European Journal of Public Health, Vol. 24, No. 1, 21–26
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doi:10.1093/eurpub/ckt063 Advance Access published on 6 June 2013

Economic impacts of environmentally attributable childhood health outcomes in the European Union

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Background: There is increasing evidence of the role that exposure to industrial chemicals plays in the development of childhood disease. The USA and the European Union (EU) have taken divergent policy approaches to managing this issue, and economic estimates of disease costs attributable to environmental exposures in children are available in the USA but not the EU. We undertook the first economic evaluation of the impacts of childhood environmental chemical exposures in the EU. **Methods:** We used a cost-of-illness approach to estimate health care system costs, and used environmentally attributable fraction modelling to estimate the proportion of childhood disease due to environmental exposures. We analysed data on exposures, disease prevalence and costs at a country level, and then aggregated costs across EU member states to estimate overall economic impacts within the EU. **Results:** We found the combined environmentally attributable costs of lead exposure, methylmercury exposure, developmental disabilities, asthma and cancer to be $70.9 billion in 2008 (range: $58.9–$90.6 billion). These costs amounted to ~0.480% of the gross domestic product of the EU in 2008. **Conclusions:** Childhood chemical exposures present a significant economic burden to the EU. Our study offers an important baseline of disease costs before the implementation of Registration, Evaluation and Authorization of Chemicals, which is important for studying the impacts of this policy regime.

Introduction

Exposures to industrial chemicals are increasingly recognized to contribute to childhood disease and disability in both industrialized and industrializing countries.[1,2] People are continuously exposed to new chemicals in their everyday environment, the majority of which has not been subject to testing for effects on human health.[3,4]

Economic costs due to exposure to leaded gasoline,[5] lead-based paint[6,7] and methylmercury[1,8] have been documented. Despite the implications for policy-making, estimates of the economic benefits of reduction in toxic exposures have been limited largely to the USA.

The USA and the European Union (EU) have taken divergent approaches to the management of chemicals. The Toxic Substances Control Act in the USA requires that regulators demonstrate that a particular chemical poses a risk to health, whereas the Registration, Evaluation and Authorization of Chemicals (REACH) directive in the EU requires that industries submit documentation on the toxicological properties of chemicals sold in quantities greater than 1 ton per year.[9–11] REACH applies to both new and existing chemicals equally, whereas all chemicals in commercial use before 1979 are not subject to the Toxic Substances Control Act's screening requirements.[12,13]

This divergence of policy represents an opportunity to examine whether costs of childhood disease and disability will be affected by new regulatory approaches. Given that no EU-wide 'pre-REACH' cost estimates for childhood disease and disability attributable to environmental factors are available, we endeavoured to quantify the economic costs attributable to environmental exposures in childhood in the 27 member countries of the EU in 2008.

Methods

In this analysis, we used a cost-of-illness (COI) approach, focusing on costs in the 27 EU member countries in the year 2008. COI studies provide an estimate of the economic burden of a disease, representing the maximum economic value that could be gained from improved health if the given disease were to be eradicated. A COI analysis incorporates direct medical costs and lost productivity per case, multiplied by the total number of cases.[14,15] This approach provides valuable information that can be applied to cost-benefit or cost-effectiveness analyses.[16]

We estimated the incidence, prevalence and costs of disease attributable to environmental pollutants in the youth population of the 27 EU member states. Here, environmental pollutants are defined as 'toxic chemicals of human origin in air, food, water and communities'.[17] We further limited the analysis to conditions attributable to environmental pollutants that individuals cannot easily control—excluding drugs and social or physical environmental factors. This definition is useful in the context of policy analysis because diseases and health problems caused by anthropogenically created toxins could, in theory, be avoided by controlling the activities responsible for generating them.[18]

We followed previous approaches to define lead poisoning, methylmercury exposure, asthma, childhood and adolescent disorders (CADs) and cancer as environmentally attributable conditions of concern.[1,17] We defined the population of concern to be children aged <18 years. We used environmentally attributable fraction (EAF) modelling to calculate environmentally attributable costs of childhood disease based on recommendations from the Institute of Medicine.[19] EAF is the product of the prevalence of one or more risk factors multiplied by the relative risk of disease associated with those risk factors.[20]

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In this analysis, 'cost per case' refers to discounted lifetime expenditures attributable to a particular disease, including direct costs of health care, costs of rehabilitation and lost productivity. The terms 'disease rate' and 'population size' refer, respectively, to either the incidence or prevalence of a disease and the size of the population at risk.

Lead poisoning

We obtained population data divided into age categories from the European Community Health Indicators for 2008.[21] Country-level data on childhood lead exposures were used wherever available; otherwise, we applied the mean and standard deviation averaged across all European countries, as reported by Bierkens *et al.*[22] We assumed that lead exposure follows a log-normal distribution to calculate the distribution of lead exposure within national populations, as recommended by the World Health Organization.[23] As lead exposures have decreased over time due to the phase-out of lead in gasoline and other control measures, we adjusted data on average blood lead level (BLL) collected before 2003 downward based on international trends given by Smolders *et al.*[24] We left all sources that collected data in the year 2003 or later unadjusted. We determined average BLLs based on country-specific data, wherever available.

Evidence demonstrates that BLLs in the range of 2–10 mg/dl cause persistent cognitive damage,[25–27] and work by Lanphear *et al.*[28] established a clear, nonlinear and negative relationship between intelligence quotient (IQ) and BLL based on a systematic pooling of international data. We coupled these data on the relationship between childhood lead exposure and decrements in IQ with results from Grosse *et al.*[5] that quantify losses in lifetime economic productivity per IQ point loss (2.00% base case, 1.76–2.39% sensitivity analysis). We then applied these values to lifetime economic productivity data from the University of California Institute for Health and Aging, which assume annual growth in productivity of 1% and a 3% discount rate.[29] We used data for lifetime economic productivity from 2007, and adjusted these to 2008 values using the general harmonized index of consumer prices for the 27 member countries of the EU.[30]

We obtained direct health care costs from estimates provided by Gould[6] based on each category of BLL. As these health care costs were provided in 2006 values, they were inflated to 2008 dollars by adjusting for changes in service costs for the Euro area.[30] We adjusted all costs for gross domestic product (GDP) purchasing power parity at the country level using 2008 values.[31] We based calculations of the cost per case on work by Gould,[6] which analysed the relationship between lowered IQ due to elevated BLLs and social costs, including direct medical costs as well as decreased lifetime earnings due to lowered IQ and lowered educational attainment.

Methylmercury poisoning

As with cognitive deficits caused by exposure to lead, the economic burden of health outcomes associated with prenatal methylmercury exposure can be quantified by examining associated productivity losses. This general approach has been applied previously by Trasande *et al.*[32]

We determined the levels of exposure of pregnant women to methylmercury based on data from hair follicle samples collected in biomonitoring studies. Data sources were obtained from a comprehensive literature review of available published papers.[33–43] Where possible, we used biomonitoring studies at the country level to determine exposure levels. Otherwise, we applied the weighted average based on mean and sample size from the available studies to extrapolate to the remaining EU nations. We excluded articles that recorded mercury exposure levels for high-risk groups that were not likely to be representative of the general population.

To correlate methylmercury exposure with health impacts, we used the linear model of prenatal methylmercury exposure and effects on intellectual function published by Daniel Axelrad *et al.*[44] This study demonstrated a loss of 0.18 IQ points for each part-per-million of maternal hair mercury. We assumed no threshold for the effects of methylmercury exposure and calculated total IQ points lost per year by multiplying the population mean methylmercury exposure by the size of the annual birth cohort and then applying the relationship of 0.18 IQ points lost per part-per-million of methylmercury in hair samples. We then applied the same approach as with the case of lead poisoning to calculate lost economic productivity based on decrements in IQ at a population level. We excluded direct medical costs in this case.

Developmental disabilities

Our analysis of the environmentally attributable costs of developmental disabilities included two categories: cases of CADs and mental retardation (MR). CADs are defined to include autism spectrum disorders, attention deficit hyperactivity disorder and conduct disorder. MR can also be denoted as intellectual disability, and is defined by an IQ score lower than 70.[45]

We made use of data on population size affected by CADs and MR as well as costs per case encompassing both direct medical costs and productivity losses from a comprehensive review of the cost of disorders of the brain in Europe in 2010 published by Gustavsson *et al.*[45] As cost data were reported in Euros, we applied a conversion rate of \$1 to €0.82 for the year 2008.[46]

We used a base case scenario of 10% for the EAF of the economic costs of developmental disorders, with a sensitivity analysis encompassing a low-end estimate for EAF of 5% and a high-end estimate of 20%. We based these values on methodology used previously in the published literature[1,17] derived from an estimate of the percentage of neurobehavioural disorders in children caused by toxic environmental exposures by an expert committee convened by the US National Academy of Sciences.[47]

To account for the fact that exposure to lead and methylmercury could be responsible for a portion of the reported cases of MR, we applied a correction to avoid double-counting these cases. We determined the number of excess cases of MR attributable to lead exposure by adjusting the population mean IQ in each country by an amount determined by the product of mean lead exposure levels and corresponding IQ decrements based on relationships reported by Gould.[6] We then assumed that IQ levels follow a normal distribution and calculated the additional number of cases of MR resulting from the adjusted population mean IQ based on the calculated portion of the population falling below an IQ of 70. Where population mean lead exposure levels were <2 μg/dl, we did not apply a correction.

Similarly, for methylmercury exposure, we applied an adjustment for methylmercury exposure levels and corresponding IQ decrements based on relationships reported by Axelrad *et al.*[44] We followed the same approach described previously using a calculated normal distribution of population IQ to determine the additional cases of MR due to methylmercury exposure. We did not apply a cutoff level for effects of methylmercury exposure. We then subtracted the number of incremental cases of MR due to both lead and methylmercury exposure from the previously calculated overall environmentally attributable costs of MR. This yielded a final estimate for environmentally attributable costs of MR due to factors other than lead and methylmercury exposure.

Asthma

For asthma, we used current prevalence in the population aged 0–18 years as the appropriate measure of disease rate, as a reduction in air pollution would decrease morbidity due to asthma across the population. We determined the prevalence of asthma in the general population from country profiles published in the Global

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Burden of Asthma report by Masoli *et al.*[48] and used data on cost per case published in a study by Van den Akker *et al.*[46] that provided both direct medical costs and indirect economic losses due to productive time lost by caretakers for children with asthma for countries within the EU. As costs per case were reported in 2004 Euros, we used a conversion rate of €0.82 per US dollar, as reported in table 4 of the article by Van den Akker *et al.*[46] We then inflated costs to 2008 values using historic consumer price index values for the EU-27 area.[30]

Cancer

To estimate the environmentally attributable costs of childhood cancer in the EU, we first obtained data on the incidence and mortality in each EU country due to brain/nervous system cancers, Hodgkin lymphoma, leukaemia and non-Hodgkin lymphoma for the population aged 0–14 years. We obtained these data from the publicly available GLOBOCAN 2008 database, which provides information on cancer incidence, mortality and prevalence on a per-country basis in 2008.[49] We used the age range 0–14 because the GLOBOCAN database groups data on ages 15–18 with older adults, whereas this study focuses exclusively on paediatric conditions. We derived costs per case of childhood cancer from reports by Barr *et al.*,[50] which contain comprehensive analyses of costs of paediatric cancer, including health care system costs and costs incurred by families in the care of a sick child. In addition to social cost per case, we also included costs associated with premature mortality by calculating lost economic productivity based on lifetime productivity estimates.[29] We inflated values for cost per case to their equivalent values in 2008 using historical consumer price index data and then adjusted for country-specific GDP purchasing power parity.[30]

For the base case estimate of costs, we applied an EAF value of 5%, and calculated the range of likely costs by completing a sensitivity analysis using EAF values of 2 and 10%, consistent with values published elsewhere in the literature.[1,17]

The Supplemental Materials section provides further information on the data and methods used to complete these analyses.

Results

The base case estimate of total costs attributable to childhood chemical exposures in the EU-27 region in 2008 is $70.9 billion, with a probable range of $58.8–$90.6 billion. This comprises 0.480% of the GDP of the EU in 2008 (range: 0.399–0.613%). The largest impact of environmentally attributable childhood illness on the economy of a single country is in Cyprus, where calculated costs amount to 2.90% of GDP (range: 2.52–3.49%). Despite having the highest prevalence of asthma in the EU, the UK had calculated costs that amount to the smallest percentage of GDP, at 0.208% (range: 0.157–0.288%). Table 1 summarizes the range of estimated costs in the EU-27 region for total costs associated with environmentally attributable childhood illness in millions of 2008 dollars, as well as a percentage of GDP.

For the 27 EU member countries as a whole, we estimated that the economic costs of childhood lead exposure are ~$57 billion dollars (range: $50.5–$67.9 billion). Prenatal methylmercury exposure was found to contribute $4.8 billion to overall costs (range: $4.2–$5.7 billion). The base case estimate for environmentally attributable costs of CADs is $2.5 billion, assuming an EAF of 10% (range: $1.25–$5.0 billion). Environmentally attributable costs of MR were estimated to be $4.9 billion, assuming an EAF of 10% and adjusting for cases of MR attributable to lead and methylmercury exposure (range: $2.3–$9.9 billion). The base case estimates of environmentally attributable costs resulting from lead poisoning, prenatal methyl mercury exposure, CAD and MR are presented for each EU member country individually as well as for the EU region as a whole in table 2. All results are reported in millions of dollars in the year 2008, with the range of values derived from low-end and high-end estimates reported in parentheses.

Table 1 Costs of environmentally attributable childhood illness, reported in millions of 2008 $

Country	Base case estimate (% of GDP)	Low-end estimate (% of GDP)	High-end Estimate (% of GDP)
Austria	1860 (0.578)	1550 (0.481)	2350 (0.730)
Belgium	1480 (0.393)	1200 (0.318)	1910 (0.507)
Bulgaria	477 (0.550)	398 (0.459)	599 (0.691)
Cyprus	620 (2.90)	540 (2.52)	746 (3.49)
Czech Republic	1300 (0.518)	1090 (0.434)	1650 (0.657)
Denmark	1340 (0.660)	1130 (0.557)	1680 (0.828)
Estonia	165 (0.575)	149 (0.519)	206 (0.718)
Finland	713 (0.379)	587 (0.312)	921 (0.490)
France	6610 (0.318)	5320 (0.256)	8810 (0.424)
Germany	16 800 (0.598)	14 100 (0.502)	21 200 (0.754)
Greece	2030 (0.619)	1700 (0.518)	2570 (0.784)
Hungary	1180 (0.615)	977 (0.509)	1490 (0.776)
Ireland	1610 (0.839)	1350 (0.703)	1990 (1.04)
Italy	8150 (0.453)	6740 (0.374)	10 400 (0.578)
Latvia	217 (0.543)	182 (0.455)	272 (0.680)
Lithuania	342 (0.57)	285 (0.475)	429 (0.715)
Luxembourg	271 (0.711)	230 (0.604)	338 (0.887)
Malta	60.8 (0.647)	50.8 (0.540)	76.3 (0.812)
The Netherlands	3570 (0.553)	2970 (0.460)	4520 (0.700)
Poland	3820 (0.613)	3170 (0.509)	4840 (0.777)
Portugal	1210 (0.522)	991 (0.427)	1540 (0.664)
Romania	1460 (0.591)	1220 (0.494)	1850 (0.749)
Slovakia	609 (0.554)	512 (0.465)	769 (0.699)
Slovenia	293 (0.521)	242 (0.431)	369 (0.657)
Spain	9220 (0.678)	7730 (0.568)	11 500 (0.846)
Sweden	1050 (0.310)	1071 (0.316)	1410 (0.416)
UK	4430 (0.208)	3340 (0.157)	6140 (0.288)
EU-27	70 900 (0.480)	58 900 (0.399)	90 600 (0.613)

Environmentally attributable costs of childhood asthma in the EU amount to $1.6 billion, applying an EAF of 30% (range: $0.52–$1.8 billion). The base case estimate of annual environmentally attributable economic impacts of morbidity and mortality from all paediatric cancers in the EU in 2008, assuming an EAF of 5%, is $90 million (range: $39–$196 million). The estimates of environmentally attributable costs resulting from asthma and paediatric cancer are presented in table 3.

Additional details of the data sources, costs per case and results for each of the disease categories discussed are presented in the Supplemental Materials for this article.

Discussion

Our findings underscore the importance of specifically considering the health effects in children when conducting analyses of the costs or benefits of environmental, health and safety policies. The three most significant contributors to costs in our analysis—lead poisoning, methylmercury poisoning and developmental disabilities—are specific to children's health, and would be omitted by any assessment that examined only health risks to adults. As no estimates of the costs or benefits of implementing REACH have specifically accounted for children's health, this analysis provides an important benchmark for evaluating the impact of REACH on childhood chemical exposures and health outcomes.

Despite common membership to the EU, levels of exposure to environmental contaminants varied from country to country. For example, the range in recorded blood lead levels was 32.5 μg/l, with Poland having the highest recorded values at 34.8 μg/l and Italy the lowest at 2.35 μg/l. Other notable variations include the UK and Ireland's high documented asthma prevalence, which at 16.1% is

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Table 2 Estimates of environmentally attributable costs due to childhood lead exposure, prenatal methylmercury exposure, MR and CAD

Country	Lead poisoning (range)	Methylmercury (range)	MR (range)	CAD (range)
Austria	1660 (1460–1980)	13.0 (12.0–16.0)	104 (48.0–216)	52.0 (25.9–104)
Belgium	1110 (972–1320)	138 (122–165)	125 (62.0–250)	65.8 (32.9–132)
Bulgaria	402 (354–479)	25.0 (22.4–30.3)	23.0 (10.7–47.2)	13.2 (6.60–26.4)
Cyprus	599 (527–713)	7.86 (6.92–9.35)	5.97 (2.98–11.9)	4.20 (2.08–8.31)
Czech Republic	1140 (1000–1360)	30.5 (26.8–36.3)	73.6 (34.1–153)	38.5 (19.2–76.9)
Denmark	1140 (1010–1360)	79.6 (70.0–94.7)	61.4 (28.1–128)	39.3 (19.6–78.6)
Estonia	144 (127–172)	9.12 (8.03–10.9)	6.85 (3.19–14.2)	4.20 (2.10–8.41)
Finland	545 (480–649)	66.9 (58.9–79.6)	56.2 (28.1–112)	32.9 (16.5–65.9)
France	4460 (3930–5310)	880 (774–1050)	743 (372–1490)	405 (202–810)
Germany	14 800 (13 100–17 700)	295 (260–352)	943 (437–1960)	423 (212–847)
Greece	1630 (1430–1940)	221 (194–297)	98.3 (45.9–203)	45.8 (22.9–91.6)
Hungary	980 (863–1170)	62.0 (54.5–73.7)	57.6 (26.8–119)	33.4 (16.7–66.7)
Ireland	1380 (1210–1640)	86.9 (76.5–103)	53.4 (24.3–112)	38.2 (19.1–76.4)
Italy	6580 (5790–7830)	557 (490–663)	569 (268–1170)	275 (137–550)
Latvia	184 (162–219)	11.6 (10.2–13.9)	9.74 (4.56–20.1)	5.80 (2.90–11.6)
Lithuania	288 (253–342)	18.2 (16.0–21.6)	16.0 (7.43–33.1)	10.3 (5.17–20.7)
Luxembourg	236 (208–281)	14.9 (13.1–17.8)	10.5 (4.84–21.8)	7.60 (3.78–15.1)
Malta	51 (45–61)	3.25 (2.86–3.87)	3.00 (1.40–6.23)	1.67 (0.83–3.33)
The Netherlands	2950 (2590–3510)	239 (210–284)	201 (93.6–416)	122 (61.2–245)
Poland	3320 (2920–3950)	68.7 (60.5–81.8)	206 (93.3–433)	125 (62.4–250)
Portugal	968 (852–1150)	74.8 (65.8–89.0)	81.0 (37.9–167)	40.8 (20.4–81.5)
Romania	1210 (1070–1440)	76.7 (67.5–91.2)	78.8 (36.7–163)	52.0 (26.0–104)
Slovakia	530 (467–631)	21.2 (18.6–25.2)	31.7 (14.7–65.7)	19.0 (9.55–38.2)
Slovenia	241 (212–287)	16.1 (14.2–19.2)	16.5 (7.71–34.2)	7.786 (3.93–15.7)
Spain	7430 (6540–8850)	918 (808–1090)	442 (207–913)	213 (107–426)
Sweden	759 (668–904)	68.6 (60.4–81.6)	118 (58.9–236)	78.1 (39.0–156)
UK	2300 (2020–2740)	798 (702–950)	729 (364–1460)	336 (168–672)
EU-27	57 100 (50 500–67 900)	4800 (4240–5750)	4860 (2320–9950)	2490 (1240–4980)

Table 3 Estimates of environmentally attributable costs due to asthma and paediatric cancer

Country	Asthma (range)	Cancer (range)
Austria	24.8 (8.25–28.9)	1.34 (0.536–2.68)
Belgium	34.1 (11.4–39.7)	3.00 (1.20–6.00)
Bulgaria	13.1 (4.37–15.3)	0.707 (0.283–1.41)
Cyprus	2.83 (0.944–3.30)	0.151 (0.0606–0.303)
Czech Republic	18.6 (6.19–21.7)	1.38 (0.551–2.75)
Denmark	17.2 (5.73–20.1)	1.61 (0.645–3.23)
Estonia	0.792 (0.264–0.924)	0.0537 (0.0215–0.107)
Finland	9.89 (3.30–11.5)	1.76 (0.706–3.53)
France	108 (36.2–127)	13.9 (5.56–27.8)
Germany	299 (99.5–348)	12.7 (5.08–25.4)
Greece	31.9 (10.6–37.3)	2.01 (0.805–4.02)
Hungary	46.4 (15.5–54.1)	1.35 (0.541–2.70)
Ireland	46.3 (15.4–54.1)	1.88 (0.754–3.77)
Italy	159 (52.9–185)	13.0 (5.21–26.0)
Latvia	5.54 (1.85–6.46)	0.275 (0.110–0.550)
Lithuania	8.92 (2.97–10.4)	0.587 (0.235–1.17)
Luxembourg	1.63 (0.542–1.90)	0 (0–0)
Malta	1.36 (0.455–1.59)	0.0229 (0.00915–0.0457)
The Netherlands	50.0 (16.7–58.3)	5.15 (2.06–10.3)
Poland	101 (33.6–118)	3.72 (1.49–7.44)
Portugal	42.1 (14.0–49.1)	1.99 (0.797–3.98)
Romania	41.8 (13.9–48.8)	2.28 (0.911–4.55)
Slovakia	5.76 (1.92–6.71)	0.792 (0.317–1.58)
Slovenia	10.9 (3.63–12.7)	0.269 (0.108–0.538)
Spain	204 (67.8–237.5)	10.5 (4.21–21.0)
Sweden	24.6 (8.21–28.7)	2.49 (0.997–4.98)
UK	247 (82.2–288)	15.0 (6.01–30.04)
EU-27	1550 (518–1810)	98.0 (39.2–196)

double that of any other EU member state. These country-level differences reflect the impact of national policies, such as phasing out leaded gasoline and air quality regulations, among other factors.

Our current work also serves to highlight the need for child-specific scientific data and environmental health indicators. Sound scientific evidence is important to aid in identifying and prioritizing problems, informing stakeholders and providing a framework for discussion and debate.[51] Overall, there is a need for coherent methodologically consistent biomonitoring studies of markers of chemical exposure. Variability of data sources and sampling methods to determine exposures is a source of uncertainty that limits the accuracy of estimates of the public health and economic impacts of environmentally attributable health outcomes. Improving the data available for such studies is important, however, as accurate information on costs of illness can serve to better focus preventive efforts and to provide perspective to arguments that focus exclusively on the costs of preventing pollution.[17]

As REACH is implemented in the EU, it will be important to monitor public health outcomes in both the EU and the USA to evaluate the impact of these divergent policy regimes. As scientific research continues to elucidate the connections between the environment and human health, further costs may be added to the present analysis. It is also important to note that a reduction in exposure and morbidity associated with environmental chemicals does not necessarily lead to complete elimination of associated costs, as the implementation of appropriate interventions and provision of health care services such as preventive screenings incur some costs as well. However, an analysis of costs of environmental exposures serves to outline the possible magnitude of economic benefits associated with preventing pollution.

Supplementary data

Supplementary data are available at *EURPUB* online.

Acknowledgements

Thesis work at Oxford for EB was supported by a Golden Key International Honor Society study abroad scholarship. A version of this work was submitted to an examination committee at the

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University of Oxford in partial completion of an MSc in Environmental Change and Management.

Funding

Thesis work at Oxford for EB was supported by a Golden Key International Honor Society study abroad scholarship.

Conflicts of interest: None declared.

Key points

- The costs of environmentally attributable childhood illnesses, including lead poisoning, methylmercury exposure, developmental disabilities, asthma and cancer, in the 27 EU member countries were $70.6 billion, as reported in 2008 dollars (range: $58.8–90.6 billion dollars). Estimation of such costs is important for evaluating the impact of the implementation of REACH, the EU's new chemicals policy.
- Costs due to environmentally attributable illness can arise owing to lost economic productivity as well as direct health care expenditures. In this analysis, lost economic productivity owing to developmental disabilities attributable to lead, methylmercury and other chemical exposures was the main contributor to overall costs.
- Variation between countries in levels of chemical exposure and associated morbidity indicates the importance of national environmental policies on human health.

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European Journal of Public Health, Vol. 24, No. 1, 26–32
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doi:10.1093/eurpub/ckt100 Advance Access published on 18 July 2013

Validation of the SDQ in a multi-ethnic population of young children

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Background: The Strengths and Difficulties Questionnaire (SDQ) is a valuable screening tool for identifying psychosocial problems. Its performance in a multi-ethnic society, common to many paediatric health care workers, has not been investigated. Because it is important that screening instruments are valid and reliable for all ethnic groups within one society, we examined differences in the SDQ's psychometric properties in a multi-ethnic society. **Methods:** The SDQ parent ($n = 8114$) and teacher form ($n = 9355$) were completed as part of a preventive health check for children aged 5–6 years of Dutch and non-Dutch ethnic backgrounds. The Child Behaviour Checklist (CBCL)/Teacher Report Form (TRF) was administered to a subsample. **Results:** Factor analysis of the parent-rated SDQ showed different rating patterns for two of the five subscales for non-Dutch children as compared with Dutch children. Cronbach's alpha for the total difficulties score varied by ethnic group (0.73–0.78 parent-rated SDQ, 0.80–0.83 teacher-rated SDQ), and coefficients were generally smaller for non-Dutch than for Dutch children ($P < 0.05$). Alpha coefficients for subscales varied between 0.31–0.85 for ethnic groups. Inter-rater correlations between parents and teachers for the total difficulties score varied between 0.20–0.41 between ethnic groups and were larger for Dutch than for non-Dutch children ($P < 0.05$). Concurrent validity was acceptable for most scales and most ethnic groups. **Conclusion:** The total difficulties score of the parent- and teacher-rated SDQ is valid and reliable for different ethnic groups within Dutch society. However, there are differences in reliability and validity of the subscales, which makes interpretation of the subscales difficult for certain ethnic groups.

Introduction

Prevalence of psychosocial problems varies between eight and eighteen per cent in young children.[1,2] Early detection and treatment have an important role in preventing psychosocial problems and may benefit the child's development, well-being and future health.[3] For early detection, professionals in paediatric care need valid and reliable screening instruments. Because societies all over the world are becoming increasingly multi-ethnic and prevalence of psychosocial problems in some minority children is higher than in native children,[4–6] it is even more important that these instruments are valid and reliable for all ethnic groups within a society.

The Strengths and Difficulties Questionnaire (SDQ) is a relatively short instrument developed to screen for emotional and behavioural