ORIGINAL RESEARCH

Market and welfare valuation of the economic burden of diseases attributable to air pollution exposure in the Western Balkans

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Abstract

Aim: The population in the Western Balkans is exposed to high air pollution concentrations, among the highest in Europe, causing death and disability. Research, however, on the resulting economic cost in the region is still limited. We estimate the economic cost of the adverse health effects from air pollution exposure, including fine particulate matter (ambient and household) and ambient ozone air pollution in the region.

Methods: We employ both market and welfare-oriented methods. According to the Cost-of-Illness (COI) approach, we estimate both the direct (healthcare expenditure) and indirect cost (mortality and morbidity cost). Against the shortcomings of a market-based valuation, the Willingness to Pay (WTP) approach is also used. The most recent data from the Global Burden of Disease Study 2019 are used.

Results: Under the COI approach, total economic cost is estimated at PPP$ 6.3 billion. Equivalently, it ranges from 0.8% of GDP in Croatia to 2.39% of GDP in Bosnia and Herzegovina. The WTP methodology yields a significantly higher estimate, equal to PPP$ 76.7 billion. The monetary amount associated with the disease burden of air pollution is significant.

Conclusion: Public health policies should include monitoring of the adverse health effects of air pollution. Abatement policies should aim at reducing ambient air pollution as well as the dependence on polluting household energy usage. The reduced economic cost can be accompanied by benefits associated with climate change mitigation and an overall improvement in population's health status, an important aspect given the current COVID-19 pandemic.

Keywords: *air pollution, economic cost, health cost, Western Balkans.*

Authors' contribution: Maria Panteli: Conceptualization; Data curation; Formal analysis; Methodology; Software; Writing - original draft; Writing - review and editing. Sofia Delipalla: Conceptualization; Methodology; Supervision; Writing - review and editing.

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Introduction

Over the last years, the problem of increased air pollution has drawn a lot of attention in the Western Balkans region. Air pollution is the fourth leading health risk factor causing death, while it is among the first seven risk factors for disability (1). Despite the clear epidemiological evidence on the adverse health effects of air pollution in the region, research on the associated economic cost is still limited.

Most of the relevant studies focus on mortality cost, with Willingness to Pay (WTP) being the valuation method most frequently employed (2-6). Only one of these studies offers estimates under the Cost-of-Illness (COI) approach as well, albeit Albania and Montenegro are not included in the analysis (3). Research on morbidity cost and/or healthcare expenditure due to air pollution is also limited for individual countries in the Western Balkans (7-10). Finally, a couple of studies estimate healthcare costs due to air pollution induced from coal-fired electricity plants (10,11).

The aim of the present study is to estimate the economic cost of air pollution-attributable health effects in all six countries in the Western Balkans region, Albania, Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, and Serbia, in 2019. Our estimates include not only the economic cost of the health effects from ambient air pollution (fine particulate matter ($PM_{2.5}$) and ozone), but also from household $PM_{2.5}$ air pollution.

We employ two different valuation methodologies, namely COI and WTP, examining the economic cost of air pollution from both a market and a welfare perspective. Within a market or income-based framework, the burden of disease from air pollution can be seen as a disinvestment in the human capital stock of a country. This disinvestment must be valued as in the case of other forms of capital degradation (12). On the other hand, WTP is more closely related to the concept of economic welfare and has become a mainstream approach in valuing pollution-related mortality risks. The use of both methods can be seen as an attempt to offer an upper (WTP) and lower (COI) bound of economic losses due to air pollution exposure. Under the COI approach, all cost components are taken into account. To the best of our knowledge, this is the first study estimating healthcare expenditure and indirect morbidity cost due to air pollution in the Western Balkans. We use the most recent data on the disease burden (1).

Methods

Cost-of-Illness

According to COI, the economic cost of air pollution is divided into annual direct and indirect cost (13,14). Direct cost includes healthcare expenditure incurred due to air pollution-related diseases. Direct costs can be health care costs resulting from the use of health care services (hospitalization, physician services, medication) and non-healthcare expenditure (transportation to health care providers, informal care for the sick, replacement expenses for sick workers, cost of cleaning up polluted air). In our analysis, direct cost includes government health spending, out-of-pocket health spending, prepaid private spending and for some countries development assistance for health. Non-healthcare expenditure is not taken into account due to lack of data, as in most COI studies.

For the three categories of air pollution under examination and their joint effect (total air pollution), the attributable healthcare expenditure is estimated as:

$$\boldsymbol{APAE_{ij} = APAF_{ij} \times THE_j} \qquad (1)$$

where $APAE_{ij}$ is the air pollution attributable healthcare expenditure by air pollution subcategory i and country j, $APAF_{ij}$ is the air pollution attributable fraction (mean value) based on data on death numbers by pollution subcategory i and country j, and THE_j is total health spending by country j.

Indirect cost is related to productivity losses due to premature mortality and morbidity resulting from air pollution attributable illnesses. The quantification of the resulting economic losses is done using the Human Capital (HC) method (3). Indirect morbidity cost, attributable to air pollution $APAIC$, is calculated as:

$$\boldsymbol{APAIC_{ijks} = APAF_{ijks} \times YLD_{ijks} \times E_{js} \times PROD_j} \quad (2)$$

where $APAF_{ijks}$ is the air pollution attributable fraction of indirect morbidity cost by air pollution subcategory i, country j, disease k and population subgroup s (mean value), YLD is the number of Years Lived with Disability, E is employment to population ratio by country j and population subgroup s and $PROD$ is Gross Domestic Product (GDP) per worker by country j. It should be mentioned that the use of GDP per worker is only an imperfect proxy for measuring lost productivity due to air pollution-induced morbidity (and mortality below). A better measure would have been the use of mean annual earnings by population subgroup, as suggested by Max et al. (15). However, in the absence of such detailed wage data by gender and age, we opt for the use of a second-best option, i.e., GDP per worker. The population subgroups of interest are males and females ages 15-19 years to 75-79 years.

Indirect mortality cost includes present and future foregone income due to premature mortality from air pollution-related illnesses. Air pollution attributable indirect mortality cost $APAMC$ for pollution subcategory i and country j, resulting from premature death from disease k in the population subgroup s is calculated as:

$$\boldsymbol{APAMC_{ijks} = APAF_{ijks} \times \sum_{a=min}^{max} (DEATH_{ijksa} \times PVLE_{jsa})} \quad (3)$$

where $APAF$ is the air pollution attributable fraction of death (mean value), $DEATH$ is the total number of deaths, $PVLE$ is the present discounted value of lifetime earnings and min - max represent the minimum and maximum age groups, respectively.

Note that the population attributable fractions used in the analysis originate from the GBD 2019 Study (1) and form a part of a complex framework developed for human health comparative risk assessment. This framework consists of six steps, including the evaluation of various risks and the formation of risk-outcome pairs to be included in the study, the estimation of exposure, the collection of sources related to the "theoretical minimum risk exposure level" (TMREL), the decision on TMREL and related uncertainty, the estimation of population attributable fractions, the estimation of summary exposure values, the collection and assessment of mediation effects and finally the estimation of the attributable health burden (16). Due to the complexities present in calculating the population attributable fractions (renamed as pollution attributable fractions in the present analysis), the reader is referred to Appendix 1 (section 2, pp. 39-40 and section 4, pp. 78-137) (16) of the GBD 2019 Study (1) for the related methodology and formulae.

In calculating the present value of productivity over all future years that a person would have worked had they not died prematurely, we take into account life expectancy for the different age groups and genders, and the percentage of people participating into the labour force by age group and gender, respectively (15). That is,

$$\boldsymbol{PVLE_{ag} = \sum_{n=a}^{max} \left(PS_{ag}(n)\right) \times [PROD \times E_g(n)] \times (1+\mu)^{n-a}/(1+r)^{n-a}} \quad (4)$$

where $PVLE$ is the present discounted value of lifetime earnings, a represents the age of a person at present and g the gender. PS is the probability that a person of gender g dying at age a would have survived at age n, $PROD$ is GDP per worker, $E_g(n)$ is the

employment to population ratio at age n and gender g, μ is the labor productivity growth rate and r is the discount rate.
We assume 1% annual increase in productivity and no discounting (0%) for human life. This decision is based on a World Health Organization (WHO) technical report (17), according to which there is no inherent justification to evaluate a year of healthy life less just because it is a future year of life. The decision for no time discounting is adopted by the report for quantifying the loss of health. Nevertheless, since our major goal is to assign a monetary value to life loss, we adopt this viewpoint and apply a 0% discount rate. A sensitivity analysis is performed, in which a 3% discount rate is applied instead (17). The maximum age group for which indirect mortality cost is calculated is 75-79 years, as in morbidity cost calculation. With respect to minimum age, an adjustment is made so that children below age 15 are not assigned with zero values.
Finally, total economic cost is the sum of direct and indirect costs. All monetary values are in 2019 PPP adjusted international dollars.

Willingness to Pay

The COI approach has been criticized on the basis that human life is valued through the stream of present and future market earnings disrupted by morbidity and premature mortality (15). To overcome the shortcomings of market-based valuation, the WTP approach has been suggested. This method reflects welfare costs as it captures the things that are "ordinarily" valued by individuals, such as leisure, consumption, health and life itself (2).
Under WTP, the economic cost of the mortality impact of air pollution is calculated using the Value of Statistical Life (elicited by a primary WTP survey) multiplied by the aggregate number of early deaths in a specific setting and in a particular time interval. In the absence of primary WTP surveys for the countries under examination, an OECD-recommended VSL "base" value can be employed, equal to US$ 3 million. This VSL is a product of a meta-analysis of 92 published VSL studies and must be adjusted for income differences between the "original" and the new policy context (18). For calculating the Western Balkans country-specific VSLs, we use the OECD-recommended formula (18,19):

$$\boldsymbol{VSL_{C,2019}} = \boldsymbol{VSL_{OECD,2005}} \times \left(\boldsymbol{Y_{C,2005}}/\boldsymbol{Y_{OECD,2005}}\right)^{\beta} \times (\mathbf{1} + \%\boldsymbol{\Delta P} + \%\boldsymbol{\Delta Y})^{\beta} \qquad (\mathbf{5})$$

where $VSL_{C,2019}$ is the VSL for country C in 2019, $VSL_{OECD,2005}$ is set equal to US$ 3 million, $Y_{C,2005}$ is 2005 GDP per capita for country C in PPP terms, $Y_{OECD,2005}$ is the 2005 value of average GDP per capita of OECD member states (in PPP terms), $\%\Delta P$ and $\%\Delta Y$ are the percentage change in consumer price and in real per capita GDP growth from 2005 to 2019, respectively. Finally, β is the income elasticity of the VSL. The income elasticity is set equal to 1.2 in all countries except for Croatia. This decision is based on the OECD recommendation for transferring VSLs from high-income to non-OECD and non-EU countries (18), and following the WB-IHME work (3). In the case of Croatia, the income elasticity is set equal to 0.8, following OECD (19).

Data sources

For the COI approach, health data are taken from IHME's GBD 2019 (1). Total national healthcare expenditure is taken from IHME's Global Expected Health Spending 2018-2050 dataset (20). Employment to population ratios by age and gender and total number of workers by country are retrieved from the International Labour Organization's (ILO) statistical database (21). GDP figures refer to nominal GDP in PPP international dollars and are taken from the International Monetary Fund's (IMF) World Economic Outlook Database (22). Survival probabilities are calculated

using country-specific life tables from the WHO (23). All data are for 2019.
For the WTP calculations, data are retrieved from the World Bank's World Development Indicators database (24).

Results

Cost-of-Illness

In the Western Balkans, total mean healthcare expenditure related to diagnosis and treatment of air pollution attributable diseases were estimated at PPP$ 3.13 billion in 2019. Direct cost due to ambient $PM_{2.5}$ air pollution comprised the largest share of direct cost due to total air pollution.
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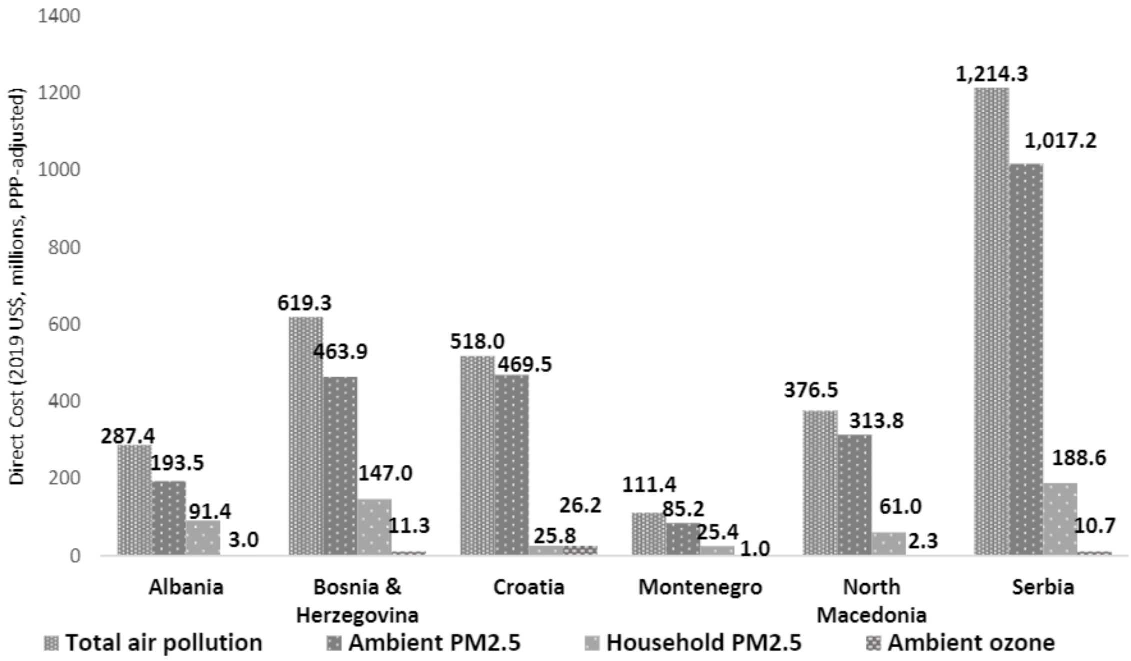
Healthcare cost due to household $PM_{2.5}$ air pollution was also significant in the region (Figure 1). Healthcare expenditure due to air pollution also comprise a significant share of total healthcare spending. In Croatia, 6.5% of total healthcare expenditure is related to air pollution attributable illnesses. In Albania, Serbia and Montenegro this share is 10%, 10.8% and 10.9%, respectively. The countries with the largest share of healthcare expenditure (out of total) due to air pollution are Bosnia and Herzegovina (12.9%) and North Macedonia (13.7%).

Figure 1. Healthcare expenditure due to air pollution by country, 2019



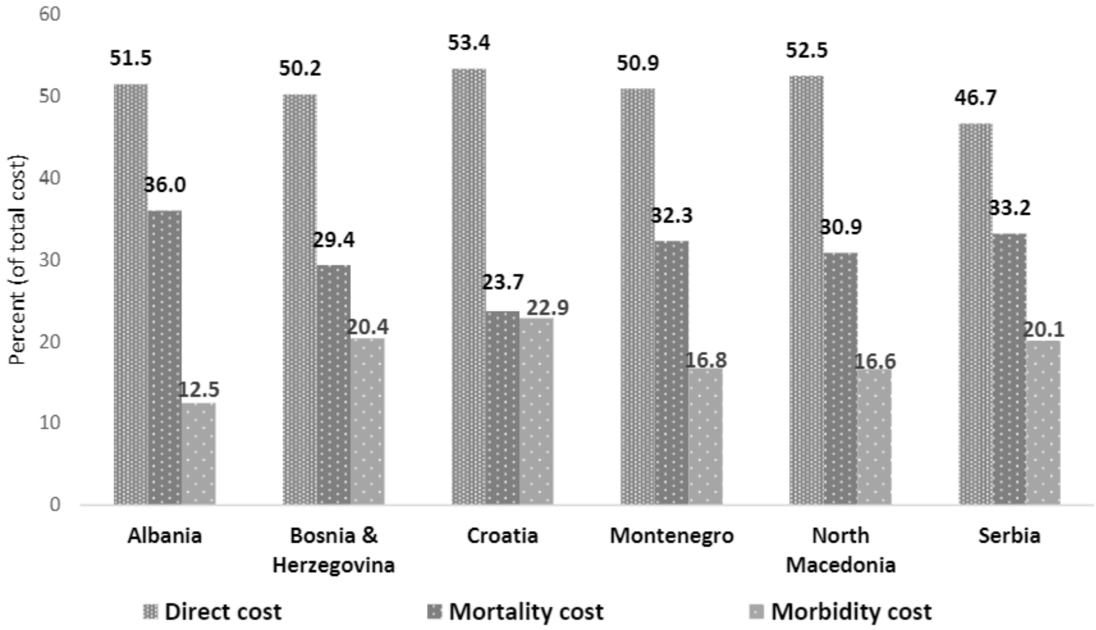
Sources: Authors' calculations based on data from the GBD 2019, the Global Expected Health spending 2018-2050 dataset (IHME) and the IMF

Mean indirect morbidity cost due to air pollution in the Western Balkans was estimated at PPP$ 1.22 billion in 2019. In all countries, the largest share of indirect morbidity cost resulted from diseases attributed to ambient $PM_{2.5}$ air pollution exposure. This share was particularly high in Croatia (94.5%), while in Serbia and North Macedonia it was 84% and 83.6%, respectively. In Bosnia and Herzegovina and Montenegro, the share of morbidity cost attributed to ambient $PM_{2.5}$ air pollution was significantly lower compared to the other countries (around 76%), indicating that household $PM_{2.5}$ air pollution exposure has been a significant problem responsible for almost 25% of total air pollution morbidity cost. Finally, in

Albania, 33.5% of morbidity cost resulted from household $PM_{2.5}$ air pollution exposure.

Indirect mean mortality cost was estimated at PPP$ 1.95 billion in the whole region. Again, in all countries, ambient $PM_{2.5}$ air pollution has been the most significant contributor to mortality cost from total air pollution, with a share ranging from 93.3% in Croatia to 68.3% in Albania. Household $PM_{2.5}$ air pollution has been the second largest contributor to mortality cost due to total air pollution. From the countries under examination, only Croatia had a significantly small share of mortality cost resulting from exposure to household $PM_{2.5}$ air pollution (4.6%). The pollutant with smallest contribution to mortality cost was ozone. The shares of mortality, morbidity and direct cost in total cost are presented by country in Figure 2. It is worth noting that more than 45% of total cost from air pollution attributable diseases was due to healthcare expenditure (direct cost), while mortality cost ranges from 23.7% of total cost in Croatia to 36% of total cost in Albania.

Figure 2. Share of mortality, morbidity and direct cost in total cost by country, 2019

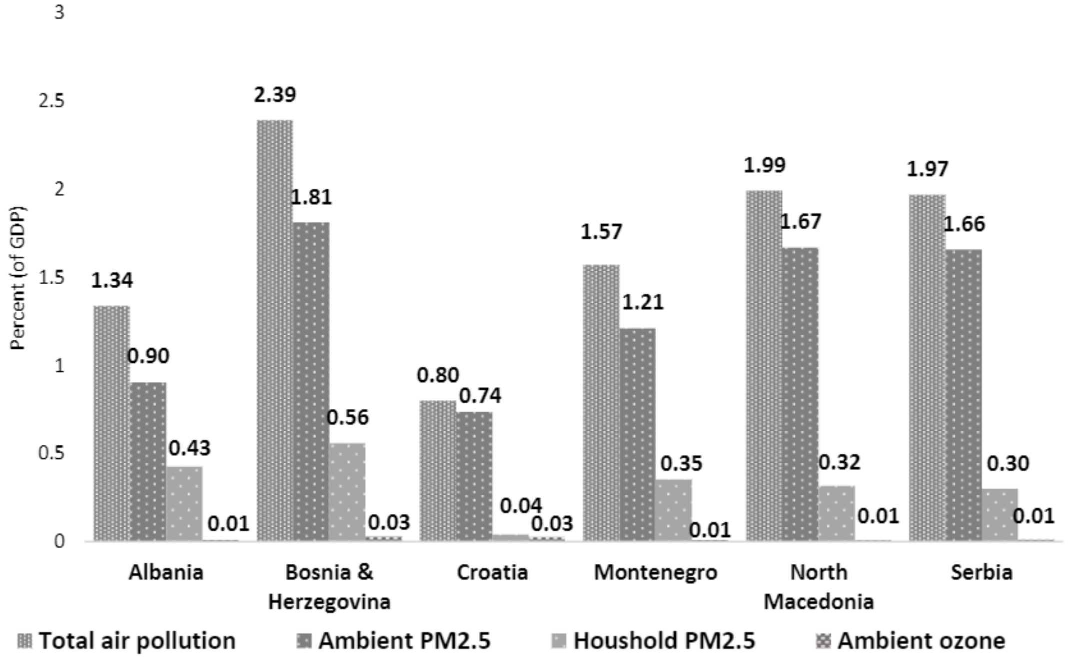


Sources: Authors' calculations based on data from the GBD 2019 (IHME), IMF and ILO

In the whole region, mean total cost from air pollution was estimated at PPP$ 6.3 billion in 2019, with estimates ranging from PPP$ 218.7 million in Montenegro to PPP$ 2.6 billion in Serbia. When we take into account the lower and upper estimated values of the disease burden of air pollution, the lower and upper bounds of total cost are estimated at PPP$ 4.7 billion and PPP$ 8.2 billion, respectively (Table 1).

In terms of cost as a percentage of GDP, the countries more heavily affected are Bosnia and Herzegovina, North Macedonia and Serbia. In Bosnia and Herzegovina, the share of total cost from air pollution in GDP was 2.39% (the highest in the region), while total cost per capita was PPP$ 373. In North Macedonia, total cost was found to be equal to 1.99% of the country's GDP and total cost per capita was estimated at PPP$ 344. In Serbia, air pollution costed 1.97% of GDP, while total cost per capita was PPP$ 375 (the highest in the region). Regarding the rest of the countries, the share of total cost from air pollution in GDP was smaller, but nevertheless it exceeded 1% of GDP, with the exception of Croatia (see, Figure 3 and Table 1). For lower and upper estimated total cost bounds, see Table 1.

Figure 3. Total cost from air pollution as a percentage of GDP by country, 2019



Sources: Authors' calculations based on data from the GBD 2019 (IHME), IMF and ILO

Assuming a 3% discount rate, mortality cost is (as expected) lower, while the decrease ranges from 20.9% in Serbia to 33.6% in Albania. Total cost is also affected with estimates ranging from 2.24% of GDP in Bosnia and Herzegovina to 0.76% of GDP in Croatia.

Table 1. Direct, indirect and total cost from air pollution, Western Balkans, 2019

		Albania	Bosnia & Herzegovina	Croatia	Montenegro	North Macedonia	Serbia	Western Balkans
Direct cost	*Value* [a]	287.4	619.3	518	111.4	376.5	1.21[b]	3.13[b]
	% GDP	0.69	1.2	0.43	0.8	1.05	0.92	0.79
	% total cost	51.5	50.2	53.4	50.9	52.5	46.7	49.7
	% total health exp.	10.0	12.9	6.5	10.9	13.7	10.8	10.2
Morbidity cost	*Value* [a]	69.8	251.5	222	36.6	119.4	523	1.22[b]
	% GDP	0.17	0.49	0.18	0.26	0.33	0.4	0.31
	% total cost	12.5	20.4	22.9	16.8	16.6	20.1	19.4
	% indirect cost	25.8	41	49.1	34.1	35	37.7	38.5
Mortality cost	*Value* [a]	201.1	362.1	230.4	70.7	221.3	864	1.95[b]
	% GDP	0.48	0.7	0.19	0.51	0.61	0.65	0.49
	% total cost	36	29.4	23.7	32.3	30.9	33.2	30.9
	% indirect cost	74.2	59	50.9	65.9	65	62.3	61.5
	Value [a]	558.3	1.23[b]	970.4	218.7	717.2	2.6[b]	6.3[b]

Total cost	*lower bound*	389.9	939.1	708.5	160.2	547.1	1.97[b]	4.7[b]
	upper bound	772.8	1.58[b]	1.29[b]	287.3	913.8	3.37[b]	8.2[b]
	% GDP	1.34	2.39	0.8	1.57	1.99	1.97	1.59
	lower bound	0.94	1.82	0.58	1.15	1.52	1.49	1.19
	upper bound	1.85	3.06	1.06	2.06	2.54	2.55	2.07

[a] *Monetary amount in 2019, 2019 US$, millions, PPP-adjusted*

[b] *Monetary amount in 2019, 2019 US$, billions, PPP-adjusted*

Sources: *Authors' calculations using data from the GBD 2019 (IHME), IMF and ILO.*

Willingness to Pay

The cost of premature mortality due to exposure to air pollution is much higher when estimated with the WTP method. It is equal to PPP$ 45.9 billion for the whole Western Balkans, using data for the same age group for which mortality cost has been estimated with the COI method (<1-79). The share of mortality cost in GDP has been found to be equal to 5.1% in Albania, 5.4% in Croatia, 7% in Bosnia and Herzegovina, 8.2% in Montenegro, 11.4% in North Macedonia and 20.4% in Serbia.

When we take into account mortality estimates for the whole population, mortality cost is estimated at PPP$ 76.7 billion. Mortality cost as a percentage of GDP is found to be equal to 8.4% (of GDP) in Albania, 10.2% in Croatia, 11.2% in Bosnia and Herzegovina, 12.3% in Montenegro and 16% in North Macedonia. An exceptionally high estimate is obtained for Serbia, equal to 34.2% of GDP.

This very high difference between the estimated mortality costs, resulting from the two alternative approaches employed, reflects the difference in the underlying logic of the two methods. The COI method is an income-based methodology, which takes into account forgone output from the working age population dying prematurely from exposure to air pollution. On the other hand, under the WTP methodology, the same value (VSL) is applied for each life lost, regardless of working status. The VSL is meant to capture intangible disutility costs, thus measuring total welfare loss resulting from a statistical case of mortality (4). In this sense, these results have been expected.

Discussion

We estimate both direct healthcare cost and indirect morbidity and mortality cost using data on the burden of disease from ambient and household air pollution exposure. Our cost estimation is more inclusive than previous studies in which only mortality impact is usually taken into account. This is important because, although morbidity cost does not have the largest share in indirect cost, it is nevertheless significant, ranging from 25.8% in Albania to 49.1% in Croatia (Table 1). Furthermore, the share of morbidity cost in total cost exceeds 10% in all countries (Table 1). At the same time, direct cost is the largest component of total cost, while healthcare expenditure due to air pollution amounts a significant share of total healthcare spending. A limitation in the calculation of direct cost is that pollution attributable fractions used in the analysis are based on mortality estimates. This may bring about either an overestimation or an underestimation of healthcare expenditure due to air pollution.

A further limitation of the current analysis is related to the productivity measure employed in estimating mortality and morbidity cost. In the absence of detailed data pertaining to the level of average annual earnings by gender and age, we decided to use GDP per worker as the best alternative option available. We believe that a possible overestimation of mortality and morbidity cost is not substantial and can be outweighed by other cost components that were not included in the analysis due to lack of available data, such as the value of lost household production (19).

Under COI, our estimates are higher than the ones in previous literature. A frequent criticism towards the COI method is that the valuation of human life is done through the calculation of PVLE in the case of mortality and foregone income due to disability. Thus, people not participating in the labour market are excluded from the analysis (19). This is an important limitation in the case of the examination of the economic cost of air pollution, since the burden of disease is particularly high among the elderly. We calculated the economic cost for a wider age range (<1-79) than is usually included in similar analyses (e.g., <1-65). Nevertheless, under the assumption of no participation in the labour market, people of 80 years of age and above are excluded. Moreover, for people in the 65-79 age group, the calculated economic cost was low, despite the fact that the burden of disease is higher in comparison to younger ages. This result is again linked to labour force participation, as the rates are low compared to rates in previous age groups. Finally, it should be also noted that intangible disutility costs are not taken into account (22). As a result, the economic cost of the air pollution-attributable health burden is most probably underestimated within a market-oriented framework.

On the other hand, the WTP method is more suitable for the valuation of the economic cost in welfare terms in the society as a whole. As expected, it has yielded significantly higher mortality cost estimates. These estimates are in line with results from other studies using the WTP method. In comparison to the WB-IHME report (3), our estimates are significantly higher, due to the fact that in the current round of GBD 2019 (1) air pollution-attributable mortality estimates have been revised upwards compared to estimates from older versions. In comparison to the WHO-OECD report (2), our estimates are lower in all countries with the exception of Serbia. Apart from the fact that we used more recent health data, we have also employed a higher value of the income elasticity of the VSL, more suitable for transferring the base VSL from high to middle and low-income economies (19).

A shortcoming in using the OECD recommended base VSL is that this value has been mainly proposed to be transferred to other policy contexts within the OECD group of countries. Although the use of the base VSL is a common practice in studying the welfare cost of the disease burden of air pollution in policy contexts in which we lack primary WTP information, it is possible that a primary WTP survey would uncover a different VSL.

Conclusions

Addressing the health and economic consequences of air pollution in an effective manner, in the Western Balkans and elsewhere, is a multifaceted task. From the three air pollution subcategories examined here, the one with the largest impact in terms of total economic cost is ambient $PM_{2.5}$ air pollution. However, exposure to household $PM_{2.5}$ air pollution also results in a significant economic cost. These findings have wider policy implications. They indicate that efforts on meeting air quality standards should not be targeted at limiting only ambient air pollution, but also at limiting the dependence on polluting household energy use. Especially in the case of Albania (and to a lesser extent in North Macedonia and Bosnia and Herzegovina), efforts on reducing energy poverty would result in a reduced child mortality rate and an improved health in adults.

Addressing the problem of air pollution in an effective manner requires a combination of policies, regarding the efficiency of heating systems, energy use and fuel management, to reduce emissions from both industry and households. The policy framework, among others, needs to provide economic incentives for consumers and industry to make the necessary adjustments and investments for air quality, to improve public health and the economy. Public

health policies should include monitoring of the adverse health effects of exposure to air pollution. Reform in the major sectors contributing to air pollution levels that are harmful for human health would also lead to a reduction in the amounts of greenhouse gas emissions as well.
Benefits in terms of direct and indirect cost reduction under air pollution mitigation efforts can be accompanied by benefits in the form of an overall improvement in the health status of the population. During the ongoing COVID-19 pandemic, several studies examined the association between, among other factors, air pollution and COVID-19 (26). The current challenges that healthcare systems have to face, the welfare costs stemming from human life loss and the consequences of the health crisis on the region's (and world) economies point to the need of preventative actions designed to make people healthier and states more efficient in coping with possible future pandemics.

References

1. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) Results [Internet]. Seattle, United States: Institute for Health Metrics and Evaluation (IHME); 2020. Available from: http://ghdx.healthdata.org/gbd-results-tool (accessed: March 1, 2021).
2. WHO Regional Office for Europe, OECD. Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. Copenhagen: WHO Regional Office for Europe; 2015. Available from: https://www.euro.who.int/__data/assets/pdf_file/0004/276772/Economic-cost-health-impact-air-pollution-en.pdf (accessed: November 10, 2020).
3. World Bank, Institute for Health Metrics and Evaluation. The Cost of Air Pollution: Strengthening the Economic Case for Action. Washington, DC: World Bank; 2016. Available from: https://openknowledge.worldbank.org/handle/10986/25013 (accessed: November 5, 2020).
4. World Bank. Air Quality Management (AQM) in Bosnia and Herzegovina. Washington, DC: World Bank; 2019. Available from: https://openknowledge.worldbank.org/handle/10986/33042(accessed: November 10, 2020).
5. World Bank. Air Quality Management (AQM) in North Macedonia. Washington, D.C.: World Bank; 2019. Available from: https://openknowledge.worldbank.org/handle/10986/33042 (accessed: November 10, 2020).
6. Martinez GS, Spadaro JV, Chapizanis D, Kendrovski V, Kochubovski M, Mudu P. Health Impacts and Economic Costs of Air Pollution in the Metropolitan Area of Skopje. Int J Environ Res Public Health 2018;15:626. DOI: 10.3390/ijerph15040626.
7. European Commission. Impact Assessment. Commission Staff Working Document, SWD(2013) 531 final. Brussels: European Commission; 2013.
8. European Commission. The EU Environmental Implementation Review – Country Report – Croatia. Commission Staff Working Document, SWD(2017) 45 final, Brussels: European Commission; 2017.
9. Meisner C, Gjorgjev D, Tozija F. Estimating health impacts and economic costs of air pollution in the Republic of Macedonia. SEEJPH 2015;IV:22-9. DOI: 10.4119/seejph-1809.

10. Puljic VM, Jones D, Moore C, Myllyvirta L, Gierens R, Kalaba I, et al. Chronic coal pollution – EU action on the Western Balkans will improve health and economies across Europe. Brussels: HEAL, CAN Europe, Sandbag, CEE Bankwatch Network and Europe Beyond Coal; 2019. Available from: https://www.env-health.org/wp-content/uploads/2019/02/Chronic-Coal-Pollution-report.pdf (accessed: November 9, 2020).
11. Holland M. Technical Report – Health Impacts of Coal Fired Power Stations in the Western Balkans. Health and Environment Alliance (HEAL); 2016. Available from: https://www.env-health.org/wp-content/uploads/2018/08/unpaid_health_bill_technical_report_balkans_EN.pdf (accessed: November 9, 2020).
12. Narain U, Sall C. Methodology for Valuing the Health Impacts of Air Pollution: Discussion of Challenges and Proposed Solutions. Washington, DC: World Bank; 2016.
13. Rice D. Estimating the Cost of Illness. Am J Public Health1967;57:424-40. DOI: 10.2105/AJPH.57.3.424.
14. Rice D, Hodgson T, Kopstein A. The economic cost of illness: a replication and update. Health Care Financ Rev 1985;7:61-80.
15. Max W, Rice D, Sung H, Michel M. Valuing Human Life: Estimating the Present Value of Lifetime Earnings, 2000. UCSF: Center for Tobacco Control Research and Education; 2004. Available from: https://escholarship.org/uc/item/82d0550k (accessed: November 10, 2020).
16. Supplementary appendix 1. Supplement to: GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2020;396:1223-49. Available from: https://www.thelancet.com/cms/10.1016/S0140-6736(20)30752-2/attachment/54711c7c-216e-485e-9943-8c6e25648e1e/mmc1.pdf (accessed: November 8, 2021).
17. World Health Organization. WHO methods and data sources for global burden of disease estimates 2000-2019. WHO: Geneva; 2020. Available from: https://cdn.who.int/media/docs/default-source/gho-documents/global-health-estimates/ghe2019_daly-methods.pdf?sfvrsn=31b25009_7 (accessed: November 8, 2021).
18. OECD. The Cost of Air Pollution: Health Impacts of Road Transport. OECD Publishing; 2014. DOI: 10.1787/9789264210448-en.
19. OECD. Mortality Risk in Environment, Health and Transport Policies. OECD Publishing; 2012. DOI: 10.1787/9789264130807-en.
20. Global Burden of Disease Collaborative Network. Global Expected Health Spending 2018-2050 [dataset]. Seattle, United States: Institute for Health Metrics and Evaluation (IHME). 2020. Available from: https://doi.org/10.6069/0PWC-PV84 (accessed: March 1, 2021).
21. International Labour Organization. Labour Force statistics: Employment-to-population ratio by sex and age [Internet]. ILOSTAT; 2020. Available from: https://ilostat.ilo.org/data/ (accessed: February 22, 2021).

22. International Monetary Fund. World Economic Outlook Database, October 2020 [Internet]. IMF; 2020. Available from: https://www.imf.org/en/Publications/WEO/weo-database/2020/October/ (accessed: February 22, 2021).
23. World Health Organization. Life tables by country [Internet]. Available from: https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/gho-ghe-global-health-estimates-life-tables (accessed: February 23, 2021).
24. World Bank. World Development Indicators [Internet]. Available from: https://databank.worldbank.org/source/world-development-indicators (accessed: May 10, 2021).
25. European Commission. Future Brief: What are the health costs of environmental pollution? Luxembourg: Publications Office of the European Union; 2018. Available from: https://ec.europa.eu/environment/integration/research/newsalert/pdf/health_costs_environmental_pollution_FB21_en.pdf (accessed: February 15, 2021).
26. Tung NT, Cheng P, Chi K, Hsiao T, Jones T, BeruBe K, et al. Particulate matter and SARS-Cov-2: A possible model of COVID-19 transmission. Sci Total Environ 2021;750:1-3. DOI: 10.1016/j.scitotenv.2020.141532.