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EUROPEAN ENVIRONMENT AND HEALTH INFORMATION SYSTEM

EXPOSURE TO AIR POLLUTION (PARTICULATE MATTER) IN OUTDOOR AIR

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Population-weighted annual mean particulate matter (PM_{10}) concentration

This summary is based on data on particulate matter (PM_{10}) concentrations measured in urban background locations. Included in the summary are national estimates which are calculated as population-weighted means of annual average PM_{10} concentrations in cities. The summary also includes information on the health and environment contexts, the policy relevance and context, and the assessment of the situation in the WHO European Region.

KEY MESSAGE

😐 In 2009, country average PM_{10} exposure levels in urban areas varied from 10-14 µg/m^3 (Iceland, Estonia, Finland, and Ireland) to 58-61 µg/m^3 (Turkey and Bosnia and Herzegovina). A two- to three-fold between-city variation in exposure levels was observed in some countries.

Average exposure to PM_{10} in the EU27 countries was substantially lower in 2007-2009 than in previous years. However, the average level for all countries of the Region for which data are available has not changed substantially. In three countries (Turkey, Romania, Bulgaria) the average urban population exposure levels in 2009 were lower by at least 7.5 µg/m^3 compared to the year before. Exposure to PM_{10} increased in eight countries from 2008 to 2009, with the largest increase (4.4 µg/m^3) observed in Lithuania.

PM_{10} data from regular population-relevant monitoring were available for 357 cities from 33 countries. In European cities where PM_{10} is monitored, 82.8% of people experience PM_{10} levels exceeding the WHO Air Quality Guideline (AQG) of 20 µg/m^3, giving rise to a substantial risk to health (1). For 23.3% of urban residents, the European Union (EU) limit value of 40 µg/m^3 was exceeded in 2009.

RATIONALE

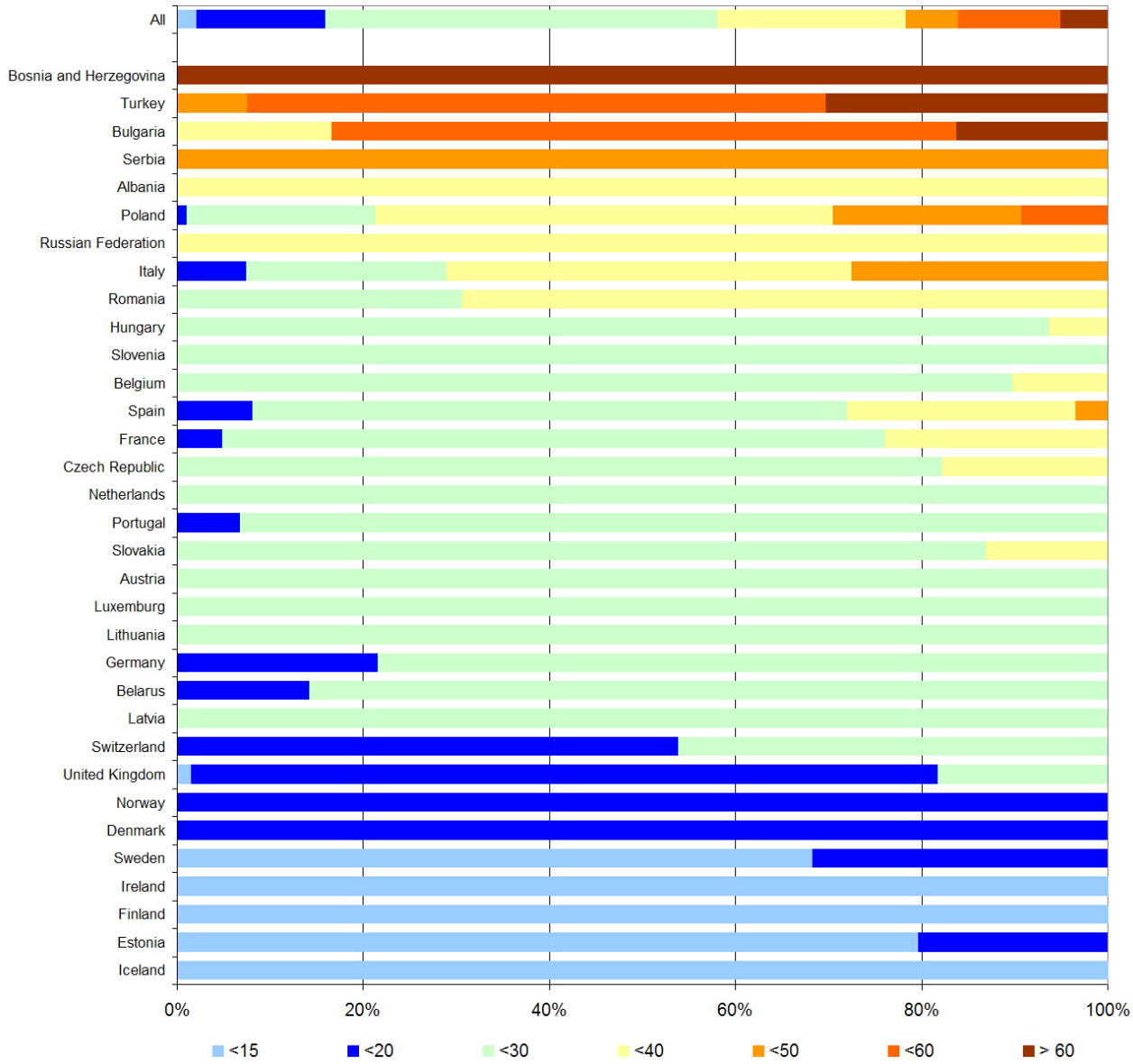
This indicator reflects population exposure to PM_{10} by combining data on PM_{10} concentrations with sizes of exposed population. Long-term exposure to PM_{10} is associated with increased risks of chronic effects on children's health, such as impaired development of lung function, and risks of acute effects, such as increased incidence of asthma attacks and respiratory symptoms. It is also associated with increased risks of various adverse health effects and death in adults. Exposure to fine particulate matter $PM_{2.5}$ is also an important predictor of reduced life expectancy. At present, $PM_{2.5}$ monitoring data are available only for a small number of European cities. Although this number is increasing, the data on $PM_{2.5}$ exposure are still insufficient for using in this indicator.

PRESENTATION OF DATA

Fig. 1 presents the distribution of population exposure levels to PM_{10} in 2009 (or the last available year) in European Region countries. For some countries, the data is available only for a small number of cities, providing only an approximation of the distribution of exposure levels in the entire urban population. In 25 out of the 33 (76%) countries for which the data are available, PM_{10} levels in at least some cities exceeded the WHO AQG level. Although this proportion remains high, it has improved compared to previous years. Also, the EU limit value of 40 $\mu g/m^3$ was exceeded in some cities of seven countries (Bosnia and Herzegovina, Turkey, Bulgaria, Serbia, Poland, Italy and Spain).

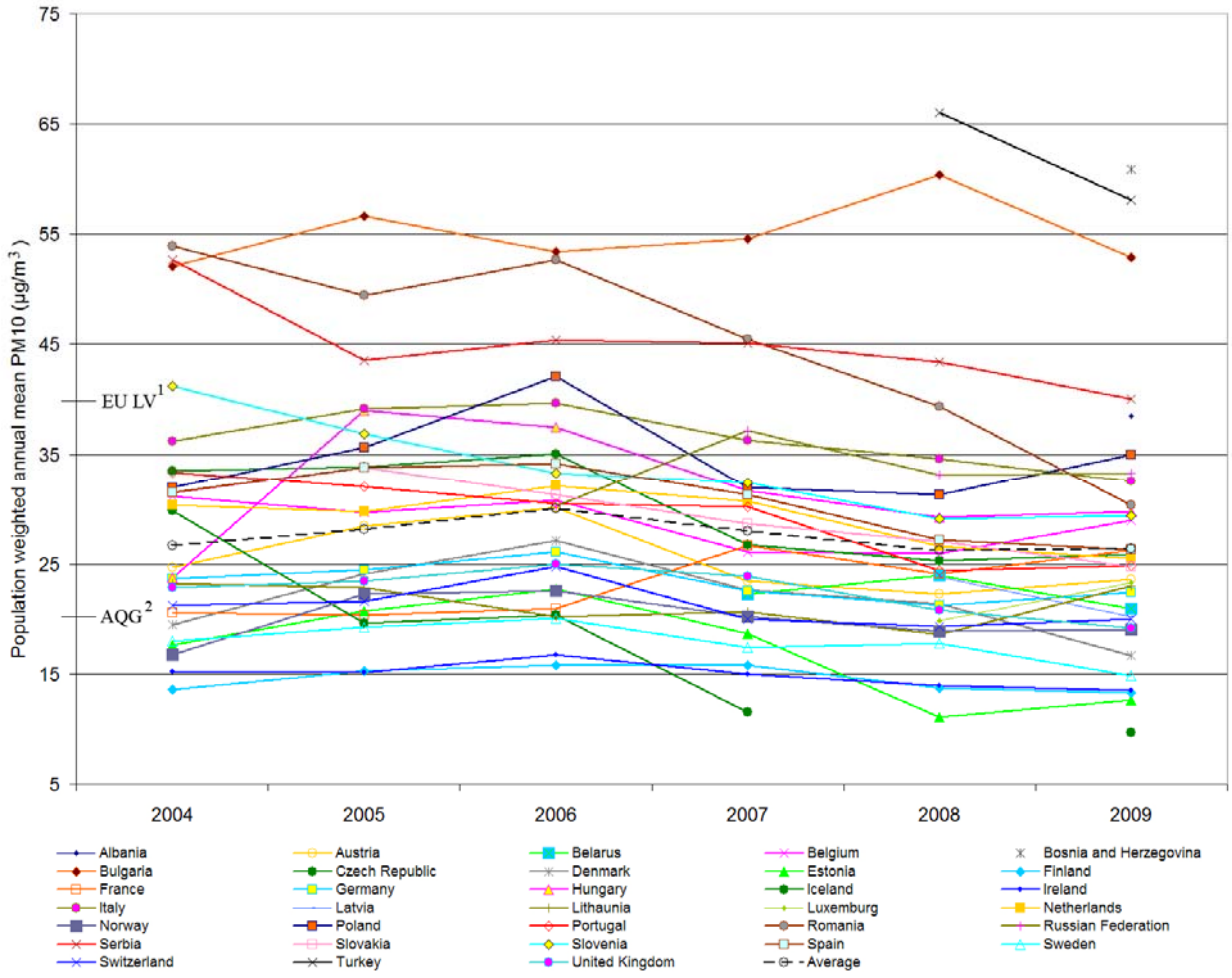
Fig. 2 presents temporal trends in population-weighted annual means of PM_{10} concentrations for 2004-2009. It should be noted that some part of the observed within-country variation is due to changes in the numbers of cities for which data was available.

Fig.1. Percentage of people living in cities with various PM_{10} levels in µg/m^3, 2009



Note. In several countries the assessment is based on one city only.
Sources: AirBase for PM_{10} concentration data *(2)*; HFA-DB (3) and Urban Audit (4) for city and country population data. For Belarus and Russian Federation, national data were used.

Fig. 2. Population weighted annual mean PM_{10} in cities, 2004–2009



[1] EU LV – EU limit value.
[2] AQG – Air quality guidelines.
Sources: AirBase for PM_{10} concentration data *(2)*; HFA-DB (3) and Urban Audit (4) for city and country population data. For Belarus and Russian Federation, national data were used.
Note: Number of cities and population covered may vary over time, see Table 1.

HEALTH AND ENVIRONMENT CONTEXT

Particulate matter $(PM)_{7}$ is a type of air pollution that is present wherever people live. It is generated mainly by human activities: transport, energy production, domestic fuel combustion and by a wide range of industries. PM consists of a mixture of solid and liquid particles suspended in the air. These particles differ in their physical properties (such as size) and chemical composition. PM can either be directly emitted into the air (primary PM) or be formed secondarily in the atmosphere from gaseous precursors (mainly sulfur dioxide, nitrogen oxides, ammonia and non-methane volatile organic compounds) (5). Health risks are associated with exposure to particles whose sizes are less than 10 µm in diameter (PM_{10}), more so with even smaller particles, that are less than 2.5 µm in diameter ($PM_{2.5}$,). There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur (1).

The range of adverse health effects of PM is broad, involving respiratory and cardiovascular systems in children and adults. Both short- and long-term exposures lead to adverse health effects (1). Very young children, probably including unborn babies, are particularly sensitive to the adverse effects of PM (4). The evidence is sufficient to infer a causal relationship between exposure to PM and deaths from respiratory diseases in the post-neonatal period. Adverse effects of PM on lung development include reversible deficits of lung function as well as chronically reduced lung growth rate and long-term lung function deficit. The available evidence is also sufficient to assume a causal relationship between exposure to PM and aggravation of asthma, as well as cough and bronchitis symptoms. Daily mortality and hospital admissions have been linked with short term variation of PM levels. Increased mortality from cardiovascular and respiratory diseases and from lung cancer has been observed in

residents of more polluted areas. This reduces the life expectancy of inhabitants of the European region by about 8.6 months (5).

Based on the existing evidence of adverse health effects at low levels of exposure, WHO revised its AQG for PM in 2005 (1). For $PM_{2.5}$, the new AQG values are 10 µg/m^3 for the annual average and 25 µg/m^3 for the 24-hour mean (not to be exceeded for more than 3 days/year). The corresponding guidelines for PM_{10} were set as 20 µg/m^3 and 50 µg/m^3.

POLICY RELEVANCE AND CONTEXT

There is sufficient evidence to indicate that reducing emissions of major gaseous air pollutants and of primary particulate matter leads to reduced concentration of PM in ambient air and reduced adverse health effects. It has been estimated that reductions in air pollution accounted for as much as 15% of the overall increase of life expectancy in the US between 1980 and 2000 (7).

Pan-European policy context
At the Fifth Ministerial Conference on Environment and Health, the Member States (MS) of the WHO European Region committed themselves to continue enhancing their efforts to decrease the incidence of acute and chronic respiratory diseases through reduction of exposure to ultrafine particles and other particulate matter, especially from industry, transport and domestic combustion in line with the WHO AQG (8). The Member States also agreed to implement provisions of the protocols related to the 1979 Convention on Long-range Transboundary Air Pollution which can become important instruments that contribute to the reduction of population exposure to PM (9).

EU policy context
The Sixth Community Environment Action Programme called for the development of a thematic strategy on air pollution with the objective of attaining "levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment" (10).

Council Directive 1999/30/EC of 22 April 1999 introduced the binding limits for PM_{10} concentrations: 40 µg/m^3 as the annual average and 50 µg/m^3 as the daily average, which is not to be exceeded more than 35 days a year (11). A new Directive on "ambient air quality and cleaner air for Europe" specifies a target maximum $PM_{2.5}$ concentration (25 µg/m^3 as annual average), which had to be met by 1 January 2010. This target values will become a limit value on 1 January 2015. The Directive also specifies national exposure reduction targets for $PM_{2.5}$ (12).

ASSESSMENT

Ambient PM_{10} concentrations are a good approximation of population exposure to PM from outdoor sources. Numerous epidemiological studies conducted in Europe and in other parts of the world have shown adverse health effects of exposure to PM_{10} and $PM_{2.5}$ at concentrations that are currently observed in European cities. WHO estimated that approximately 700 annual deaths from acute respiratory infections in children aged 0–4 years could be attributed to PM_{10} exposure in the WHO European Region in the late 1990s (13). A 10 µg/m^3 reduction in PM_{10} concentrations is expected to reduce the number of days that children suffer lower respiratory symptoms (wheezing, chest tightness, shortness of breath and cough) in children aged 5–14 years by 1.9 days per year per child, and reduce days of bronchodilator usage by 18% in asthmatic children of the same age group (5).

Population health effects of exposure to PM in adults are dominated by mortality associated with long-time exposure to fine PM ($PM_{2.5}$) (5). It has been estimated that exposure to PM from anthropogenic sources results in the loss of 8.6 months of life expectancy in Europe. Country specific estimates range from approximately 3 months in Finland to more than 13 months in Belgium. The total estimated annual number of premature deaths in the members states of European Union since 2004 (EU 25), attributed to PM exposure is 348 000. In most cities of Europe, exposure to fine PM constitutes more than 70% of all PM_{10} exposure.

It is expected that the implementation of new EU legislation related to the emission of air pollutants will reduce adverse health effects of exposure to PM by one third. Implementing all currently feasible emission reduction measures (the maximum feasible emission reduction scenario) would reduce health effects of PM by approximately 50% (1).

DATA UNDERLYING THE INDICATOR

Data source
PM10 data: AirBase (2). For Belarus and Russian federation: national data sources.
Population data: WHO's Health for All Database HFA-DB (3) and Urban Audit database (4).
Percentage of population living in cities: HFA-DB (3).

Description of data
PM_{10} monitoring data are submitted by national authorities to the AIRBASE of the European Environment Agency. Only data from urban or suburban background locations, for which PM measurements are available for at least 75% of days in the year, are used in analysis. Data quality check and verification of the station's location classification are carried out by the European Topic Centre on Air and Climate Change (14).

For several countries, the assessment is based on data from one, or a few, cities only. In six countries, coverage of the urban population was 20% or less in 2009.

Method of calculating the indicator
Exp = SUM {(Pi/P)*Ci}, where:
Ci = annual mean PM10 concentration in sub-population Pi,
P = SUM (Pi), which is the total population in cities with data.

Geographical coverage
All data from cities with PM_{10} measured in urban (or suburban) background locations included in the AirBase have been used for this analysis (Table 1). In addition, data obtained by WHO from Belarus and the Russian Federation (Moscow only) were used. PM_{10} monitoring is not conducted in many of the non-EU countries, which makes it difficult to assess exposure in those parts of the Region.

Period of coverage
PM_{10} data used in this analysis cover the period from 2004 to 2009. Data from earlier years are available for a limited number of countries. In the EU, PM_{10} monitoring is required under the Sixth Community Environment Action Programme (10). PM monitoring strategy for the European Union countries was developed in the framework of the Clean Air for Europe programme adopted in September 2005 (10), which resulted in a significant expansion of monitoring to include more European cities.

Frequency of update
Air quality data (daily concentration of PM_{10}) are submitted by national authorities to AirBase annually. After data quality checks and data processing, the data are made available on-line (with a delay of about one year). Although city-specific population data are updated less frequently, it does not affect the indicator values appreciably due to the relative stability of European urban populations.

Data quality
Quality assurance and control procedures apply to the PM_{10} data submitted to AirBase (2).

Table 1. Availability of data for the indicator RPG3_Air_Ex2_PM

	2009		2004		2005		2006		2007		2008		2009	
	PM_{10} weighted mean	Population covered by PM_{10} data (in thousands)	No. of cities	Proportion of urban population covered	No. of cities	Proportion of urban population covered	No. of cities	Proportion of urban population covered	No. of cities	Proportion of urban population covered	No. of cities	Proportion of urban population covered	No. of cities	Proportion of urban population covered
Albania	38.5	365											1	26%
Austria	23.6	2 165	4	40%	4	40%	4	40%	4	40%	4	40%	4	40%
Belarus	20.6	2 619							4	39%	4	39%	4	37%
Belgium	29.0	2 245	5	22%	4	20%	4	20%	4	20%	5	22%	5	22%
Bosnia and Herzegovina	60.9	375											1	22%
Bulgaria	52.9	2 097	2	27%	4	34%	6	39%	6	39%	6	39%	6	39%
Czech Republic	25.8	2 584	12	36%	12	36%	12	36%	11	34%	11	34%	11	34%
Denmark	16.7	502	1	11%	4	25%	3	21%	2	14%	1	11%	1	11%
Estonia	12.6	493	1	42%	1	42%	1	42%	1	42%	1	42%	2	53%
Finland	13.3	691	2	22%	1	18%	2	22%	2	22%	2	22%	2	22%
France	26.2	20 619	84	42%	89	43%	90	43%	90	42%	99	46%	91	44%
Germany	22.4	20 178	54	34%	54	34%	54	34%	53	34%	53	33%	53	33%
Hungary	29.8	2 028	3	31%	3	31%	3	31%	3	31%	3	31%	3	31%
Iceland	9.7	114	1	41%	1	41%	1	41%	1	41%			1	41%
Ireland	13.5	586	2	23%	1	19%	2	23%	2	23%	2	23%	2	23%
Italy	32.5	10 175	13	16%	15	14%	24	26%	24	22%	28	26%	29	26%
Latvia	20.2	735									1	47%	1	47%
Lithuania	23.0	1 039	1	24%	1	24%	1	24%	2	29%	2	29%	3	46%
Luxembourg	23.3	83									1	22%	1	22%
Netherlands	25.5	2 326	4	15%	6	17%	6	17%	5	11%	6	12%	7	18%
Norway	19.0	759	3	14%	5	31%	3	21%	3	23%	3	23%	2	21%
Poland	35.0	10 632	15	26%	33	41%	32	41%	36	44%	37	45%	38	45%
Portugal	24.8	1 485	5	17%	7	21%	5	16%	6	20%	5	18%	8	24%
Romania	30.3	217	3	20%	3	20%	3	20%	6	26%	10	35%	2	2%
Russian Federation	33.3	10 579					1	10%	1	10%	1	10%	1	10%
Serbia	40.1	1 124	1	15%	1	15%	1	15%	1	15%	1	15%	1	15%
Slovakia	24.8	653	5	30%	5	30%	6	32%	7	35%	6	32%	4	22%
Slovenia	29.4	268	1	26%	1	26%	1	26%	1	26%	1	26%	1	26%
Spain	26.3	10 106	13	17%	23	30%	25	31%	22	24%	24	25%	27	30%
Sweden	14.8	1 507	3	20%	4	21%	4	21%	4	21%	3	20%	3	20%
Switzerland	20.0	677	3	12%	3	12%	3	12%	3	12%	3	12%	3	12%
Turkey	58.1	21 793									12	33%	20	45%
United Kingdom	19.2	12 975	34	32%	30	30%	33	32%	30	30%	28	30%	19	24%

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