5.5 Inequalities in chemical exposure

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Status

Human exposure to chemicals is unequally distributed across socioeconomic strata. Higher exposure is associated with higher socioeconomic status for some chemicals and with lower status for others. Lifestyle and behaviours appear to be mediating factors.

Trend

European data on inequalities in chemical exposure are only sporadically available. Making a time-trend analysis is therefore not justified.

5.5.1 Introduction and health relevance

Chemical pollution is a growing global problem, with significant impacts on human health. Pollutants are emitted from industrial processes, traffic and housing, among others, and are released from manufactured and chemical products, including pesticides, biocides and pharmaceuticals. Related health impacts are unevenly distributed across society, with a disproportionate burden falling on poor and vulnerable populations, affecting their rights to health, water, food, life, housing and development (UNEP, 2017). Knowledge about the magnitude of inequality in chemical exposure within countries in the WHO European Region is very limited, however.

It has been estimated that risks related to selected chemicals and chemical mixtures in the home, community or workplace caused 1.3 million deaths from noncommunicable diseases globally in 2016 – mainly cardiovascular diseases, chronic obstructive pulmonary disease and cancers (Prüss-Ustün et al., 2019). Lead poisoning alone was estimated to cause more than 500 000 deaths worldwide in 2016 (WHO, 2018). A significant part of the burden of disease is attributed to chemical exposure, with people of lower socioeconomic status more likely to be affected (Prüss-Ustün et al., 2017).

Initial economic estimates reveal that chemical exposure entails a cost to society that may exceed 10% of global domestic product (Grandjean & Bellanger, 2017). These calculations are based on limited information on human exposure and related health outcomes for only a few chemicals; thus, the real burden is expected to be larger. Associations taken into account in such estimates (Hänninen et al., 2014; Trasande et al., 2015; Grandjean & Bellanger, 2017) include:

- exposure to lead, organophosphates, brominated flame retardants and methylmercury with IQ loss;
- exposure to phthalates with obesity, diabetes and infertility;
- exposure to air pollution with premature mortality;
- exposure to second-hand smoke with respiratory diseases and cancer.

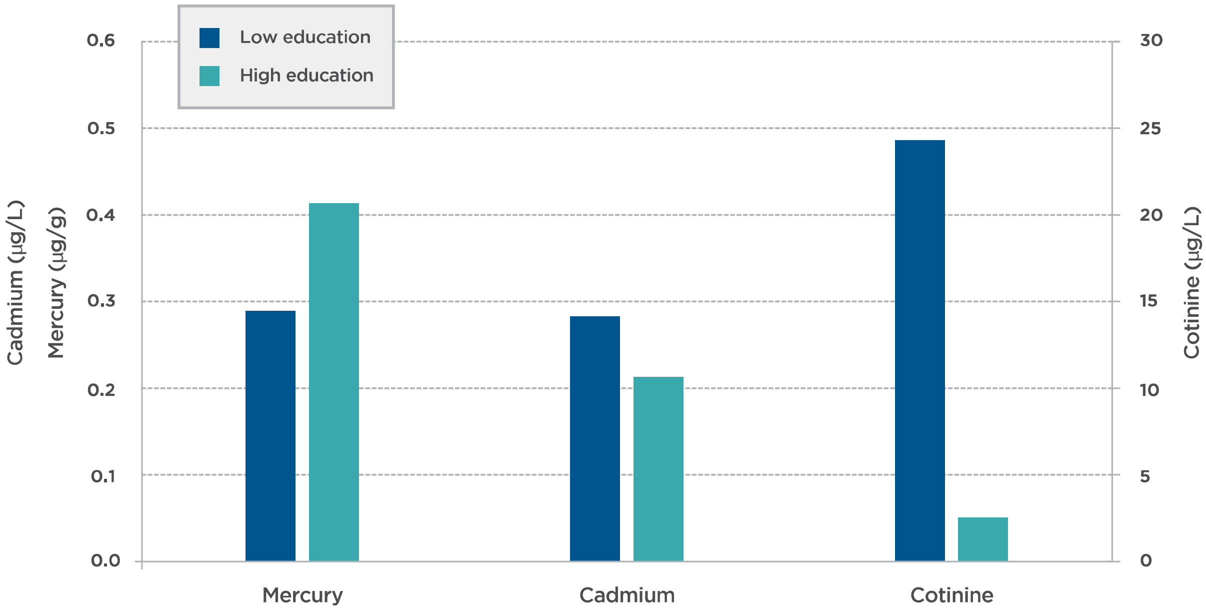
Factors underlying the disproportionate burden on people of lower socioeconomic status include increased exposure, increased susceptibility to chemicals, reduced capacity to avoid impacts and access health care and combined exposure to other (non-chemical) stressors. Human biomonitoring is a recognized tool for assessing integrated exposure to chemicals and variations in chemical exposure across temporal, geographical, demographic, lifestyle and socioeconomic dimensions, but such data are currently scarce at the European level. Separate human biomonitoring programmes in Germany and Belgium analysed the social distribution of their national data. Both found that children and adolescents with lower socioeconomic status or migrant status had higher body concentrations of heavy metals (lead, cadmium, nickel). In contrast, children and adolescents with higher socioeconomic status or a native background had higher concentrations of persistent organic pollutants (Becker et al., 2008; Morrens et al., 2012).

5.5.2 Indicator analysis: inequalities in exposure to cadmium, cotinine and mercury by education level

There are no international databases on inequalities in chemical exposure, and in the eastern part of the WHO European Region data on chemical exposure are generally lacking. This indicator analysis provides data on chemical exposure differences by education, based on data from the EU's DEMOCOPHES human biomonitoring project covering 17 countries (FPS Health, 2019).[9] While data on cadmium, cotinine and mercury are presented here, inequalities in exposure by socioeconomic status were also found for other chemicals. The DEMOCOPHES project surveyed 1844 children and 1844 mothers from 17 European countries, but was not representative for the whole of Europe. Stratification for socioeconomic status at the country level results in small groups, meaning that results must be interpreted with caution. Nevertheless, consistent trends were observed across the participating countries.

The difference in chemical body burden in mothers (generally n=120/country), stratified by the highest education level in the family, was studied, building further on the analysis of DEMOCOPHES data by Den Hond et al. (2015). Fig. 42 presents the average concentrations by education level for all countries studied. Overall, urinary cadmium and especially cotinine concentrations were higher in the group with lower educational attainment, while mercury concentrations in hair were higher in the group with higher education levels.

Fig. 42. Average concentration of cadmium, cotinine and mercury in mothers by education level, 2011–2012

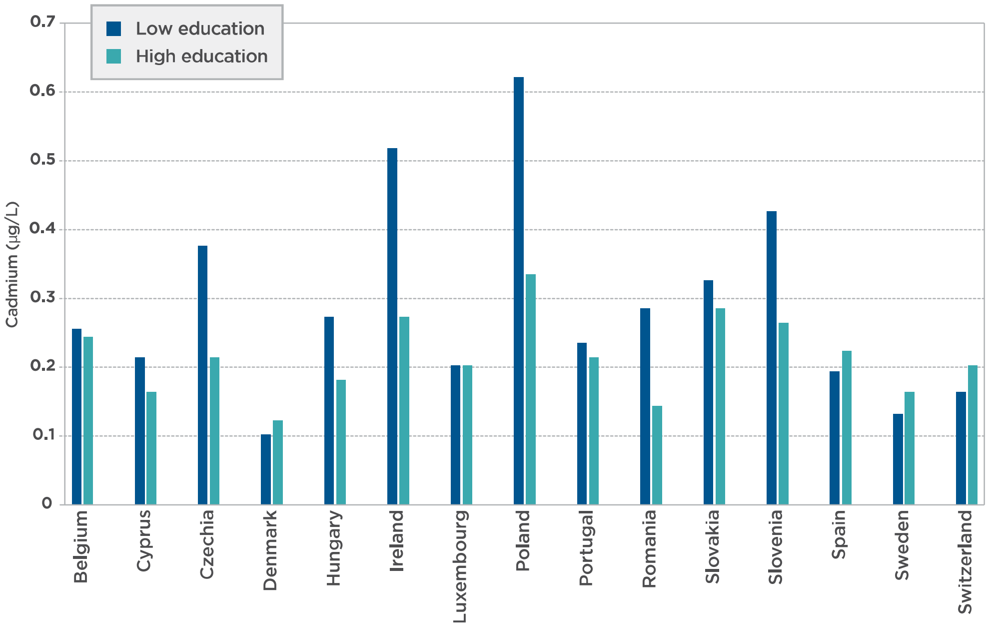


Note: includes one measurement per person only.
Source: data from DEMOCOPHES country-specific statistical analysis reports.

Looking at individual countries, concentrations of cadmium showed no clear differences across education categories for more than half the countries studied (ratio of low:high education between 0.8:1 and 1.2:1). For seven countries, mothers in the low education group clearly showed higher cadmium concentrations than those in the high education group (Fig. 43). The greatest inequalities were found in countries where the sample population exhibited the highest cadmium concentrations (such as Ireland and Poland). Contributory factors may include differences in smoking behaviour, diet (for example, cadmium is present in offal and a low iron intake facilitates cadmium intake), occupational exposure, proximity to industrial hot spots and the age of the dwelling (with higher cadmium exposure in older houses).

[9] Data are taken from DEMOCOPHES country-specific statistical analysis reports provided by the Belgian Federal Public Service Health, Food Chain Safety and Environment (Coordinating beneficiary of the DEMOCOPHES PROJECT LIFE09/ENV/BE000410, co-funded by the LIFE programme, and by the participating countries). The reports are unpublished but are available on request from the Belgian Federal Public Service Health, Food Chain Safety and Environment.

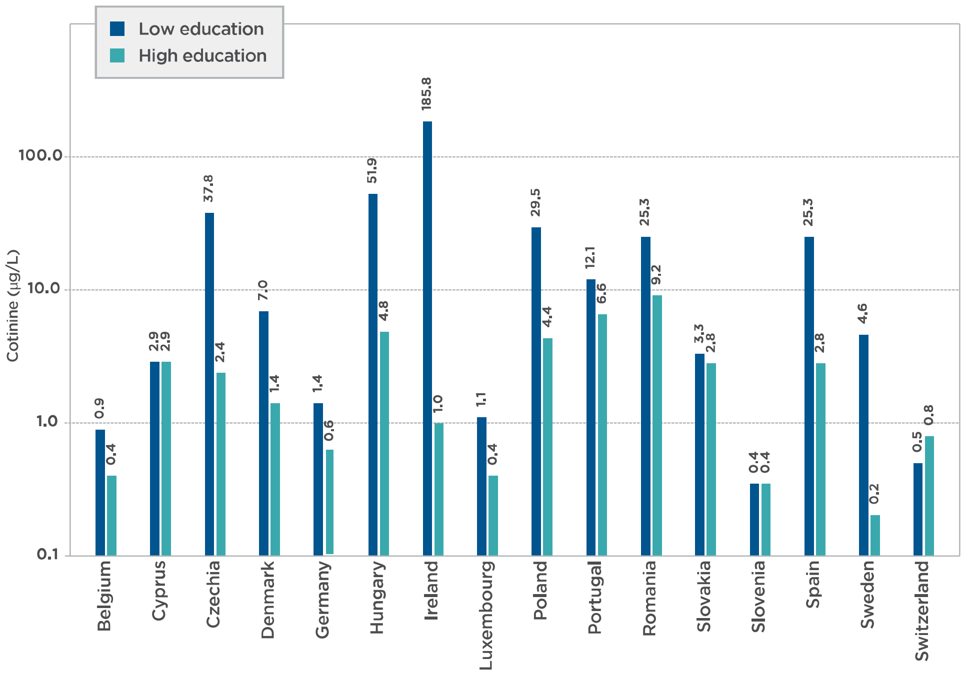
Fig. 43. Average concentration of cadmium in mother's urine by education level, 2011–2012



Note: low and high education can represent different education categories across countries.
Source: data from DEMOCOPHES country-specific statistical analysis reports.

Smoking, in particular, is an important source of cadmium exposure. In the DEMOCOPHES survey a metabolite of nicotine (cotinine) was consistently higher in mothers of the low education group (Fig. 44). The difference by education was large, reaching more than 20-fold in Ireland and Sweden. In absolute terms, the highest concentrations for all education groups were found in countries that had weak antismoking legislation at the time of sampling (Smolders et al., 2015).

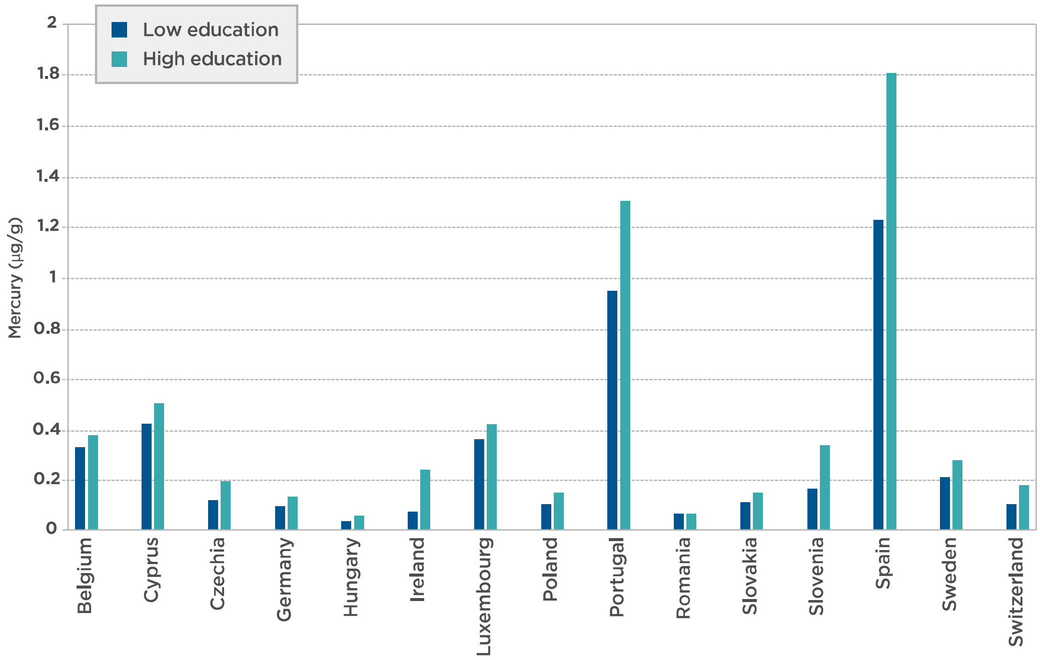
Fig. 44. Average concentration of cotinine in mother's urine by education level, 2011–2012



Notes: low and high education can represent different education categories across countries; for Switzerland no participants in the low education group exceeded the limit of quantification; the cotinine concentration was set at half the limit of quantification value; for clarity, values are presented on a logarithmic scale.
Source: data from DEMOCOPHES country-specific statistical analysis reports.

A different pattern of inequality emerges for mercury: mothers in the high education group exhibit higher concentrations in hair than those in the low education group, with a ratio of low:high education below 1. This is consistent for all countries in the DEMOCOPHES project (Fig. 45). Consumption of fish and shellfish has been associated with increased levels of mercury, and fish consumption is generally higher among groups with higher education and/or income. Mercury concentrations were highest in countries adjacent to the sea – Portugal and Spain in particular – where fish consumption is part of the daily diet. The largest social disparities in mercury concentration, however, were seen in countries where the overall exposure was lower (Ireland, Slovenia).

Fig. 45. Average mercury concentration in mother's hair by education level, 2011–2012



Note: low and high education can represent different education categories across countries.
Source: data from DEMOCOPHES country-specific statistical analysis reports.

Differences of biomarker concentrations in mothers by education level corresponded with findings in children for cotinine and mercury. For cadmium, the results were less clear for children.

5.5.3 Conclusions and suggestions

Overall, information on the distribution of chemical exposure and related inequalities within countries in the WHO European Region is insufficient, especially in the eastern part of the Region where there are no – or very limited – data on chemical exposure in general.

Based on the DEMOCOPHES project findings, concentrations of chemicals in mothers are distributed unequally across socioeconomic groups within many EU countries, but the patterns of inequality go in both directions. Exposure to cadmium and cotinine was higher in groups with lower socioeconomic status (indicated by low education level), while for mercury, exposure increased with educational attainment. Lifestyle practices such as food consumption may partly explain these inequalities, although the real causal factors are not yet fully understood.

Large-scale human biomonitoring studies that include social and lifestyle variables – such as the ongoing EU project HBM4EU (Environment Agency, 2019) – are needed to unravel the nexus between socioeconomic factors, environment and health. This would enhance understanding of the drivers of unequal exposure to chemicals and provide a knowledge base to inform policies and measures to target these inequities. One example for such coordinated action is the work on the Minamata Convention on Mercury, which includes both political and technical measures and aims to develop national capacities for prevention, diagnosis, treatment and monitoring of health risks related to exposure to mercury (WHO Regional Office for Europe, 2018).

Suggested mitigation actions are:

- establishment of adequate monitoring systems for chemical exposure, including human biomonitoring surveillance;
- human biomonitoring with exposure biomarkers to serve as an early warning for emerging (social) exposure differences and, in combination with effect biomarkers, to target the early onset of diseases;
- further efforts to reduce emissions of pollutants from industrial installations, agriculture, transport and waste to contribute to a nontoxic and healthy living environment;
- implementation of safe-by-design principles and green chemistry to reduce the toxicity and persistency of chemicals in products;
- ensuring that chemical risk assessments focus not only on average exposure levels but also on inequalities in exposure;
- preventing exposure at different levels (local, national, global), tailored to specific communities with relatively high exposure levels;
- advising citizens on how to reduce their chemical exposure through healthy lifestyles;
- creating knowledge about the causal factors underlying the inequality in chemical exposure needed for awareness-raising and policy development.

References

Becker K, Müssig-Zufika M, Conrad A, Lüdecke A, Schulz C, Seiwert M et al. (2008). German Environmental Survey for Children 2003/06 – GerES IV – human biomonitoring: Levels of selected substances in blood and urine of children in Germany. Dessau-Roßlau: Federal Environment Agency (https://www.umweltbundesamt.de/en/publikationen/german-environmental-survey-for-children-200306, accessed 28 March 2019).

Den Hond E, Govarts E, Willems H, Smolders R, Casteleyn L, Kolossa-Gehring M et al. (2015). First steps toward harmonized human biomonitoring in Europe: demonstration project to perform human biomonitoring on a European scale. Environ Health Perspect. 12(3):255–63. doi:10.1289/ehp.1408616.

Environment Agency (2019). HBM4EU [website]. Dessau-Roßlau: Federal Environment Agency (https://www.hbm4eu.eu/, accessed 28 March 2019).

FPS Health (2019). DEMOCOPHES [website]. Brussels: Federal Public Service Health, Food Chain Safety and Environment (http://www.eu-hbm.info/democophes, accessed 28 March 2019).

Grandjean P, Bellanger M (2017). Calculation of the disease burden associated with environmental chemical exposures: application of toxicological information in health economic estimation. Environ Health. 16(1):123. doi:10.1186/s12940-017-0340-3.

Hänninen O, Knol AB, Jantunen M, Lim T-A, Conrad A, Rappolder M et al. (2014). Environmental burden of disease in Europe: assessing nine risk factors in six countries. Environ Health Perspect. 122(5):439–46. doi:10.1289/ehp.1206154.

Morrens B, Bruckers L, Den Hond E, Nelen V, Schoeters G, Baeyens W et al. (2012). Social distribution of internal exposure to environmental pollution in Flemish adolescents, Int J Hyg Environ Health. 215(4):474–81. doi:10.1016/j.ijheh.2011.10.008.

Prüss-Ustün A, Wolf J, Corvalán C, Neville T, Bos R, Neira M (2017). Diseases due to unhealthy environments: an updated estimate of the global burden of disease attributable to environmental determinants of health. J Public Health (Oxf). 39(3):464–75. doi:10.1093/pubmed/fdw085.

Prüss-Ustün A, van Deventer E, Mudu P, Campbell-Lendrum D, Vickers C, Ivanov I et al. (2019). Environmental risks and non-communicable diseases. BMJ. 28;364:l265. doi:10.1136/bmj.l265.

Smolders R, Den Hond E, Koppen G, Govarts E, Willems H, Casteleyn L et al. (2015). Interpreting biomarker data from the COPHES/DEMOCOPHES twin projects: using external exposure data to understand biomarker differences among countries. Environ Res. 141:86–95. doi:10.1016/j.envres.2014.08.016.

Trasande L, Zoeller RT, Hass U, Kortenkamp A, Grandjean P, Myers JP et al. (2015). Estimating burden and disease costs of exposure to endocrine-disrupting chemicals in the European Union. J Clin Endocrinol Metab. 100(4):1245–55. doi:10.1210/jc.2014-4324.

UNEP (2017). Towards a pollution-free planet: background report. Nairobi: United Nations Environment Programme (https://europa.eu/capacity4dev/unep/documents/towards-pollution-free-planet-background-report, accessed 27 March 2019).

WHO (2018). The public health impact of chemicals: knowns and unknowns. Data addendum for 2016. Geneva: World Health Organization (https://apps.who.int/iris/bitstream/handle/10665/279001/WHO-CED-PHE-EPE-18.09-eng.pdf?ua=1, accessed 13 March 2019).

WHO Regional Office for Europe (2018). Assessment of prenatal exposure to mercury: standard operating procedures. Copenhagen: WHO Regional Office for Europe (http://www.euro.who.int/en/health-topics/environment-and-health/chemical-safety/publications/2018/assessment-of-prenatal-exposure-to-mercury-standard-operating-procedures-2018, accessed 13 March 2019).