Health at a Glance: Europe 2020
State of Health in the EU Cycle

PART I

Chapter 2

Air pollution and its impact on health in Europe: Why it matters and how the health sector can reduce its burden

This chapter reviews the health and welfare impacts of air pollution in Europe. Although air pollution has decreased in most European countries over the past two decades, it remains above WHO guidelines in most countries, particularly in some large Central and Eastern European cities. This has serious consequences on people's health and mortality: in the EU, estimates attribute between 168 000 and 346 000 deaths to air pollution from fine particles ($PM_{2.5}$) alone in 2018. The welfare losses from air pollution are substantial. A conservative estimate of the welfare impact of $PM_{2.5}$ and ozone shows that this amounts to an annual loss of 4.9% of GDP in the EU. This welfare loss is mainly attributable to the impact of these pollutants on mortality, along with lower quality of life, lower labour productivity and higher spending on health.

Efforts to reduce air pollution need to focus on the main sources of emissions. These include the use of fossil fuels in energy production, transportation and the residential sector, as well as industrial and agricultural activities. The EU recovery plan from the COVID-19 crisis provides a unique opportunity to promote a green economic recovery by integrating environmental considerations in decision-making processes, thereby supporting the achievement of the 2030 EU national emission reduction targets. The health sector itself can contribute to achieving this objective by implementing various measures to minimise its own environmental footprint. Through multi-sectoral approaches, public health authorities can also contribute to environmentally friendly urban and transport policies, which may also promote greater physical activity.

Introduction

Air pollution is the main environmental risk factor for health in Europe and around the world. It has substantial health, economic and welfare consequences, including ill-health and greater premature mortality, increased health care costs, as well as reduced labour productivity and economic output in some sectors (e.g. agriculture and forestry sectors). The main sources of air pollution arise from the burning of fossil fuels in energy production, transport and households, and from some industrial and agricultural activities.

Depending on the methods of estimation, between 168 000 and 346 000 premature deaths across all EU member states in 2018 can be attributed to exposure to outdoor air pollution in the form of fine particles ($PM_{2.5}$) alone (Institute for Health Metrics and Evaluation, 2020[1]; European Environment Agency, 2020[2]). This represented 4% to 7% of all deaths in 2018. In addition, hundreds of thousands of people develop various illnesses associated with air pollution, leading to a loss of about 3.9 million disability-adjusted life years (DALYs) annually in the European Union (Institute for Health Metrics and Evaluation, 2020[1]).

While most European countries have substantially reduced their emissions of various air pollutants since 2005, most EU member states are still at risk of failing to fulfill their 2030 national emission reduction commitments unless additional measures are taken (European Commission, 2020[3]). A key element of the European Green Deal, announced in December 2019, is the zero-pollution ambition for a toxic-free environment. A proposed zero-pollution action plan for air, water and soil will be announced for 2021 (European Commission, 2019[4]). The EU recovery plan from the COVID-19 crisis, approved by the European Council in July 2020, aims to promote a green recovery by integrating environmental considerations into the recovery process (European Council, 2020[5]). This plan should also promote the achievement of national emission reduction commitments.

This chapter first reviews the evidence of the health effects of air pollution in Europe and offers estimates of the welfare losses associated with its considerable impact on morbidity and mortality. It then reviews some of the main EU policy goals and actions to achieve good air quality and to promote steady reductions in air pollution, including progress in the implementation of the 2016 National Emission reduction Commitments (NEC) Directive (European Commission, 2016[6]). This chapter ends with a discussion of the potential contribution of the health sector to efforts to reducing air pollution, including through decreasing its ecological footprint and encouraging lifestyle and environmental changes that both promote better health and benefit the environment.

The health and economic burden of air pollution in Europe

Air pollution causes different health problems, particularly respiratory and cardiovascular diseases. Different air pollutants can affect different parts of the body (Box 2.1). The greatest health damage from air pollution is caused by chronic exposure to particulate matter, in particular to fine particulate matter ($PM_{2.5}$) which increases the risk of heart diseases, stroke, lung cancer and many respiratory diseases including asthma, bronchitis, chronic obstructive pulmonary disease (COPD) and respiratory infections. This explains why this chapter focuses primarily on the health and welfare consequences of exposure to $PM_{2.5}$.

Box 2.1. **Main air pollutants with adverse effects on health**

Particulate matter (including PM_{10} and $PM_{2.5}$) are particles that are suspended in the air. Primary PM emissions result from the combustion of fuels, such as for power generation, domestic heating and in vehicle engines. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, irritates eyes, nose and throat, causes disorders in the reproductive and central nervous systems, as well as increases the risk of lung cancer. Small particulates of less than 10 microns in diameter (PM_{10}) are capable of penetrating deep into the respiratory tract and causing significant health damage. Fine particulates smaller than 2.5 microns in diameter ($PM_{2.5}$) cause even more severe health effects because they penetrate deeper into the respiratory tract and are potentially more toxic.

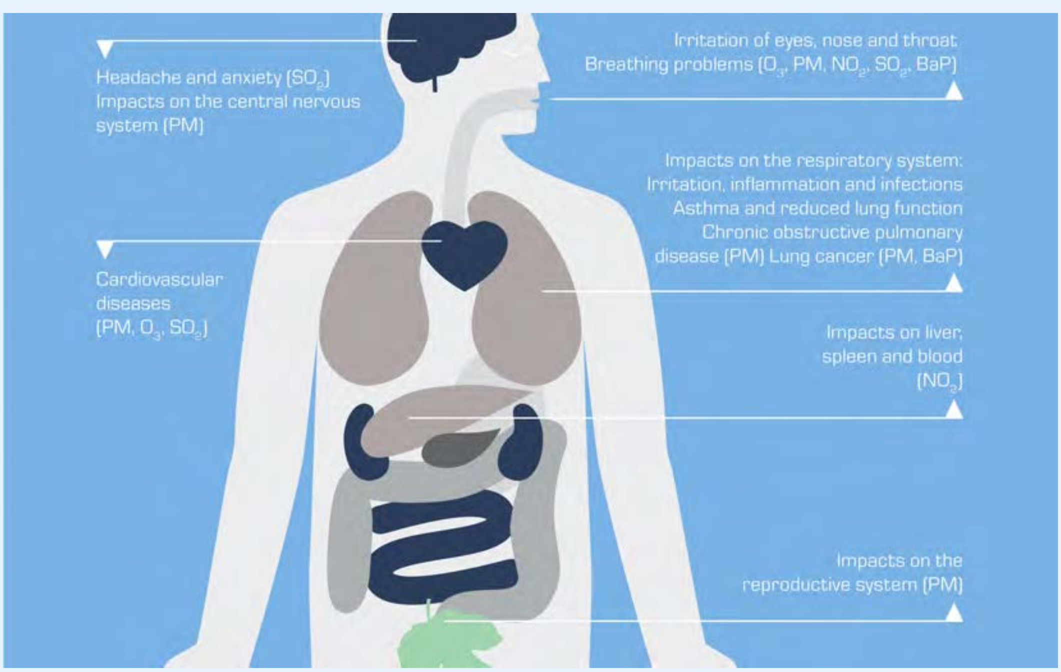
Nitrogen dioxide (NO_2) is formed primarily from vehicle exhausts, especially from diesel vehicles, power plants and combustion in industry. In addition to being a primary pollutant, it contributes to the formation of particulate matter and ozone. NO_2 can cause bronchitis and asthma, lead to irritations of eyes, nose and throat, cause respiratory infections and reduced lung function, and impact on liver, spleen and blood.

Ozone (O_3) at ground level, is formed by chemical reactions (triggered by sunlight) involving pollutants emitted into the air, including those by transport, natural gas extraction, landfills and household chemicals. Excessive ozone in the air can cause cardiovascular diseases as well as lead to breathing problems, irritations of eyes, nose and throat, trigger asthma and reduce lung function.

Sulphur dioxide (SO_2) is emitted mainly from the burning of fossil fuels such as coal and oil, and the smelting of mineral ores that contain sulphur. Sulphur dioxide can affect the respiratory system, central nervous system and lung function, and can cause headaches, anxiety and eye irritation. It can also aggravate bronchitis and asthma, and be a cause of cardiovascular diseases.

Benzo(a)pyrene (BaP) originates from incomplete combustion of fuels. Main sources include wood and waste burning, coke and steel production and vehicle engines. BaP can affect the respiratory system, and irritates eyes, nose and throat.

Infographic 2.1. **Potential health impacts of major sources of air pollution**



Source: European Environment Agency, *https://www.eea.europa.eu/signals/signals-2013/infographics/health-impacts-of-air-pollution/view*.

Exposure to air pollutants can take place both in outdoor (ambient) and indoor (household) environments. In Europe, the impact on population health from exposure to outdoor air pollutants is much greater compared to that from indoor air pollutants (see Figure 2.7 below).

Due to its impact on respiratory and cardiovascular diseases, emerging evidence suggests that increased long-term exposure to air pollution (notably $PM_{2.5}$) increases the risk of severe COVID-19 complications (Box 2.2). In general, having pre-existing conditions linked to exposure to air pollutants appears to make people more vulnerable to the effects of COVID-19 (OECD, 2020[9]).

Box 2.2. **Air pollution and COVID-19**

As widely illustrated in this chapter, exposure to air pollution is a risk factor for many chronic diseases, including chronic respiratory and cardiovascular diseases. There is wide recognition that people with such conditions are at increased vulnerability from COVID-19, and may thus be prone to a more severe course of the disease (Clark et al., 2020[10]). The World Health Organization and a number of national public health authorities have also issued warnings for citizens with these pre-existing conditions of greater risks of complications from COVID-19 (WHO, 2020[11]). It has been estimated that long-term exposure to air pollution from $PM_{2.5}$ contributed to about 19% of COVID-19 mortality in Europe through its effect in increasing respiratory and cardiovascular diseases, but the confidence intervals around this estimate are wide (8-41%), reflecting high levels of uncertainties (Pozzer et al., 2020[12]).

In addition, some studies suggest that air pollution ($PM_{2.5}$ in particular) may increase the risk of infection by acting as a vehicle spreading the virus (Copat et al., 2020[13]). While there are some concerns that air pollution could carry the virus over longer distances, at this stage it is not known whether the virus remains viable on pollution particles (European Environment Agency, 2020[7]). Further research is needed to verify this hypothesis.

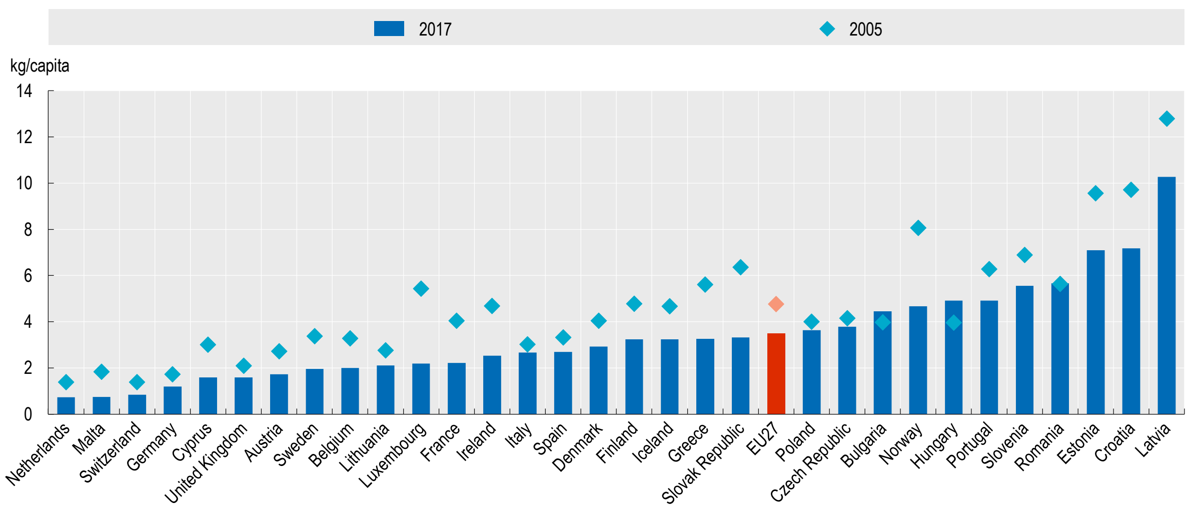
On the other hand, the confinement measures that have been put in place to reduce the spread of the coronavirus have led to at least a temporary reduction in air pollution. Reductions in economic and social activities led to significant decreases in certain types of pollution, notably in nitrogen dioxide (NO_2), largely due to reduced traffic and other activities, especially in major cities. The extent of reductions varied considerably, with the largest reductions of up to 70% observed in urban centres in those countries like Spain, Italy and France that were most affected by COVID-19 in the spring of 2020. Concentrations of particulate matter (PM_{10}) also fell across Europe, although to a lesser extent than NO_2. However, these reductions were short lived, with levels of air pollution rebounding as lockdowns were eased and vehicular transport resumed across Europe (European Environment Agency, 2020[7]).

Air quality is improving in Europe, but exposure to various air pollutants remains very high

Since 2005, most European countries have made progress in reducing air pollution and notably $PM_{2.5}$ emissions (Figure 2.1), following the provisions included in the 2008 Ambient Air Quality Directive and the more recent adoption of the EU Directive on National Emission reduction Commitments (NEC) of certain air pollutants in 2016. On average across EU countries, emissions of $PM_{2.5}$ have reduced by over 25% between 2005 and 2017. These reductions reflect mainly improvements in combustion processes in both industry and residential heating, a decrease in the use of coal in the energy mix, and lower emissions from transport and to a lesser degree from agriculture. However, this progress is not reflected in public opinion polls that show that most people believe that air quality has deteriorated (see Box 2.3).

Reductions in emissions have led to reductions in (population-weighted) concentrations and, therefore, reductions in population exposure to $PM_{2.5}$ in most EU countries. Nonetheless, in 21 out of 31 European countries, the annual concentrations of $PM_{2.5}$ exceeded the 10 microgrammes/m^3 values recommended by the WHO Air Quality Guidelines in 2018. This is particularly the case in many Central and Eastern European countries, mainly because of greater reliance on fossil fuels and other dirty energy sources for heating and other purposes. Northern European countries have the lowest levels of population exposure, generally well below the WHO guideline value for $PM_{2.5}$ (Figure 2.3).

Figure 2.1. **Emissions of fine particulate matters ($PM_{2.5}$) per capita have fallen in the vast majority of European countries between 2005 and 2017**



Note: The EU average is unweighted.
Source: OECD Environment Database - Emissions of air pollutants, 2020. For non-OECD countries, the source is the Convention on Long-Range Transboundary Air Pollution, UNECE-EMEP emissions database.

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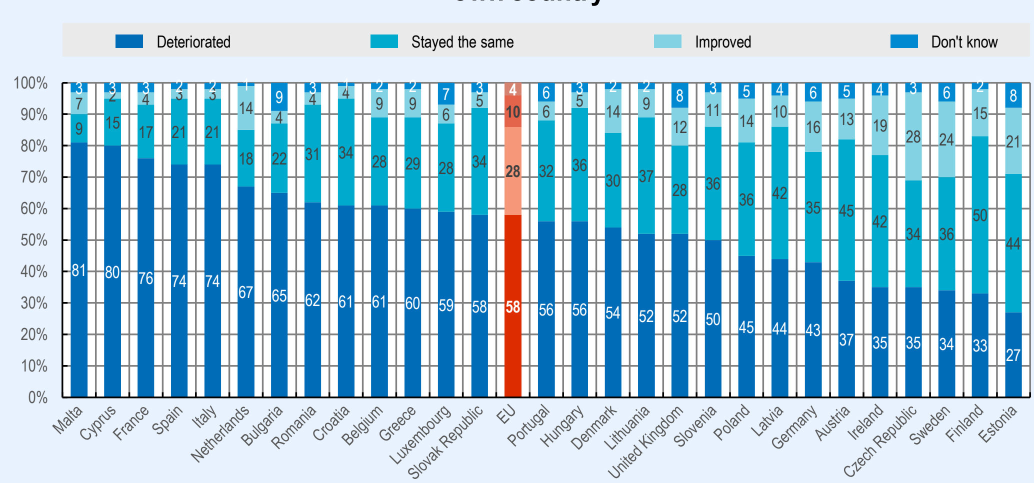
Box 2.3. **Why do most Europeans think that air quality has deteriorated when the evidence shows the contrary?**

Despite evidence that significant progress has been achieved over the past decade in improving air quality in most European countries, there is a widespread perception among Europeans that air quality has generally deteriorated. According to a 2019 Eurobarometer survey conducted across all EU member states, 58% of respondents reported they thought that air quality had deteriorated over the past decade, another 28% thought that it had stayed the same, while only 10% believed that it had improved (Figure 2.2). The proportion of respondents who thought that air quality had deteriorated increased by more than 10 percentage points compared with the previous survey in 2017.

Figure 2.2. **People's perception of changes in air quality over the last 10 years in their own country**



Source: European Commission, (2019[15]), "Attitudes of Europeans towards Air Quality. Special Eurobarometer 497".

StatLink https://stat.link/xms9ul

Box 2.3. **Why do most Europeans think that air quality has deteriorated when the evidence shows the contrary?** *(cont.)*

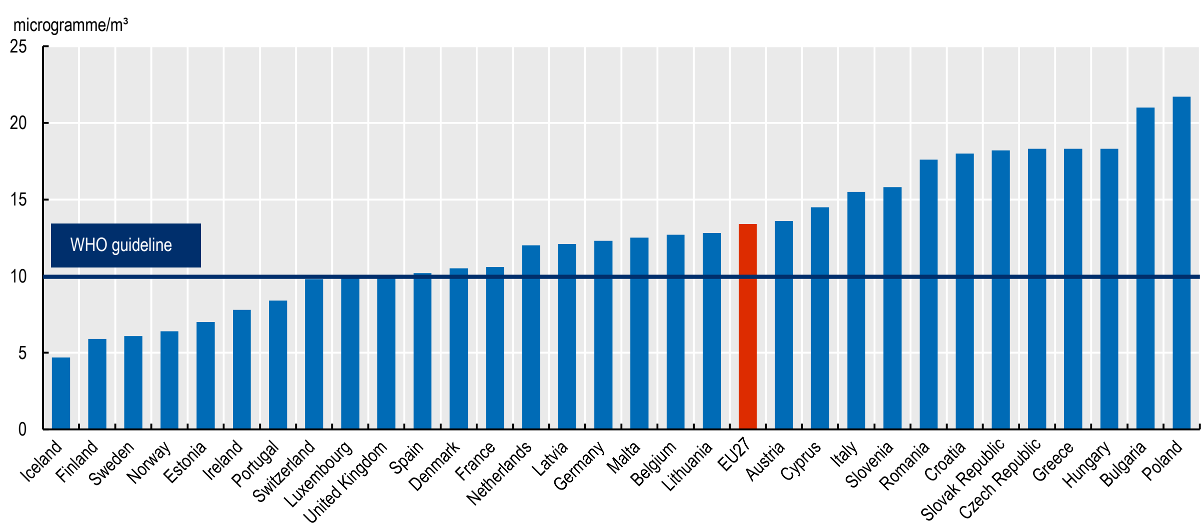
In a minority of countries such as Bulgaria, Hungary and Romania, the public perception is in line with the objectively measured situation, as levels of air pollution measured in terms of $PM_{2.5}$ emissions have in fact increased. However, this is not the case in the vast majority of European countries.

One possible explanation for the apparent inconsistency between objective indicators and subjective perceptions of air quality trends is that, given the close relationship between air pollution and climate change, a growing awareness among the public of the contribution of pollution to climate change may have led citizens to assess that air quality must have also worsened.

Increasing media attention on the subject of air pollution itself, as well as the growing public awareness of the health impact of exposure to air pollutants may have also played a role in shaping the perception that air quality is deteriorating. At the same time, most respondents in the 2019 Eurobarometer survey did not feel well-informed about air quality in their country. Interestingly, those respondents who reported that they were well-informed were less likely to believe that air quality had deteriorated. For example in Finland, where more than 80% of the population believed that they were well-informed about air quality, only a third of respondents thought that the quality of air had deteriorated.

Various initiatives have been taken to better inform people about air quality, for example through the EU Ambient Air Quality directives. At the local level, a growing number of municipalities are issuing alerts when air pollution levels exceed some thresholds, possibly contributing to the perception that air pollution levels are getting worse. Both at national and European levels, key measurements on air pollution are regularly collected and reported at various levels of aggregation, allowing people to monitor the situation on a day-to-day basis and progress over time. The EEA Air Quality Index is a good example of the effort to widely disseminate information about air quality in real time at the EU level (European Environment Agency, 2020[2]).

Figure 2.3. **In 2018, annual country-level mean concentrations of $PM_{2.5}$ in the atmosphere exceeded the WHO guideline in most European countries**



Note: Country values are population-weighted concentrations. The EU average is unweighted.
Source: European Environment Agency (2020[2]), *Air quality in Europe – 2020 Report*.

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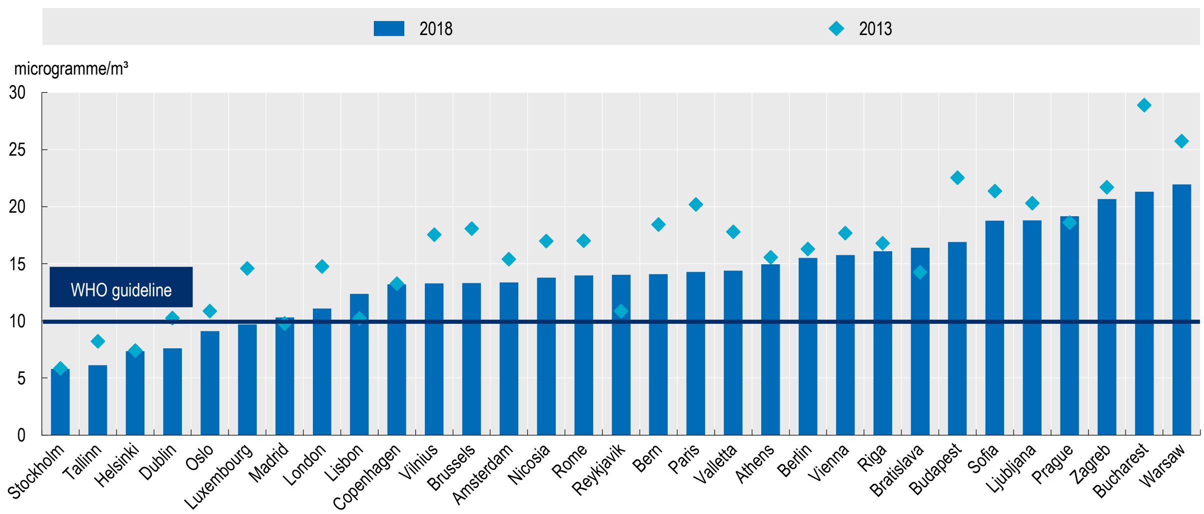
Some countries have a relatively high level of $PM_{2.5}$ emissions per capita (Figure 2.1) but a relatively low level of population-weighted concentration of such air pollutants (Figure 2.3). This is the case, for example, in Finland and Estonia. This may be partly explained by the fact that emissions of $PM_{2.5}$ largely occur in areas outside national capitals and other large cities where most people live.

While some progress has been achieved in reducing exposure to $PM_{2.5}$ in many European capital cities between 2013 and 2018, the annual mean concentrations of $PM_{2.5}$ still exceed the WHO guideline by a wide margin in almost all European capitals (Figure 2.4). This is especially the case in Warsaw, Bucharest, Zagreb, Prague, Ljubljana and Sofia, where the average $PM_{2.5}$ levels in 2018 were about twice as high as the WHO guideline. On the other hand, $PM_{2.5}$ concentrations were below the WHO guideline in several Northern European capitals – Stockholm, Tallinn, Helsinki and Oslo – and in Dublin.

Figure 2.4. **The annual mean concentration of $PM_{2.5}$ in the atmosphere has declined in most European capital cities, but remains above the WHO guideline in most of them**



Note: For Valletta, only data from the neighbouring city of Msida was available. For Lisbon, initial data are from 2014 (not 2013). For Bratislava and Bucharest, initial data are from 2016.

Source: European Environment Agency Air Quality Statistics database, 2020 *https://www.eea.europa.eu/data-and-maps/dashboards/air-quality-statistics-expert-viewer*. City-level data were estimated by averaging the station-level data in 2013 and 2018. As much as possible, the data from the same stations were used in both years for each city.

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Beyond differences in $PM_{2.5}$ concentrations between capital cities and the rest of the country, there can also be significant variations across different regions in each country. For example, $PM_{2.5}$ pollution levels are much greater in the north of Italy than in the south. In Poland, $PM_{2.5}$ levels are particularly high in the central and southern parts of the country (European Environment Agency, 2020[2]).

Some population groups are particularly vulnerable to the effects of air pollution. Older people, children, those with chronic diseases and those experiencing material deprivation are typically more vulnerable to the effects of air pollution than the general population. Lower-income households are more vulnerable to the health effects of air pollution, either because of greater exposure or greater susceptibility to serious health consequences when they are exposed (Box 2.4). Improvements to air quality may therefore particularly benefit lower-income households and ultimately contribute to reducing health inequalities.

Box 2.4. **Unequal exposure and unequal impacts of air pollution**

People's ability to avoid or cope with the health impacts of air pollution is influenced by their socio-economic status (i.e. income level and employment status). Lower-income households are generally more vulnerable to the health effects of air pollution, both because of potentially greater exposure, and because of increased susceptibility to its negative health consequences. This might be because they are in poorer health to start with, have limited access to high quality health care, are more exposed to other risk factors (like smoking) and have limited ability to invest in protective measures such as air filtration systems and better housing quality (Mackie and Haščič, 2019[16]).

Socioeconomically disadvantaged groups may be more exposed to indoor air pollution because they lack access to cleaner energy sources for heating. In addition, people in lower socio-professional categories may be exposed to higher levels of pollution in workplaces. Having said that, socio-economic disadvantage does not always correlates with air pollution exposure in the expected direction, as in some cases wealthier households may prefer to live in more central and more polluted parts of cities (Cournane et al., 2017[17]; European Environment Agency, 2018[18]).

Between 168 000 and 346 000 deaths each year in EU countries can be attributed to outdoor air pollution

Between 168 000 and 346 000 people across all EU countries died prematurely in 2018 from diseases attributable to outdoor air pollution ($PM_{2.5}$), according to the most recent estimates from the Global Burden of Disease study (Institute for Health Metrics and Evaluation, 2020[1]) and the European Environment Agency (European Environment Agency, 2020[2]), respectively.[1] Box 2.5 provides information about differences in sources and methods that result in different estimates of the mortality attributed to air pollution.

Box 2.5. **Estimating the mortality burden of air pollution**

All estimates of the impact of air pollution on mortality are based on some models and assumptions about the links between exposure to different types of air pollution and mortality from various diseases, which are subject to a certain degree of uncertainty. The models also often use different data inputs. Hence, it is not surprising to see that the use of different data sources based on different estimation methods provide different results.

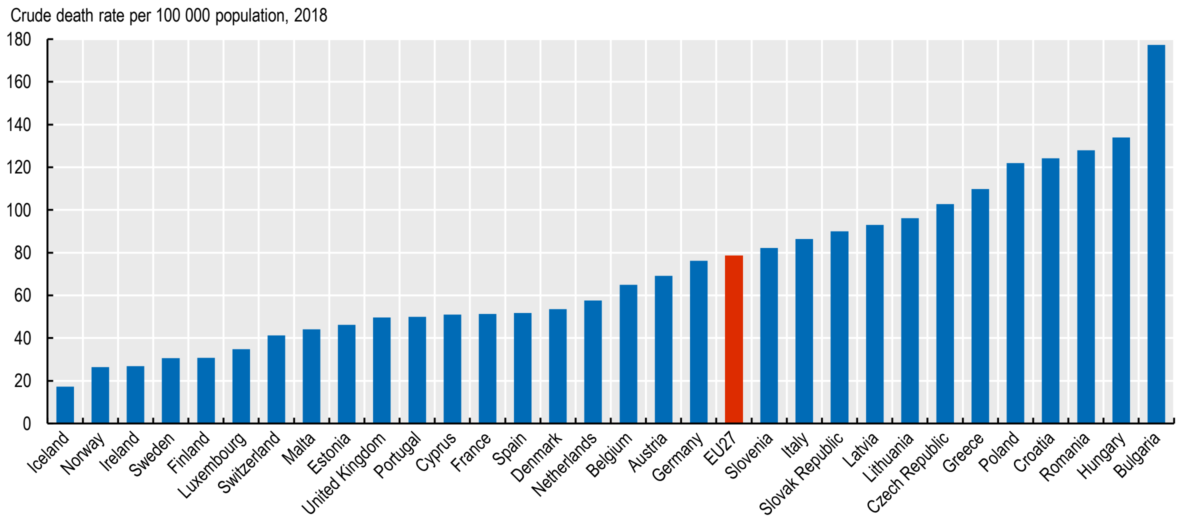
The European Environment Agency provides higher estimates of the number of premature deaths attributable to the effect of outdoor air pollution from $PM_{2.5}$ (346 000 in 2018 across the current 27 EU member states) compared with IHME estimates (168 000 in 2018) and WHO estimates (204 000 in 2016). At least three methodological reasons can explain these different results.

First, the EEA, following the WHO's recommendations (WHO Europe, 2013[19]), takes a broader approach in estimating the excess mortality due to $PM_{2.5}$ emissions that takes into account all possible related causes of premature death. By comparison, the IHME estimates take into account mortality from five main causes (cardiovascular diseases, diabetes, chronic respiratory diseases, respiratory infections and tuberculosis, and some cancers), while the WHO estimates focus on mortality from three main causes (ischemic heart disease, stroke and respiratory diseases). A second reason for the differences is that the EEA estimates are based on more granular, location-based air pollution exposure data, while both the IHME and WHO estimates are based on average country-level exposure to $PM_{2.5.}$ Thirdly, the EEA assumes that the counterfactual minimum exposure level for $PM_{2.5}$ equals zero, which is lower than in the other two cases. Although WHO and IHME estimates rely on a similar "population attributable fraction"-based methodology that estimates the fraction of deaths potentially linked to air pollution levels, some differences in their final estimates arise due, for example, to differences in the assumed minimum exposure levels or in the underlying data sources.

All the available model-based estimates are subject to considerable uncertainty. In the case of EEA, the uncertainty (or confidence) intervals of the number of estimated premature deaths from $PM_{2.5}$ across all EU member states range approximately between 218 000 and 462 000 (European Environment Agency, 2020[2]). When it comes to the 2016 WHO estimates, the uncertainty (or confidence) intervals range from 155 000 to 264 000 (WHO, 2018[20]), while the range for the 2018 IHME estimates is between 128 000 and 211 000 (Institute for Health Metrics and Evaluation, 2020[1]).

Premature death rates attributable to air pollution ($PM_{2.5}$) were the highest in 2018 in Central and Eastern European countries, reaching up to between 120-180 deaths per 100 000 population in Bulgaria, Hungary, Poland, Romania and Croatia. Deaths were the lowest in Nordic countries, with rates about six times lower at 20-30 deaths per 100 000 population (Figure 2.5).

Figure 2.5. **Premature death rates attributable to outdoor air pollution ($PM_{2.5}$) are generally the highest in Central and Eastern Europe, and lowest in Northern Europe**



Note: The EU average is weighted.
Source: Based on European Environment Agency (2020[2]), *Air quality in Europe – 2020 report*.

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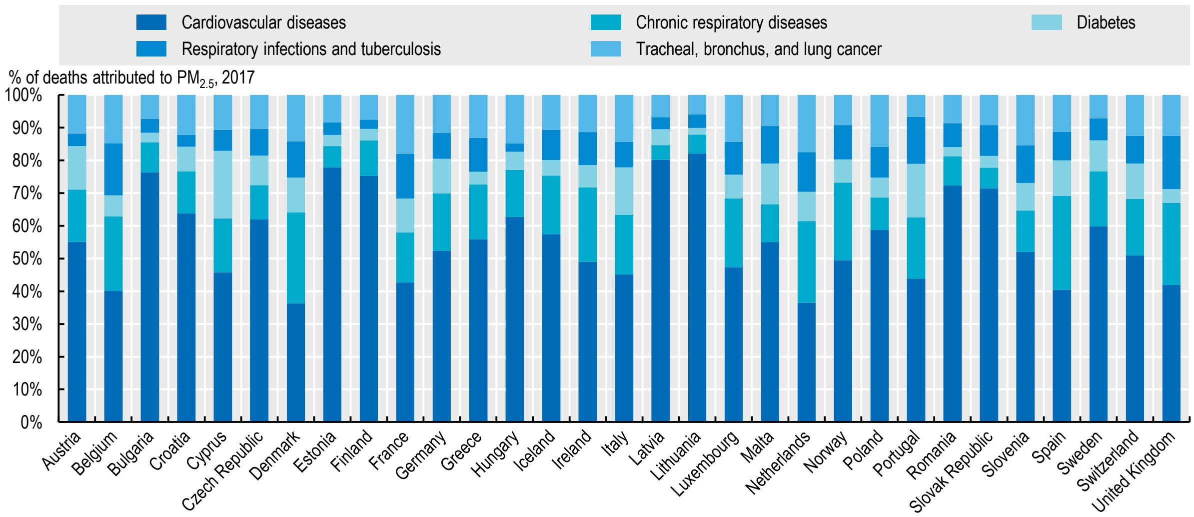
Based on IHME estimates, the two main causes of premature deaths attributable to air pollution ($PM_{2.5}$) are cardiovascular and chronic respiratory diseases. The proportion of mortality from cardiovascular diseases attributed to $PM_{2.5}$ exposure accounted for the largest share of premature deaths associated with air pollution in all countries in 2017 (Figure 2.6).

While outdoor air pollution accounts for a much larger proportion of deaths than indoor air pollution in all European countries, exposure to indoor $PM_{2.5}$ also contributes to a sizeable number of deaths, particularly in some Central and Eastern European countries like Estonia, Romania, Hungary and Bulgaria (Figure 2.7). This is mainly due to the still prevalent use of solid fuels for cooking and heating inside houses. Several countries have taken measures to improve indoor air quality, including for example financial support for the phasing out of high emission boilers and stoves in Latvia (Asikainen et al., 2016[21]).

Figure 2.6. **Deaths attributable to air pollution ($PM_{2.5}$) relate mainly to cardiovascular and respiratory diseases**



Note: This figure shows estimates of the proportion of these causes of death that are attributed to air pollution.
Source: IHME (2018), "GBD Results Tool", *http://ghdx.healthdata.org/gbd-results-tool*.

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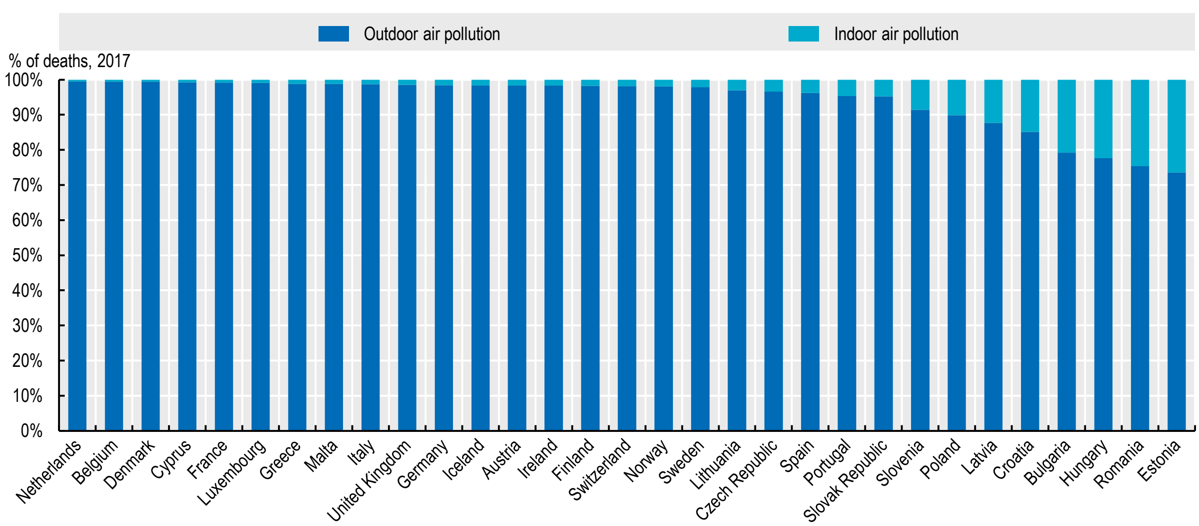
Figure 2.7. **A relatively high proportion of premature deaths from $PM_{2.5}$ exposure in Central and Eastern Europe are due to indoor air pollution**



Note: The data on indoor air pollution refers to the indoor use of solid fuels for cooking.
Source: IHME (2018), "GBD Results Tool", *http://ghdx.healthdata.org/gbd-results-tool*.

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Air pollution causes about EUR 600 billion in welfare losses each year across EU countries

The serious health consequences of air pollution result in large welfare losses because of greater mortality and morbidity (lower quality of life due to ill-health), greater health spending care costs to treat related conditions, and reduced labour productivity arising from greater absences from work due to illness. Box 2.6 describes the methodology that is used to estimate the different welfare losses related to air pollution, which is based on previous OECD work (OECD, 2016[22]). The estimates have been updated to 2017 based on the assumption that the share of each cost category has remained constant in recent years. The estimates relate to the impact of $PM_{2.5}$ (both outdoor and indoor) and ground-level ozone.

Box 2.6. **Methodology used to estimate the welfare losses from air pollution**

The methodology used in this chapter to estimate the welfare losses from air pollution is based on previous work by the OECD as described in the publication *The Economic Consequences of Outdoor Air Pollution* (OECD, 2016[22]). Table 2.1 below summarises the different categories of welfare losses considered in this analysis.

Table 2.1. **Non-market and market consequences considered in assessing the welfare losses of air pollution**

Health impacts	Non-market consequences	Market consequences
Mortality from cardiovascular and respiratory diseases, lung cancer and other diseases due to high concentrations of $PM_{2.5}$ and ozone	Premature deaths	[see note below]
Morbidity from cardiovascular and respiratory diseases, lung cancer and other diseases due to high concentrations of $PM_{2.5}$ and ozone	Quality of life losses due to ill-health (e.g. pain and suffering)	Higher health expenditure Lower labour productivity (due to absence from work)

Note: Premature deaths also have market consequences as it involves a loss of potential workers for premature mortality related to the working-age population and a loss of potential consumers for mortality at all ages, but these losses are not taken into account in this analysis.
Source: OECD (2016[22]), *The Economic Consequences of Outdoor Air Pollution*, *http://dx.doi.org/ 10.1787/9789264257474-en*.

The first and main welfare loss from air pollution is related to its impact on premature death. These welfare losses are calculated based on the value of a statistical life (VSL) approach, a standard economic method to measure the cost of premature mortality. The VSL method is based on assumptions about how much people would be willing to pay to reduce their risk of death, or how much additional money they would require to accept an additional risk, based on information from stated preference surveys. For example, on average, people may be willing to pay USD 30 (EUR 24) to reduce their risk of dying from diseases associated with air pollution by 1 per 100 000 people each year. If 100 000 people are willing to pay on average USD 30, the value of statistical life is then equal to USD 3 million (EUR 2.4 million) per life saved.

Using information from such surveys, previous OECD work has estimated that one statistical year of life was approximately equivalent to USD 3 million (EUR 2.4 million) on average across OECD countries (OECD, 2012[23]). Country-specific estimations are adjusted to take into account differences in national income and standards of living. These estimations, adjusted for purchasing power parity (PPP), range from USD 2.5 million in Greece (EUR 2 million) to USD 7.3 million (EUR 5.8 million) in Luxembourg in 2017. This monetary value is then multiplied by the number of premature deaths to calculate the total statistical value of life lost due to air pollution. The number of premature deaths is based on IHME estimates, which are at the lower end of the range considered in this chapter, so estimates of these welfare losses can be considered to be conservative.

The second category of welfare losses relates to the lower quality of life for people who are falling ill because of air pollution. These values are estimated based on stated preference surveys and willingness to pay values from earlier work (Holland, 2014[24]). For each of the morbidity impacts, the results are multiplied by an estimated value to calculate the welfare costs related to the quality of life losses (or disutility) from different illnesses (e.g. respiratory diseases). The third and fourth categories relate to market costs that are more directly measurable. These include the additional health care costs for people requiring care for respiratory, cardiovascular and other diseases that are attributed to air pollution, as well as lower labour productivity as measured by lost working days due to these illnesses among the working-age population (OECD, 2016[22]).

Table 2.2 shows that premature mortality due to air pollution from $PM_{2.5}$ and ozone resulted in the loss of an estimated EUR 527 billion across EU countries in 2017. Such costs account for about 88% of total welfare losses from air pollution (OECD, 2016[22]).

Welfare losses related to the lower quality of life of people living with illnesses that can be attributed to air pollution accounted for about 8% of total welfare losses, which is equivalent to about

Table 2.2. **Estimated welfare losses from air pollution ($PM_{2.5}$ and ground-level ozone), 2017**

	Total cost		Premature mortality		Quality of life losses		Health care cost		Productivity losses	
	bn EUR	**% GDP**	bn EUR	% GDP	bn EUR	% GDP	bn EUR	% GDP	bn EUR	% GDP
EU27 total	**601.45**	**4.92**	527.2	4.32	48.26	0.40	14.85	0.12	11.14	0.09
Austria	**14.98**	**4.35**	13.1	3.81	1.20	0.35	0.37	0.11	0.28	0.08
Belgium	**20.15**	**4.84**	17.7	4.24	1.62	0.39	0.50	0.12	0.37	0.09
Bulgaria	**6.01**	**13.16**	5.3	11.54	0.48	1.06	0.15	0.32	0.11	0.24
Croatia	**4.21**	**9.44**	3.7	8.27	0.34	0.76	0.10	0.23	0.08	0.17
Cyprus	**0.94**	**5.28**	0.8	4.63	0.08	0.42	0.02	0.13	0.02	0.10
Czech Republic	**11.87**	**7.05**	10.4	6.18	0.95	0.57	0.29	0.17	0.22	0.13
Denmark	**12.45**	**4.56**	10.9	4.00	1.00	0.37	0.31	0.11	0.23	0.08
Estonia	**0.86**	**4.16**	0.8	3.65	0.07	0.33	0.02	0.10	0.02	0.08
Finland	**4.79**	**2.26**	4.2	1.99	0.38	0.18	0.12	0.06	0.09	0.04
France	**71.86**	**3.27**	63.0	2.87	5.77	0.26	1.77	0.08	1.33	0.06
Germany	**168.15**	**5.55**	147.4	4.86	13.49	0.45	4.15	0.14	3.11	0.10
Greece	**13.68**	**7.72**	12.0	6.76	1.10	0.62	0.34	0.19	0.25	0.14
Hungary	**11.08**	**9.88**	9.7	8.66	0.89	0.79	0.27	0.24	0.21	0.18
Ireland	**6.11**	**2.33**	5.4	2.04	0.49	0.19	0.15	0.06	0.11	0.04
Italy	**95.14**	**5.75**	83.4	5.04	7.63	0.46	2.35	0.14	1.76	0.11
Latvia	**2.24**	**9.18**	2.0	8.04	0.18	0.74	0.06	0.23	0.04	0.17
Lithuania	**3.17**	**8.49**	2.8	7.44	0.25	0.68	0.08	0.21	0.06	0.16
Luxembourg	**1.44**	**2.76**	1.3	2.42	0.12	0.22	0.04	0.07	0.03	0.05
Malta	**0.54**	**5.61**	0.5	4.92	0.04	0.45	0.01	0.14	0.01	0.10
Netherlands	**29.18**	**4.23**	25.6	3.71	2.34	0.34	0.72	0.10	0.54	0.08
Poland	**33.61**	**7.81**	29.5	6.85	2.70	0.63	0.83	0.19	0.62	0.14
Portugal	**9.04**	**5.03**	7.9	4.41	0.73	0.40	0.22	0.12	0.17	0.09
Romania	**14.89**	**9.29**	13.0	8.14	1.19	0.75	0.37	0.23	0.28	0.17
Slovak Republic	**5.42**	**6.79**	4.7	5.96	0.43	0.55	0.13	0.17	0.10	0.13
Slovenia	**1.98**	**5.09**	1.7	4.46	0.16	0.41	0.05	0.13	0.04	0.09
Spain	**46.46**	**4.31**	40.7	3.78	3.73	0.35	1.15	0.11	0.86	0.08
Sweden	**11.20**	**2.46**	9.8	2.16	0.90	0.20	0.28	0.06	0.21	0.05
Iceland	**0.29**	**1.85**	0.25	1.62	0.02	0.15	0.01	0.05	0.01	0.03
Norway	**7.82**	**2.25**	6.9	1.97	0.63	0.18	0.19	0.06	0.14	0.04
Switzerland	**17.77**	**2.90**	15.6	2.54	1.43	0.23	0.44	0.07	0.33	0.05
United Kingdom	**109.61**	**4.15**	96.1	3.64	8.80	0.33	2.71	0.10	2.03	0.08

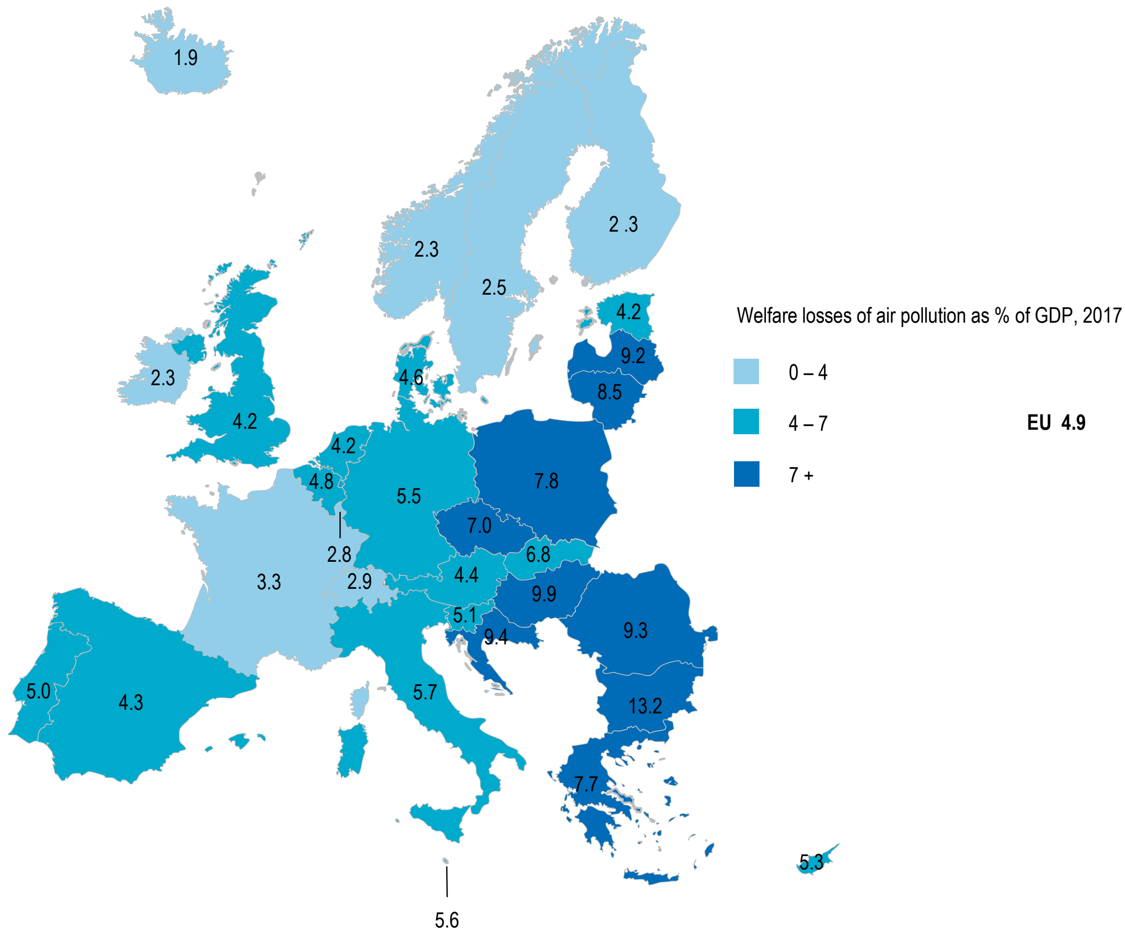
Source: OECD calculations, based on methodology described in Box 2.6 and OECD (2016[22]), *The Economic Consequences of Outdoor Air Pollution*, *http://dx.doi.org/ 10.1787/9789264257474-en*, using data from 2017.

EUR 48 billion across all EU countries. Greater health care costs related to air pollution represented about 2.5% of total welfare losses, equivalent to about EUR 15 billion across EU countries. Finally, the labour productivity losses from lost working days due to illnesses related to air pollution accounted for the remaining 2% of welfare losses, equivalent to about EUR 11 billion across EU countries.[2]

Taken together, the overall welfare losses of these air pollutants amounted to about EUR 600 billion in 2017, equivalent to 4.9% of the EU GDP. As a share of GDP, the estimated welfare losses related to air pollution were highest in Central and Eastern European countries (reaching over 9% of GDP in Bulgaria, Croatia, Hungary, Latvia and Romania), and lowest in Nordic countries (except Denmark), Ireland and Luxembourg (less than 3% of GDP) (Figure 2.8). These variations mainly reflect differences in the burden of premature mortality due to air pollution, the main driver of welfare loss estimates.

The main challenges to reducing the heavy impact of air pollution on people's health and welfare consist of further reducing the emissions of air pollutants at all levels (local, regional, national),

Figure 2.8. **Estimated welfare losses due to air pollution ($PM_{2.5}$ and ozone) as share of GDP, 2017**



Source: OECD calculations, based on methodology described in Box 2.6 and OECD (2016[22]), *The Economic Consequences of Outdoor Air Pollution*, *http://dx.doi.org/ 10.1787/9789264257474-en*.

StatLink *https://stat.link/9eb5q8*

achieving a strong decoupling of emissions from economic growth, and limiting people's degree of exposure to air pollutants. This implies implementing effective pollution prevention and control policies, sustainable transport and mobility policies, stimulating investment in cleaner technologies, promoting more sustainable agricultural methods, energy efficiency and the substitution of dirty energy sources with cleaner ones (OECD, 2020[8]).

EU countries have set ambitious goals to reduce air pollution by 2030

Since the 1970s, the EU has been working with its member states and international organisations to improve air quality by controlling the emissions of air pollutants and integrating environmental protection requirements into the energy, transport, industrial and agricultural sectors. In the international context, EU member states have worked since 1979 with other countries in and outside Europe to control international air pollution under the UNECE Convention on Long-Range Transboundary Air Pollution (the Air Convention), recognising that air pollution does not respect national borders. Reducing the negative impacts of air pollution is also part of the 2030 Global Agenda for Sustainable Development Goals (SDG), notably under Goal 3 (Good health and well-being) that calls for substantial reductions in the number of deaths from air pollution, under Goal 11 (Sustainable cities and communities) that aims to reduce the negative environmental impact of cities, and under Goal 13 (Combat climate change) that calls for urgent actions to combat climate change.

At the EU level, most of the provisions under the current Ambient Air Quality Directive (2008/50/EC) and the Directive on heavy metals and polycyclic aromatic hydrocarbons in ambient air (2004/107/EC) were originally established in the Air Quality Framework Directive in 1996 or in one of the four Daughter Directives adopted between 1999 and 2004. The two current directives are driving improvements in ambient air quality in Europe. They have set the basic principles for assessing and managing air quality and pollutant concentration thresholds that should not be exceeded (Box 2.7).

Box 2.7. **EU air quality standards and WHO guidelines**

The EU's air quality directives (2008/50/EC Directive on Ambient Air Quality and Cleaner Air for Europe and 2004/107/EC Directive on heavy metals and polycyclic aromatic hydrocarbons in ambient air) set pollutant concentrations thresholds that shall not be exceeded in a given period of time. If the limit or target values are exceeded, competent authorities are required to implement measures to improve air quality.

Selected EU air quality standards and WHO guidelines are summarised in Table 2.3 below. The WHO guidelines are set for health protection and are generally stricter than the current EU standards. Some European countries have chosen to apply these more stringent WHO guidelines. Under the European Green Deal, the European Commission is expected to propose to revise the air quality standards to align them more closely with the WHO guidelines (European Commission, 2019[15]).

Table 2.3. **Current EU Air Quality Directive and WHO guidelines for selected air pollutants**

Pollutant	Time period	EU Air Quality Directive	WHO guidelines
$PM_{2,5}$	Calendar year	Limit value, 25 microgrammes/m^3	10 microgrammes/m^3
PM_{10}	Calendar year	Limit value, 40 microgrammes/m^3	20 microgrammes/m^3
0_3	Maximum daily 8-hour mean	Target value, 120 microgrammes/m^3 (1)	100 microgrammes/m^3
NO_2	Calendar year	Limit value, 40 microgrammes/m^3	40 microgrammes/m^3

1. Not to be exceeded on more than 25 days per year, averaged over three years.

Source: European Environment Agency, "Air quality standards", *https://www.eea.europa.eu/themes/air/air-quality-concentrations/air-quality-standards*.

The 2013 Clean Air Programme for Europe reconfirmed the objective to achieve full compliance with existing air quality standards across the EU as soon as possible and set objectives for 2020 and 2030. A new EU Directive (2016/2284) on national emission reduction commitments (NEC) of certain air pollutants came into force at the end of 2016 (repealing the previous Directive 2001/81/EC), and is the main legislative instrument to achieve the 2030 objectives of the Clean Air Programme. This Directive sets national emission reduction commitments for each EU member state for the period 2020 to 2029 and more ambitious ones from 2030 onwards. It targets five pollutants responsible for serious health and environmental damages: sulphur dioxide, nitrogen oxide, volatile organic compounds, ammonia and fine particulate matter ($PM_{2.5}$). The aim of the Clean Air Programme is to reduce the health impact of air pollution by half by 2030 compared with 2005.

Emissions standards have also been set for key sources of pollution. These standards are set out at EU level in legislation targeting industrial emissions, emissions from power plants, vehicles and transport fuels, as well as the energy performance of products (European Commission, 2018[25]).

The effective implementation of this clean air legislation forms an essential contribution to the zero-pollution ambition for a toxic-free environment announced by the European Commission in

December 2019 under the European Green Deal. The European Green Deal proposes to adopt a "Zero-Pollution Action Plan" by 2021 (European Commission, 2019[15]).

According to the first European Commission report assessing the implementation of the 2016 NEC Directive released at the end of June 2020, 10 member states projected that they will be able to fulfill all of their 2020 emission reduction commitments under current measures, while the number falls to four only when it comes to the 2030 commitments. Regarding primary $PM_{2.5}$ emissions specifically, 23 EU countries projected that they will be able to meet their 2020 emission reduction commitments, but the number falls to 13 when it comes to the 2030 commitments (Table 2.4). Other member states will need to put in place additional measures to fulfil their emission reduction commitments (European Commission, 2020[3]).[3] Compliance with the 2020 emission reduction commitments can only be checked in 2022, when emission data for 2020 will become available.

Table 2.4. **Projected compliance as reported by EU member states in 2019 under existing policies and measures against 2020-29 and 2030-onwards national emission reduction commitments**

Member State	NO_x		NMVOCs		SO_2		NH_3		$PM_{2.5}$	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Austria	✓	×	✓	✓	✓	✓	×	×	✓	×
Belgium	✓	✓	✓	✓	✓	✓	✓	×	✓	✓
Bulgaria	✓	×	×	×	✓	✓	✓	×	×	×
Croatia	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cyprus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Czech Republic	✓	×	✓	×	✓	✓	✓	×	✓	✓
Denmark	✓	✓	✓	✓	✓	×	×	×	×	×
Estonia	✓	✓	✓	✓	✓	✓	×	×	✓	✓
Finland	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
France	×	×	✓	✓	✓	✓	×	×	✓	✓
Germany	✓	×	✓	✓	✓	×	×	×	✓	×
Greece	✓	×	✓	×	✓	✓	✓	✓	✓	✓
Hungary	✓	×	×	×	✓	×	×	×	×	×
Ireland	✓	×	×	×	✓	×	×	×	✓	✓
Italy	✓	×	×	×	✓	✓	✓	×	✓	×
Latvia	×	×	✓	✓	✓	✓	×	×	✓	×
Lithuania	×	×	✓	×	✓	✓	×	×	✓	×
Luxembourg	✓	×	✓	×	✓	✓	×	×	✓	×
Malta	✓	×	×	×	✓	✓	✓	×	✓	✓
Netherlands	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Poland	×	✓	×	✓	×	×	✓	×	✓	×
Portugal	✓	✓	✓	×	✓	✓	✓	✓	✓	×
Romania	×	×	×	×	✓	×	✓	✓	×	×
Slovak Republic	✓	×	✓	✓	✓	×	✓	✓	✓	✓
Slovenia	×	✓	✓	×	✓	×	✓	✓	✓	×
Spain	✓	×	✓	×	✓	×	✓	×	✓	×
Sweden	✓	×	✓	✓	✓	✓	×	×	✓	✓
United Kingdom	✓	×	✓	×	✓	×	×	×	×	×
✓	**22**	**10**	**21**	**14**	**27**	**18**	**16**	**9**	**23**	**13**
×	**6**	**18**	**7**	**14**	**1**	**10**	**12**	**19**	**5**	**15**

Note: NOx are nitrogen oxides; NMVOCs are non-methane volatiles organic compounds; SO_2 are sulphur oxides; NH_3 is ammonia; $PM_{2.5}$ are fine particles.

Source: First EC report on implementation of NEC Directive, 2020, *https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593765728744&uri=CELEX:52020DC0266*.

Beyond enforcing the relevant EU legislation, a number of EU actions also support the implementation of the National Emission reduction Commitments (NEC) Directive and the Ambient Air Quality Directives. These actions focus on promoting the sharing of best practices and providing EU funding to support measures to improve air quality (European Commission, 2018[25]).

The European Commission has organised two European Clean Air Fora so far to facilitate the coordinated implementation of air quality legislation and policies across the EU. The first forum took place in Paris in November 2017, and the second in Bratislava in November 2019. Both events were met with strong interest from stakeholders. The Clean Air Forum 2017 focused on the themes of air quality in cities, air pollution from the agricultural sector, as well as clean air business opportunities. The Clean Air Forum 2019 followed up on the discussion on agricultural impacts of air pollution and put an emphasis on clean air and health, domestic heating, as well as funding opportunities for clean air measures (European Commission, 2020[3]).

EU funding has also been made available in recent years under various programmes and used by member states to improve air quality. This funding either directly supports clean air projects or effectively includes clean air objectives in other investments (e.g. infrastructure, rural and regional development). During the period 2014-20, an estimated EUR 46.4 billion of EU funds have been allocated to contribute to clean air objectives through these various programmes (Table 2.5).

Table 2.5. **Estimates of EU funds dedicated to clean air objectives from various programmes**

Programme	Estimated Clean Air Contribution 2014-20 (in million EUR)
Horizon 2020	4 219
EFSI (European Fund for Strategic Investments)	819
CEF (Connecting European Facility)	8 830
ERDF (European Regional and Development Fund)	20 458
CF (Cohesion Fund)	10 874
EAFRD (European Agriculture Fund for Regional Development)	1 138
LIFE (Financial Instrument for Environment)	105
Total	**46 443**

Source: First EC report on implementation of NEC Directive, 2020 (Annex 4), *https://www.eea.europa.eu/themes/air/air-pollution-sources-1/national-emission-ceilings/nec-directive-reporting-status-2019*.

How can the health sector contribute to reducing the burden of air pollution?

Most policies that aim at reducing air pollution target those human activities that are its major sources – notably energy production and consumption, transportation, and the industrial and agricultural sectors. The role and involvement of the health sector in achieving air pollution reductions has to date been more limited.

The health sector can also contribute directly or more indirectly to overall efforts to reduce air pollution in at least two ways:

1. the health sector can reduce its own "ecological footprint" by improving its energy efficiency and reducing its use of various products that contribute to air pollutant emissions;
2. public health authorities and health professionals can also encourage a transition to less polluting and more active modes of transportation through behavioural changes and promoting urban and transport policies that are more supportive of health and environmental protection.

The health sector can reduce its ecological footprint

The health sector accounts for more than 8% of GDP on average across EU countries, and its wide range of activities contribute to air pollution and climate change in various ways. The approximately 13 000 hospitals across the EU have a high demand for heating and also use a large amount of energy for their day-to-day operations and activities. Health systems also consume a lot of medical goods and equipment that can contribute to air pollution during the production and disposal process (Health Care Without Harm Europe, 2016[26]). It has been estimated that the health sector is responsible for 3% to 8% of the total greenhouse gas emissions in EU countries through energy consumption and the industrial production of pharmaceuticals and other medical goods (WHO, 2015[27]).

Under the project “Health Care Without Harm”, more than 43 000 hospitals and health centres in 72 countries around the world (including in all EU countries) have already committed to reduce their environmental footprint and promote both human and environmental health through improving their supply chain through the Global Green and Healthy Hospitals initiative. Many hospitals started a long time ago to leverage their significant purchasing power to become more environmental-friendly. For example, in Vienna, public hospitals and all other public institutions are expected to consider the environmental impact of their purchasing decisions. This has led to phasing-out the use of toxic and potentially carcinogenic chemicals in disinfectants, surfaces and instruments, from four tonnes annually in 1997 to almost zero in 2014 (Health Care Without Harm Europe, 2016[26]).

There is also great potential for hospitals and other health care facilities to achieve energy efficiency gains and reduce their reliance on fossil fuels and other dirty energy sources. In Germany, energy savings in hospitals are stimulated by the award of an “Energy Saving Hospital” quality label (*Bund Für Umwelt Und Naturschutz Deutschland*). In Sweden, the region of Skåne has set an ambitious goal to eliminate the use of fossil fuels in all public buildings managed by the region, including hospitals. The region was already 86% fossil fuel-free in 2016 (Health Care Without Harm Europe, 2016[26]).

The health sector can also reduce its environmental footprint by reducing its use and waste of polluting materials and products. In many cases, the disposal of such waste involves incineration, with the potential to generate harmful emissions, ashes, nitrogen oxides, particulate matter and various volatile substances. Some hospitals in France and other countries have started to implement a comprehensive waste management policy to minimise the quantities of materials going to landfill or incineration (Health Care Without Harm Europe, 2016[26]).

Large amounts of food are wasted in hospitals and other health care facilities, contributing to food overproduction, additional strains on available natural resources and air pollution (OECD, 2017[28]). Estimates of food wasted in European hospitals range from 6% to 65% of all the food served (Williams and Walton, 2011[29]). France has set a national objective to reduce food waste in hospitals and other collective establishments by 50% by 2025 compared with 2015, in order to reduce greenhouse gas and other emissions and avoid the unnecessary use of natural resources while reducing costs (Ministère de la transition écologique, 2020[30])

More broadly, public health authorities can work with other government, environmental, agricultural and industrial stakeholders to identify more effective ways to encourage both a healthy diet and more sustainable food production for the population as a whole. Results from such collaborations can be used to update nutritional guidelines to help the population make healthy choices. At the European level, the new “Farm to Fork” strategy provides a good example of a strategy designed to make food production and consumption more healthy and environment-friendly, with the aim of reducing the emission of greenhouse gases and air pollutants (Box 2.8).

Box 2.8. **The EU Farm to Fork Strategy**

Linked to the *European Green Deal*, the new EU Farm to Fork Strategy, announced in May 2020, is designed to make food systems more sustainable, fair, healthy and environmentally friendly. The Strategy sets out various initiatives, both regulatory and non-regulatory, to achieve several key changes to the food systems in Europe. The main goals of the Strategy are to:

- Ensure that food systems will have at least a neutral or preferably positive environmental impact;
- Help everyone achieve access to safe, nutritious and sustainable food;
- Address simultaneous challenges of ensuring food affordability, generating fair economic returns, fostering competitiveness of the EU supply sector and promoting fair trade;
- Help to mitigate climate change and adapt to its impacts;
- Reverse the loss of biodiversity;
- Make sure that trade policies and international cooperation instruments support global transition to sustainable agri-food systems.

Source: European Commission, (2020[31]), "Farm to Fork Strategy: For a fair, healthy and environmentally friendly food system", *https://ec.europa.eu/food/farm2fork_en*.

Public health authorities can promote a transition to greener urban policies and more active transportation

A substantial part of PM emissions and other air pollutants are due to the use of cars and other motor vehicles, which also contributes to physical inactivity, another important cause of morbidity and mortality. Public health authorities can work with other partners to encourage a transition to cleaner and more active modes of transportation, such as cycling, walking or using public transport, with benefits including less air pollution, fewer car accidents and greater physical activity (Infographic 2.2).

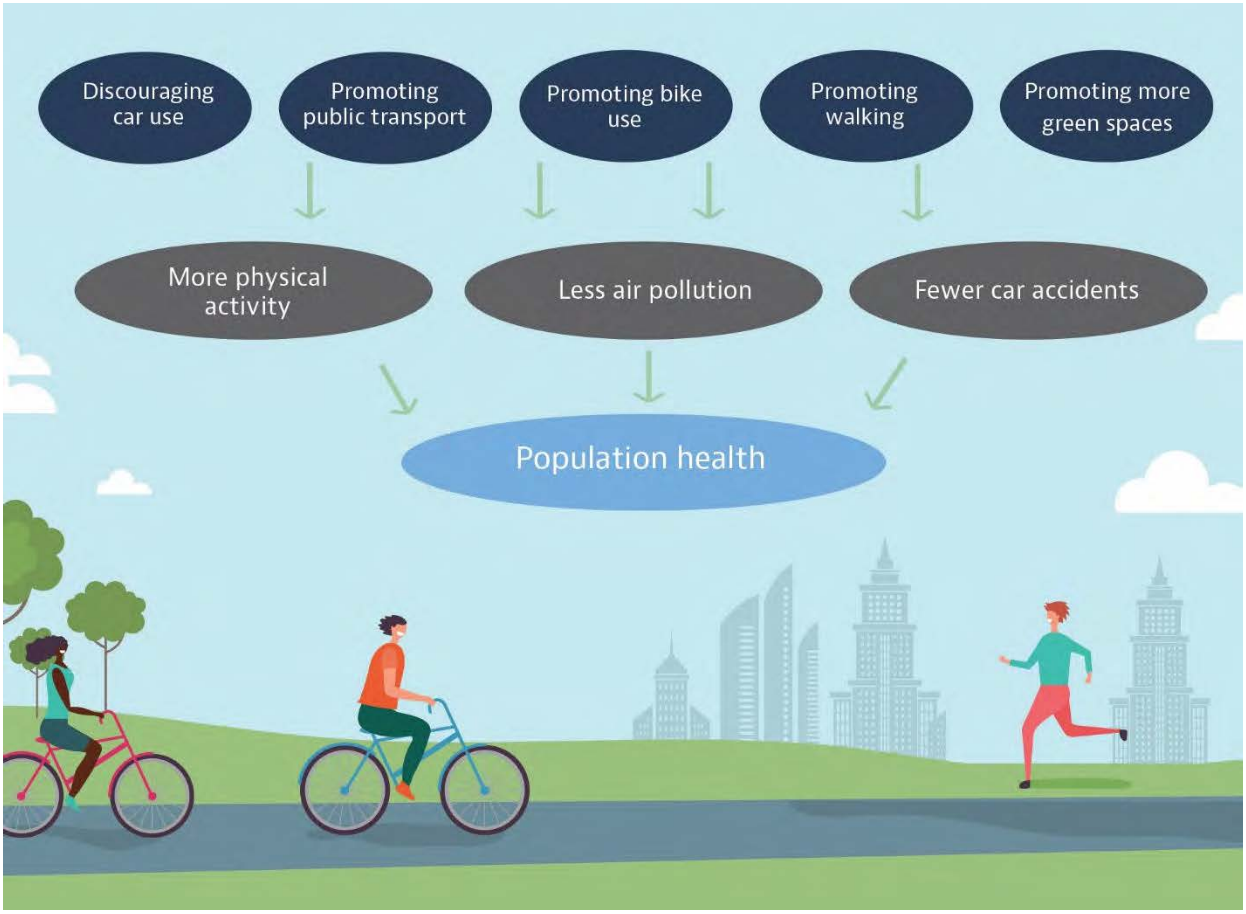
Health care systems can directly contribute to achieving these health and environment benefits by making adjustments to their transportation services for patients, staff and supplies. For example, over the past five years the network of public hospitals in Paris (APHP) has put in place a number of green mobility options for its staff (Health Care Without Harm Europe, 2016[26]; European Commission, 2020[33]).

Doctors and other health workers can also play an important role in promoting changes in people's behaviours, by discussing with their patients the benefits of greater physical activity for transportation and other purposes. Evidence shows that GP prescriptions of physical activity for people at risk of developing chronic diseases may increase their physical activity by about one hour of moderate-level exercise per week – more than one third of the 150 minutes per week of moderate exercise recommended by the WHO (Goryakin, Suhlrie and Cecchini, 2018[34]). To the extent that such increases in physical activity reduce the use of motor vehicles, this may have the added benefit of reducing air pollution.

Public health authorities can also contribute to the roll-out of mass media campaigns to encourage greater levels of physical activity among the population in general, thereby also possibly contributing to the use of less polluting modes of transportation. Such campaigns can be implemented through both traditional media (television, radio, newspaper) and new media (online marketing, social networks), and be implemented at the national or local levels. Evidence shows that well-designed mass media campaigns can increase the proportion of people who are at least moderately active by more than one-third (OECD, 2019[35]).

Since 2002, the European Mobility Week campaign has sought to improve public health and quality of life by promoting clean and sustainable urban transport. Actions during this week typically include a Car-free Day, where participating towns and cities set aside one or several areas solely for

Infographic 2.2. **Encouraging less polluting and more active modes of transportation can lead to multiple health and environmental benefits**



Source: Adapted from © ONYXprj/Shutterstock and Figure 1 in Rojas-Rueda et al. (2016[32]), "Health Impacts of Active Transportation in Europe", *http://dx.doi.org/10.1371/journal.pone.0149990*.

pedestrians, cyclists and public transport. Over 2 700 towns and cities across Europe participated in the European Mobility week in September 2020 under the theme of promoting zero-emission for all.

Population behaviour and the quality of air in cities are also influenced by urban design and infrastructures. Most obviously, urban sprawl encourages the use of motor vehicles and discourages more active modes of travelling (Stone et al., 2007[36]). While urban and transport policies are beyond the usual responsibilities of public health authorities, a greater public health perspective can be brought in these policies to improve both air quality and population health. Such policies can promote a greater availability of public transportations, facilitate the use of more active modes of transportation and increase the number of green spaces.

For example, Luxembourg has implemented a nation-wide free-of-charge public transportation policy since the end of February 2020 (Luxembourg.public.lu, 2020[37]). The development of public transportation systems generally increases the amount of walking, on average by about 30 minutes per person per week (Xiao, Goryakin and Cecchini, 2019[38]), which is a fifth of the time that people should spend on physical activity as recommended by WHO. The importance of public transportation for air quality was highlighted, for example, during public transit strikes in five large German cities between 2000 and 2011. During these strikes, PM_{10} levels in these cities increased by 14%, while hospital admissions for respiratory diseases among young children increased by 11%

(Bauernschuster, Hener and Rainer, 2017[39]). In Barcelona, nitrogen oxide emissions increased by 8% during public transit strikes between 2005 and 2016 (Basagaña et al., 2018[40]).

The introduction or expansion of bicycle lanes and bike-sharing schemes increases the use of bicycles and can help improve air quality. For example, in Barcelona, bike-sharing was estimated to reduce yearly CO_2 emissions by about 9 000 tonnes per year (Rojas-Rueda et al., 2011[41]). In Warsaw, a study estimated that CO_2 emissions could be reduced by up to 26 000 tonnes per year if cycling accounted for 35% of all trips (Rojas-Rueda et al., 2016[32]). Another study, simulating the impact of investment in cycling infrastructure in London and Antwerp, estimated that if the cycling share of all trips increased by 23%, there would be a reduction of annual emissions of NO_x by up to 27% in London and of PM_{10} by up to 19% in Antwerp (Hitchcock and Vedrenne, 2014[42]). While it is possible that for individual bike users, exposure to air pollution can sometimes increase because they may spend more time on the roads, the evidence indicates that benefits from physical activity at the individual level far outweigh this risk (Rojas-Rueda et al., 2016[32]).

Several European countries have also introduced various financial incentives to encourage a switch from cars to more active modes of transportation. These include greater parking fees in urban centres, and subsidies for bike purchases in countries like Belgium, France, Luxembourg and Italy (European Commission, 2020[33]).

Other urban and transport policies are also beneficial both to air quality and population health, including the introduction of low emission zones, speed limits and congestion charges (Box 2.9). Low-emission zones are areas within a city where vehicles with certain emission ratings cannot enter or are charged a fee for entering. These zones have been implemented in over 200 cities in 10 European countries with the aim to meet EU Air Quality Standards (Holman, Harrison and Querol, 2015[43]). In Germany and the Netherlands, these low emission zones have contributed to a reduction in various air pollutants (Boogaard et al., 2012[44]; Holman, Harrison and Querol, 2015[43]). The implementation of low-emission zones may also provide an opportunity to take stock of available transportation choices in a city and to develop more environmental-friendly options such as public transportation, bicycle and pedestrian-friendly infrastructure.

Box 2.9. **Examples of good practices in transportation policies with the potential to reduce air pollution and improve population health**

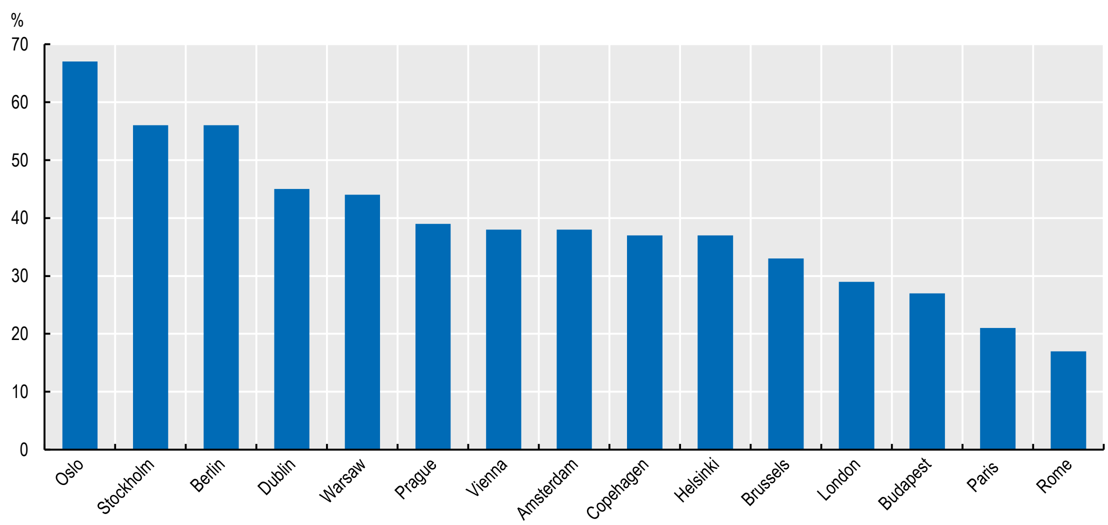
- In Stockholm, it was estimated that the Congestion Charges, introduced on a pilot basis in 2006 and on a more permanent basis in 2007, resulted in a 15% drop in vehicle miles travelled, leading to emissions reductions of 8.5% for nitrogen oxides, and 13% for PM_{10} (Johansson, Burman and Forsberg, 2009[45]).
- In Berlin, a speed limit of 30 km/h was imposed in several areas with particularly high air pollution levels in 2018, with the aim of decreasing both the number of road accidents and air pollution. According to one evaluation, a speed limit of 30 km/h in Berlin has resulted in the reduction of NO_2 pollution levels by 10 to 15% (Berlin.de, 2018[46]).
- In Paris, the municipal authorities have announced the intention to phase out the use of diesel cars by 2024 and petrol cars by 2030, with only electric cars being allowed. In 2019, all diesel vehicles aged 13 years or over were banned from streets in the city centre. Likewise, the region of Brussels has decided to ban diesel cars from 2030, and all petrol cars (although not trucks nor vans) from 2035.
- Low emission zones are implemented in a number of European cities. For example, in Belgium, to enter parts of Antwerp, Brussels or Ghent, drivers have to check in advance whether their vehicles meet the emission level thresholds, and in certain cases register their vehicles on relevant websites.

Public health authorities and other public health stakeholders can also advocate for a greater number of green spaces and parks that can help reduce particulate matter levels, while also helping to promote greater physical activity, more active lifestyles and lead to other benefits such as noise reduction. This can be achieved by rehabilitating sites previously used for industrial or other purposes to create new parks, playgrounds and recreational areas. Some of these interventions explicitly aim to improve air quality, such as through the installation of green vegetated screens along main and heavy traffic roads. Other projects may have other primary goals in mind, but nevertheless may lead to better air quality as a by-product. For example, a project to facilitate everyday walks in Stavanger, Norway, provides access to green trail system to 98% of its population within 500 metres of their home. In Stuttgart, a former stone quarry was transformed into a green nature reserve, while also promoting more active lifestyles. Another interesting example is the conversion of an old train track into a bike and pedestrian path in central Copenhagen (WHO Europe, 2013[19]).

A study covering 245 cities worldwide found that investing USD 4 per resident to increase the number of trees in a city can reduce particulate matter-related mortality by 2.7% to 8.7% (McDonald, 2016[47]). In general, such returns on investment were found to be higher in cities with higher population density like Paris or Madrid. In Paris, it was estimated that 2.3 million people could potentially benefit from a reduction in $PM_{2.5}$ by at least 1 µg/m³, at a cost of about USD 10 million per year.

The availability of green spaces varies significantly between European cities (Figure 2.9). This suggests significant potential for improvement especially in cities where this proportion is low.

Figure 2.9. **Percentage of population living in areas with green spaces (forests, gardens and parks) in selected European cities (2014)**



Source: Joint Research Centre, "Urban Centres database", *https://ghsl.jrc.ec.europa.eu/ucdb2018visual.php#*.

StatLink *https://stat.link/0fs8ep*

At a global level, the C40 network of cities around the world, encompassing more than 650 million people, represents a good example of how changes in the urban environment may promote a more active lifestyle and a reduction of air pollution (Box 2.10).

At the EU level, a new Green City Accord has been launched in October 2020 to make cities greener, cleaner and healthier, and accelerate the implementation of relevant EU environmental directives and laws. By signing the Accord, cities will commit to tackling the most urgent environmental challenges they are facing. With respect to air pollution, mayors who will join the Accord will agree to step up their efforts to significantly improve air quality by moving closer to respecting the WHO

Box 2.10. **The world's largest cities collaborate to take action on climate change and air pollution while supporting active lifestyles**

The C40 Cities Climate Leadership Group was established in 2005 to promote sustainable urban development through knowledge and best practice sharing. Originally, the network was composed of 40 large cities of at least 3 million people on all continents, but gradually opened up to smaller cities committed to sustainable development.

The network shares good practices to help tackle climate change and reduce urban air pollution. Many of these practices promote active travelling and active lifestyle, as well as the use of less polluting modes of transportation. For example, the Transport Authority of Milan plans to convert the local public transport network to electric power by 2030, which is expected to lead to CO_2 emission reductions by almost 75 000 tons/year and the reduction of emissions of PM and several other air pollutants (C40, 2019[48]). In Warsaw, there are plans to make 25% of the bus fleet electric by 2030 (C40, 2017[49]).

In 2018, the city of Venice signed an agreement to test the supply of fuel with 15% reusable content (with one source being oil wastes supplied by local residents) for its public boat fleet, at the same cost as the more polluting diesel fuel. The initial agreement was for seven months, but the programme is still in operation. It is expected to help reduce pollutants like nitrogen oxides and primary and secondary particulate matters (C40, 2020[50]).

guidelines and ending exceedances of EU air quality standards as soon as possible (European Commission, 2020[51]).

Conclusion

Although air pollution has decreased in most European countries over the past two decades, it still exceeds the WHO guideline in most countries, particularly in large cities. In almost all European capital cities, population exposure to air pollutants like $PM_{2.5}$ exceeds the WHO guideline, and by up to twice in several Central and Eastern European capitals.

The impact of air pollution on health and mortality is considerable. Across all EU member states, estimates of the number of premature deaths attributable to outdoor air pollution from $PM_{2.5}$ alone range from 168 000 to 346 000 deaths in 2018. The mortality attributed to air pollution is particularly high in Central and Eastern European countries mainly because of greater use of fossil fuels and other dirty energy sources for heating and other purposes. Premature death rates from air pollution reach between 120-180 per 100 000 population in Bulgaria, Hungary, Romania, Poland and Croatia. This is six times higher than in most Nordic countries.

The welfare losses associated with air pollution are enormous. Taking into account the impact on mortality, lower quality of life for people falling sick because of air pollution, lower labour productivity and higher health spending, the total welfare losses from air pollution from $PM_{2.5}$ and ozone across all EU countries was estimated to reach EUR 600 billion in 2017, which is equivalent to 4.9% of the total EU GDP.

Three EU Directives are driving improvements in air quality across Europe: the 2008 Ambient Air Quality Directive, the 2004 Directive on heavy metals and polycyclic aromatic hydrocarbons in ambient air, and the 2016 Directive on National Emission reduction Commitments (NEC) of certain air pollutants. This latter Directive has set emission reduction commitments for each member state for the period 2020-29 and more ambitious ones from 2030 onwards, targeting five pollutants that have serious negative health and environmental consequences. The first EC report assessing the implementation of the 2016 NEC Directive released at the end of June 2020 concluded that most EU member states were not on track to meet all of their 2030 emission reduction commitments under current measures, hence additional measures will be required in these countries (European Commission, 2020[3]). Work is also done for cooperation on these issues beyond the EU within the framework of the UNECE Air Convention.

Efforts to reduce air pollution have usually focused, first and foremost, on those sectors and human activities that are the main sources of air pollutants (including energy production and consumption, transport, industry and agriculture). Even though the direct role the health sector can play in reducing air pollution is limited, it can nonetheless contribute to the overall effort. The health sector can reduce its own environmental footprint by decreasing its reliance on fossil fuels in electricity generation and achieving greater energy efficiency, as well as reduce its use and waste of toxic and polluting products. Public health authorities can also work with other relevant agencies and stakeholders to promote more healthy and clean urban planning and a transition from the use of cars and other motor vehicles to less polluting and more active modes of transportation. During consultations, doctors and other health professionals can encourage people to change their behaviours and become more physically active, contributing to a reduction in air pollution to the extent that this decreases the use of motor vehicles. Such behavioural changes will be easier to achieve if accompanied by changes in the urban environment and infrastructures that are more conducive to promoting more active modes of transportation, like cycling, walking or taking public transportations.

As European countries start implementing recovery plans from the COVID-19 crisis, there is a great opportunity for governments, businesses and citizens to promote a green recovery to avoid the looming health, economic and welfare consequences of environmental degradation, including climate change, biodiversity collapse and air pollution. While the economic crisis following the COVID-19 pandemic has led to at least a temporary reduction in various air pollutants in many countries, whether these reductions will become more permanent depends on the policy actions that will be put in place to support the economic recovery. A green recovery will require a systematic integration of environmental considerations. The EU recovery plan that was adopted by the European Council in July 2020 is designed to support the economic recovery from the COVID-19 pandemic and investments in the green and digital transitions of EU economies (European Council, 2020[5]).

Strengthening efforts in the short and longer-term to protect the environment and improve air quality are key to reducing the huge health and mortality burden of air pollution in Europe and around the world.

Notes

1. In addition to deaths related to $PM_{2.5}$, the EEA estimates that about 48 000 people died in 2018 from exposure to nitrogen dioxide (NO_2) and about 18 000 from exposure to ozone (O_3) across all EU countries (European Environment Agency, 2020[2]). These numbers cannot be added with premature mortality from $PM_{2.5}$ due to potential double counting.
2. These estimates of labour productivity losses can also be considered to be conservative. Another recent OECD study of the economic cost of air pollution in Europe, using other data sources and methods, found that a 1 microgramme/m^3 increase in $PM_{2.5}$ concentration (or a 10% increase at the sample mean) led to a 0.8% reduction in GDP, with most of the impact due to reductions in labour productivity from greater absence from work. These results suggest that policies to reduce air pollution may contribute to economic growth (Dechezleprêtre, Rivers and Stadler, 2019[52]).
3. Alongside this first implementation report, at the end of June 2020 the European Commission also released an analysis of the risk of non-compliance with national emission reduction commitments based on the National Air Pollution Control Programme and the quality of projections. Over half of the countries assessed (12 out of 20) were identified as facing medium to high risks of not meeting their 2020 national emission reduction commitments of $PM_{2.5}$ and three-quarters (15 out of 20) of not meeting their 2030 national emission reductions (European Commission, 2020[3]).

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