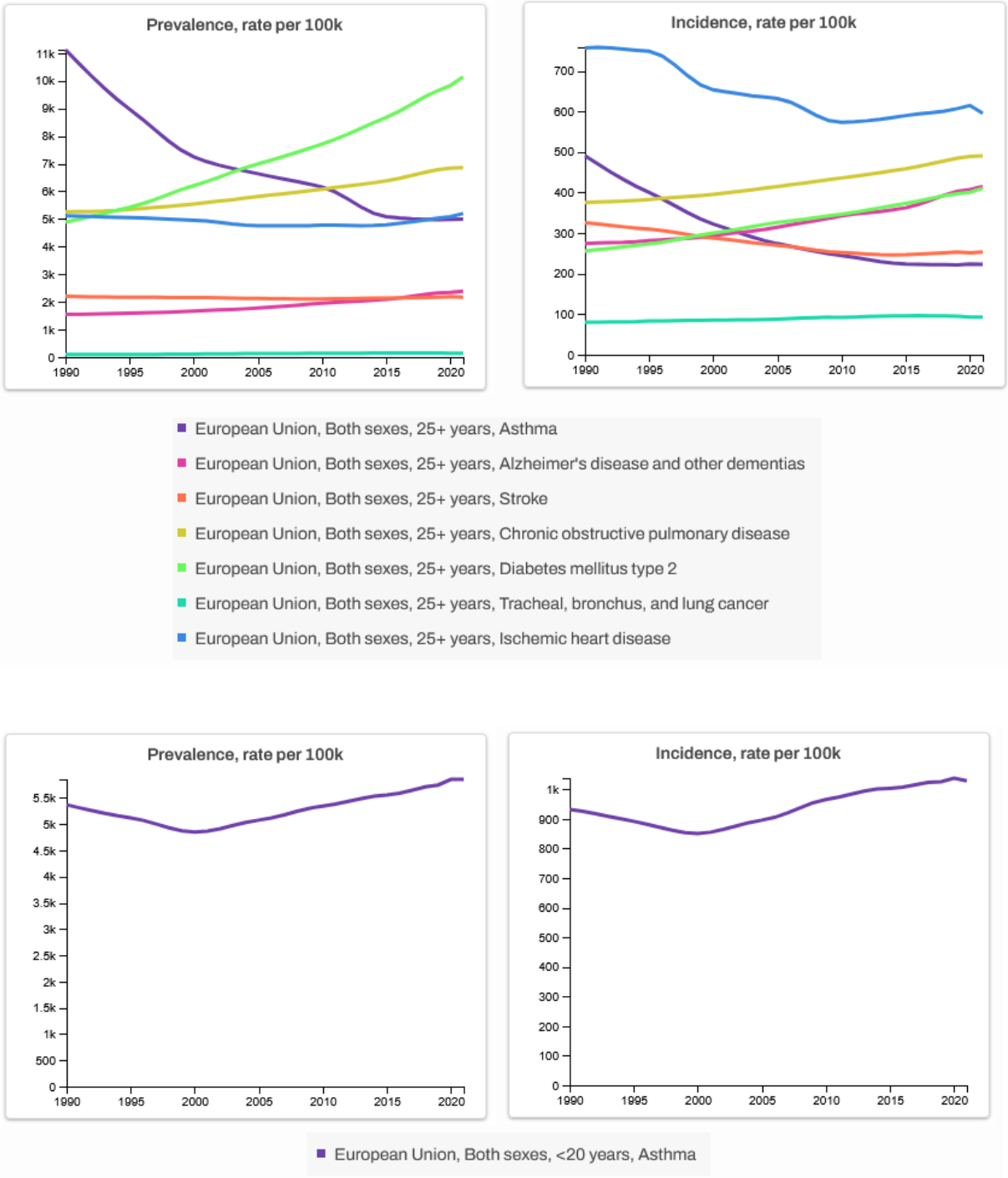
$$\begin{matrix} Morbidity \\ cost \end{matrix} = AF \cdot d_W \cdot \begin{pmatrix} Prevalent \\ cases \end{pmatrix} \cdot \begin{pmatrix} Cost\ per \\ YLD \end{pmatrix} \tag{9}$$

with

$$\begin{matrix} Cost\ per \\ YLD \end{matrix} = \frac{1}{d_W} \cdot \begin{pmatrix} \frac{Lifetime\ cost\ per}{Incident\ case} \\ Disease \\ duration \end{pmatrix} \tag{10}$$

Substituting (10) into (9) reduces to (5).

Burden of Disease



Source: IHME 2021

Annex 7 Health data extracted from the EEA web site and used in this study

Table 76: Results of the EBD aggregated over EU27 and EEA41

Air Pollutant	Data aggregation ID	Category	Outcome	Description Of Age Group	Health Indicator	EU27			All countries		
						Impact result - central	Impact result - lower CI	Impact result - upper CI	Impact result - central	Impact result - lower CI	Impact result - upper CI
NO_2	P1Y	Morbidity	Asthma, adult	>= 19 years of age	YLD	33 005	3 593	62 844	71 144	8 030	130 937
			Asthma, childhood	< 19 years of age	YLD	12 155	5 116	16 448	25 628	11 094	34 121
			Chronic obstructive pulmonary disease	>= 25 years of age	YLD	32 734	18 731	45 489	69 605	40 536	95 222
			Diabetes Mellitus	>= 25 years of age	YLD	74 507	43 876	112 639	146 044	86 865	218 107
			Stroke	>= 25 years of age	YLD	34 352	17 860	49 623	47 294	24 755	67 897
		Mortality	All causes	>= 30 years of age	AD	47 571	24 029	93 204	69 057	34 953	134 789
			All causes	>= 30 years of age	YLL	460 889	232 855	902 949	719 849	364 570	1 403 757
			Asthma, adult	>= 19 years of age	AD	230	17	448	507	46	952
			Asthma, adult	>= 19 years of age	YLL	2 547	268	4 855	5 581	615	10 308
			Asthma, childhood	< 19 years of age	AD	0	0	1	1	0	3
			Asthma, childhood	< 19 years of age	YLL	148	60	203	273	113	368
			Chronic obstructive pulmonary disease	>= 25 years of age	AD	8 283	3 562	12 631	13 298	5 834	19 934
			Chronic obstructive pulmonary disease	>= 25 years of age	YLL	79 566	34 216	121 489	132 999	58 436	199 248
			Diabetes Mellitus	>= 25 years of age	AD	12 432	6 545	17 670	18 609	10 002	25 994
			Diabetes Mellitus	>= 25 years of age	YLL	111 768	58 863	158 880	186 430	100 753	259 264
			Stroke	>= 25 years of age	AD	11 425	1 950	20 439	16 420	2 833	29 091
			Stroke	>= 25 years of age	YLL	93 817	16 082	167 805	150 085	26 081	265 106
		Total burden of disease	Asthma, adult	>= 19 years of age	DALY	35 566	3 875	67 716	76 745	8 665	141 267
			Asthma, childhood	< 19 years of age	DALY	12 306	5 180	16 658	25 907	11 216	34 501
			Chronic obstructive pulmonary disease	>= 25 years of age	DALY	112 314	52 958	166 992	202 627	98 991	294 490
			Diabetes Mellitus	>= 25 years of age	DALY	186 289	102 751	271 534	332 494	187 635	477 392
			Stroke	>= 25 years of age	DALY	128 181	33 954	217 441	197 395	50 856	333 023

Air Pollutant	Data aggregation ID	Category	Outcome	Description Of Age Group	Health Indicator	EU27			All countries		
						Impact result - central	Impact result - lower CI	Impact result - upper CI	Impact result - central	Impact result - lower CI	Impact result - upper CI
O_3	PEAK	Mortality	All causes	>= 25 years of age	AD	71 873	0	140 623	81 516	0	159 502
			All causes	>= 25 years of age	YLL	707 585	0	1 384 542	813 309	0	1 591 487
			Chronic obstructive pulmonary disease	>= 25 years of age	AD	7 433	7 101	7 929	8 583	8 197	9 155
			Chronic obstructive pulmonary disease	>= 25 years of age	YLL	73 466	70 173	78 346	85 623	81 783	91 313
	SOMO35	Mortality	All causes	>= 0 years of age	AD	27 744	21 957	33 524	32 282	25 547	39 009
			All causes	>= 0 years of age	YLL	280 724	222 236	339 201	336 893	266 703	407 073
$PM_{2.5}$	P1Y	Morbidity	Asthma, childhood	< 19 years of age	YLD	40 489	14 793	61 886	43 311	15 864	66 057
			Chronic obstructive pulmonary disease	>= 25 years of age	YLD	111 292	44 530	168 199	119 717	48 073	180 385
			Dementia	>= 60 years of age	YLD	349 090	181 988	493 220	372 394	194 671	524 923
			Diabetes Mellitus	>= 25 years of age	YLD	111 444	57 713	161 612	121 467	62 958	175 996
			Ischemic heart disease	>= 25 years of age	YLD	19 454	8 021	30 605	23 341	9 657	36 592
			Lung cancer	>= 25 years of age	YLD	3 820	1 614	6 052	4 160	1 761	6 570
			Stroke	>= 25 years of age	YLD	108 456	12 162	200 891	116 100	13 052	214 476
		Mortality	All causes	>= 30 years of age	AD	238 378	181 959	265 859	267 655	204 429	298 424
			All causes	>= 30 years of age	YLL	2 351 955	1 795 285	2 623 119	2 634 641	2 012 250	2 937 552
			Asthma, childhood	< 19 years of age	AD	3	0	4	3	0	4
			Asthma, childhood	< 19 years of age	YLL	410	143	637	469	165	726
			Chronic obstructive pulmonary disease	>= 25 years of age	AD	18 288	314	33 176	19 882	340	35 911
			Chronic obstructive pulmonary disease	>= 25 years of age	YLL	176 401	3 135	321 295	192 825	3 444	349 484
			Diabetes Mellitus	>= 25 years of age	AD	37 662	20 700	51 127	41 561	22 993	56 121
			Diabetes Mellitus	>= 25 years of age	YLL	346 851	190 658	470 838	385 223	213 223	520 038
			Ischemic heart disease	>= 25 years of age	AD	72 881	39 441	103 515	78 865	42 766	111 806
			Ischemic heart disease	>= 25 years of age	YLL	655 680	354 774	931 554	714 315	387 372	1 012 765
			Lung cancer	>= 25 years of age	AD	26 580	10 194	41 290	29 258	11 256	45 323
			Lung cancer	>= 25 years of age	YLL	381 940	146 465	593 741	421 135	162 026	652 751
			Stroke	>= 25 years of age	AD	54 117	22 504	81 768	60 481	25 256	91 035
			Stroke	>= 25 years of age	YLL	452 867	188 259	684 513	510 673	213 280	768 721
			Asthma, childhood	< 19 years of age	DALY	40 902	14 943	62 531	43 786	16 039	66 794

Air Pollutant	Data aggregation ID	Category	Outcome	Description Of Age Group	Health Indicator	EU27			All countries		
						Impact result - central	Impact result - lower CI	Impact result - upper CI	Impact result - central	Impact result - lower CI	Impact result - upper CI
		Total burden of disease	Chronic obstructive pulmonary disease	>= 25 years of age	DALY	287 708	47 680	489 506	312 564	51 537	529 889
			Diabetes Mellitus	>= 25 years of age	DALY	458 307	248 385	632 464	506 709	276 206	696 052
			Ischemic heart disease	>= 25 years of age	DALY	675 151	362 808	962 175	737 679	397 049	1 049 376
			Lung cancer	>= 25 years of age	DALY	385 772	148 088	599 805	425 313	163 801	659 339
			Stroke	>= 25 years of age	DALY	561 334	200 434	885 419	626 791	226 352	983 220

Source: https://discomap.eea.europa.eu/App/AQViewer/index.html?fqn=Airquality_Dissem.ebd.countries_and_nuts

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