European Environment Agency

8th Environment Action Programme

Environmental inequalities: GDP-related air pollution exposure inequalities between regions in Europe

8TH EAP HEADLINE INDICATOR, 2025

European Environment Agency

GDP-related air pollution exposure inequalities between regions in Europe

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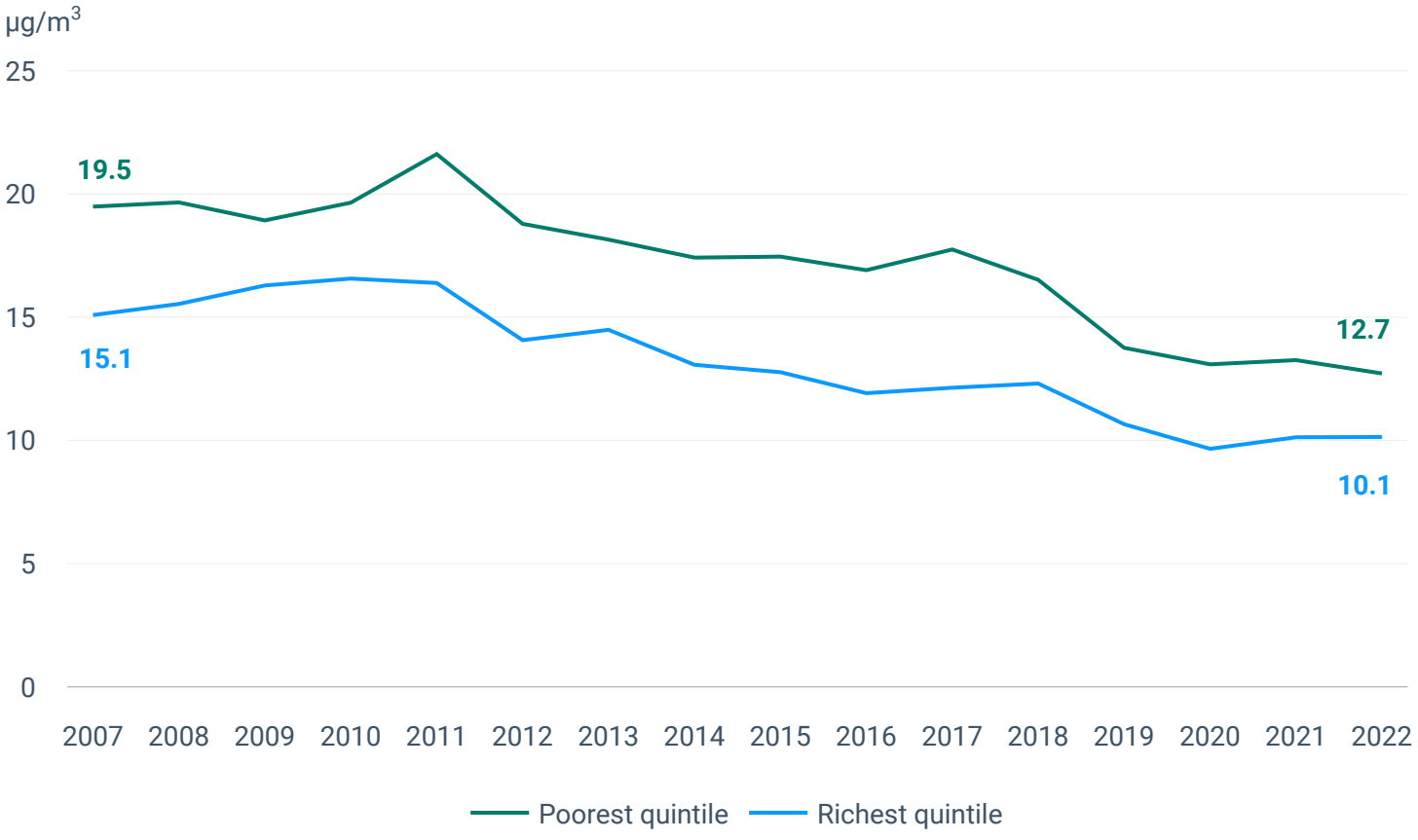
Air pollution poses the greatest environmental risk to health in Europe. Fine particulate matter ($PM_{2.5}$) causes more premature deaths in Europe than any other air pollutant. Despite improving trends in air pollution in both the richest and poorest regions of the European Union over the 2007-2022 period, inequalities remain with $PM_{2.5}$ concentrations consistently higher by around one third in the poorest regions.

Figure 1. Population-weighted concentration of $PM_{2.5}$ in the richest and poorest (as measured by GDP per capita, PPS) quintile of NUTS3 regions in the EU-27, 2007-2022



Air pollution poses the greatest environmental risk to health in Europe. Fine particulate matter with a diameter of 2.5µm or less ($PM_{2.5}$) is the ambient air pollutant associated with the highest number of **premature deaths**, with no threshold below which exposure is considered safe for human health[1]. $PM_{2.5}$ exposure has also been shown to be a reliable indicator of risk associated with air **pollution** in general[2]. Monitoring $PM_{2.5}$ levels is thus useful for exploring inequalities in the distribution of exposure to and potential health impacts of air pollution across EU regions.

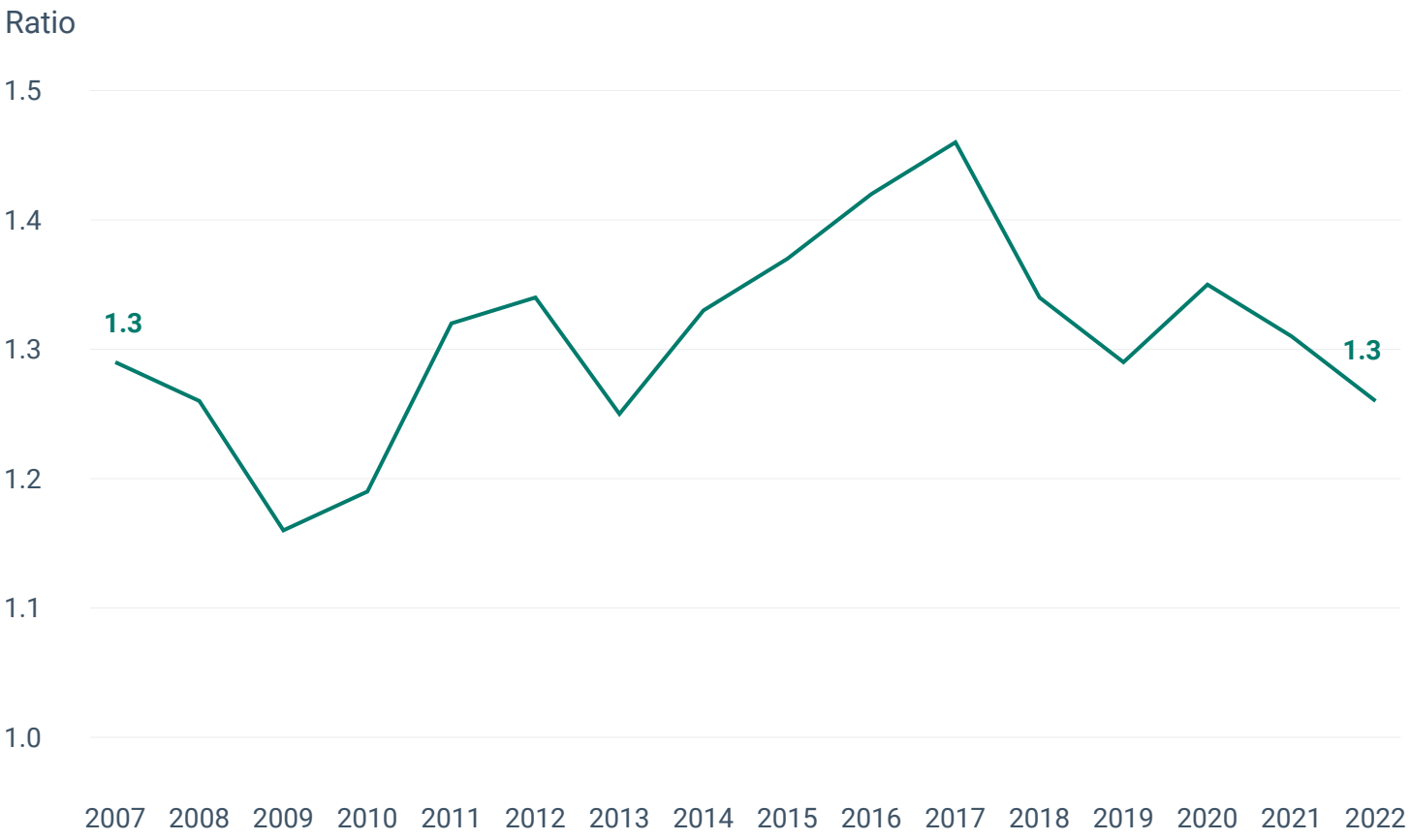
This indicator explores these **inequalities** by comparing the exposure to air pollution from fine particulate matter experienced by the population living in the poorest regions of the EU with that in the richest regions. The analysis uses population-weighted concentrations of $PM_{2.5}$ in the 20% NUTS3 regions (i.e. in small regions similar to a prefecture) with the lowest GDP per capita (in terms of purchasing power) and in the 20% NUTS3 regions with the highest GDP per capita. Exposure at NUTS3 is an imperfect proxy for actual inequalities in air pollution exposure, yet data availability limitations currently preclude a finer analysis[3].

Between 2007 and 2022, air quality, measured as population-weighted **concentrations** of $PM_{2.5}$, improved in both the richest and poorest quintiles of the EU-27's NUTS3 regions (Figure 1). However, regions in the richest quintile had lower initial $PM_{2.5}$ levels (around 15µg/m^3 in 2007) than those in the poorest quintile (19.5µg/m^3 in 2007). Compared with 2021, $PM_{2.5}$ concentrations decreased slightly in 2022 on average in the poorest quintile (an average decrease of 0.54µg/m^3) but did not vary greatly in the richest quintile (average increase of 0.01µg/m^3).

$PM_{2.5}$ concentrations have **decreased** at relatively similar rates[4] in regions in the richest quintile (2.40% average annual decrease in the period of analysis)[5] and poorest quintile (2.58% average annual decrease). However, despite improving trends in air pollution in both the richest and the poorest regions of the EU over the 2007-2022 period, inequalities remained with levels of $PM_{2.5}$ consistently higher by around one third in the poorest regions (Figure 2).

This indicator, defined as the ratio of population weighted concentration of $PM_{2.5}$ in EU NUTS3 regions in the poorest and richest quintiles, remained **overall stable**[6] over the 2007-2022 period, and well above 1.0. This indicates that there has been no progress in reducing air pollution exposure inequalities in the EU so far.

Figure 2. Ratio of $PM_{2.5}$ population weighted concentrations: poorest quintile/richest quintile (GDP per capita PPS) of NUTS3 regions



Some of the **most polluted** NUTS3 regions spatially coincide with the poorest regions in the eastern part of Europe, yet there are pockets of highly polluted NUTS3 regions elsewhere in Europe with both high and low purchasing power per capita. However, almost no NUTS3 regions in the richest quintile are in the quintile with the most pollution.

The absence of disaggregated projections at the NUTS3 level for both $PM_{2.5}$ concentrations and purchasing power means that **no reasonable outlook can be given** for this indicator based on existing evidence. While there are national level projections in $PM_{2.5}$ emissions and concentrations (including cross-border transfers) by country stemming from the Fourth Clean Air Outlook, these cannot be readily used to derive NUTS3-level extrapolations. Nor would it be reasonable to assume that NUTS3 GDP per capita levels will remain constant or grow linearly. However, the lack of significant progress in the past does not support the expectation of better performance in the near future.

Supporting information

Definition

This indicator monitors concentrations of $PM_{2.5}$ in the richest and poorest NUTS3 regions of the EU-27. More specifically, it measures the ratio of population-weighted $PM_{2.5}$ concentrations of the poorest quintile compared to the ones of the richest quintile (based on GDP per capita at purchasing power standard) at NUTS3-region level. Population-weighting is a statistical technique that assigns greater weight to the air pollution experienced where most people live. Gross Domestic Product (GDP) is a basic measure of the overall size of a country's or region's economy. Per capita (Latin: "per head") indicates the average per person in a group, in this case the population of a given NUTS3 region. NUTS3 is the smallest subdivision of the NUTS classification (Nomenclature of territorial units for statistics), a hierarchical system for dividing up the economic territory of the EU. PPS, purchasing power standard, is an artificial currency unit with which theoretically, one could buy the same amount of goods and services in each country. PPS is a more accurate way to compare wealth per capita than raw GDP because it reduces the effect of price differences. $PM_{2.5}$ refers to particulate matter with a diameter of 2.5µm or less.

The definitions of GDP, per capita and PPS come from the Eurostat glossary: (https://ec.europa.eu/eurostat/statistics-explained).

Methodology

The indicator is formally defined as '$PM_{2.5}$ exposure ratio between the poorest and the richest quintile (GDP per capita at purchasing power standard) of NUTS3 regions'.

The indicator is calculated via the formula:

Exposure ratio = Pop. weighted $PM_{2.5}$ exposure (µg/m^3) PQ/Pop.weighted $PM_{2.5}$ exposure (µg/m^3) RQ.

Where:

'Pop. weighted $PM_{2.5}$ exposure (µg/m^3) PQ' is the annual average population-weighted concentration of $PM_{2.5}$ in ambient air measured in micrograms per cubic meter of the poorest quintile of NUTS3 regions, measured based on GDP per inhabitant at purchasing power standard in euros.

'Pop. weighted $PM_{2.5}$ exposure (µg/m^3) RQ' is the annual average population-weighted concentration of $PM_{2.5}$ in ambient air measured in micrograms per cubic meter of the richest quintile of NUTS3 regions, measured based on GDP per inhabitant at purchasing power standard in euros.

Because the numberator and denominator of this indicator are in the same units, the resulting ratio has no units. Both parts of this ratio are easily measurable and based on readily available data. In an "environmentally equal" Europe, in terms of $PM_{2.5}$, this ratio would be close to one. If the poorer regions were more polluted than the richer regions, the ratio would be greater than one; a ratio of lower than one would indicate the opposite.

Policy/environmental relevance

This indicator provides an objective and comparable estimate over time of the inequalities in $PM_{2.5}$ exposure (and thus of associated health risks) between the poorest and the richest regions in Europe. This indicator is also a proxy headline indicator on environmental inequalities for monitoring progress towards the 8th Environment Action Programme (8th EAP). It contributes mainly to monitoring aspects of the 8th EAP Article 2.1 that requires 'by 2050 at the latest, people live well, within the planetary boundaries in a well-being economy where nothing is wasted, growth is regenerative, climate neutrality in the Union has been achieved and inequalities have been significantly reduced'. It further contributes to monitoring aspects of the Article 3.f which requires 'ensuring that social inequalities resulting from climate- and environmental-related impacts and policies are minimised and that measures taken to protect the environment and climate are carried out in a socially fair and inclusive way'. The European Commission Communication on the 8th EAP monitoring framework specifies that this indicator should monitor whether the EU 'reduces environmental inequalities and ensures a fair transition', (EC, 2022).

EU, 2022, Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030, OJL 114, 12.4.2022, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022D0591 accessed October 24, 2022.

Accuracy and uncertainties

GDP per capita at NUTS3 level is an imperfect measure of economic deprivation, but it is a fair proxy that is published regularly and easy to understand for most audiences. The assessment of population weighted concentrations also has uncertainties inherent to the estimation, though those are known and limited. The trend analyses for this indicator is performed via linear regression and a T test for the significance of slope value. The indicator showed from 2007 to 2022 a small but statistically significant ($p<0.05$) upward linear slope of 0.02. However, with such a small value and a standard error of around 0.01, this trend cannot be assessed as significantly different from stable.

Data sources and providers

- Burden of disease of air pollution (Countries & NUTS), European Environment Agency (EEA)
- Gross domestic product (GDP) at current market prices by NUTS 3 region (nama_10r_3gdp), Statistical Office of the European Union (EUROSTAT)

Metadata

DPSIR

State

Topics

 # Air pollution **# Environmental inequalities** **# Environmental health impacts**

Tags

8th EAP # income # AIR009 # inequalities # air pollution

Temporal coverage

2007-2022

Geographic coverage

Austria
Belgium
Bulgaria
Croatia
Cyprus
Czechia
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
Netherlands
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden

Typology

Descriptive indicator (Type A - What is happening to the environment and to humans?)

UN SDGs

SDG3: Good health and well-being

Unit of measure

The population-weighted concentrations of $PM_{2.5}$

are measured in micrograms per cubic meter and the ratio of population-weighted concentrations of $PM_{2.5}$ has no units, it is expressed as ratio.

Frequency of dissemination

Once a year

References and footnotes

1. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide, 2021, (https://www.who.int/publications-detail-redirect/9789240034228) accessed March 5, 2023.
↲

2. Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., Amann, M., Anderson, H. R., Andrews, K. G., Aryee, M., Atkinson, C., Bacchus, L. J., Bahalim, A. N., Balakrishnan, K., Balmes, J., Barker-Collo, S., Baxter, A., Bell, M. L., Blore, J. D. et al., 2013, 'A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010', *Lancet* 380(9859), pp. 2224–2260.
↲

3. Within a city the inequalities can be much higher than between NUTS3 regions, depending on the local situation (proximity to main roads, industry, etc.). However, while we have data on exposure to fine particles at a very fine scale (down to a 1 by 1 km cell grid), we do not have Europe-wide data on GDP at a level smaller than NUTS3. Therefore, NUTS3 is the smallest scale at which we can calculate the indicator as currently defined.
↲

4. No statistically significant difference in the trends.
↲

5. Mean change of three-year moving average.
↲

6. With a small but statistically significant ($p<0.05$) upward linear slope of around 0.02 and a standard error of around 0.01.
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