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Place, Not Poverty: What Explains Lead in the Blood of Bangladesh's Children

Xeon Nasif

Abstract

Bangladesh's 2025 national survey found that nearly two-fifths of children aged one to four have blood lead at or above 5 µg/dL, that levels are highest in Dhaka division, and that richer children have more lead than poorer ones. This paper uses the survey's microdata, together with four other data sources, to ask what lies behind those facts. It reports five results. First, the wealth gradient reverses within neighbourhoods: children in the richest fifth of households have 31 percent more lead than the poorest nationally but 10 percent less than their poorest neighbours. The national pattern reflects where richer households live, and place accounts for far more of the variation than any household characteristic (intraclass correlation within survey clusters 0.37). Second, the excess in Dhaka, Gazipur and Narayanganj, where the geometric mean is twice that of the rest of the country, is specific to lead: blood arsenic and mercury are lower there, and blood arsenic follows the arsenic in each household's water, as it should, while lead does not. Pregnant women show the same geography as children. Third, the sources the survey asks about (battery work nearby, surma, paint, cooking fuel, soil lead at the home) explain about a tenth of that excess; the industrial composition of district employment and modelled ambient air pollution explain none of it. Fourth, across 33 districts with a monitored river, children's blood lead rises with an index of river pollution, by 20 log points per standard deviation and by 14 outside the three Dhaka districts, an association carried by organic waste load and not specifically by industrial effluent. Fifth, the association between lead and shorter stature holds among children in the same neighbourhood, of the same age in months and with the same household wealth and mother's schooling: a doubling of blood lead goes with a height-for-age z-score lower by 0.10. The estimate is larger within neighbourhoods than across them, is graded across the range of blood lead, and is not shared by arsenic, cadmium or mercury. All of these are associations in one cross-section and are not estimates of causal effects.

Keywords: lead exposure; child growth; stunting; environmental health; wealth gradient; Bangladesh.

1 Introduction

Lead damages children at concentrations once considered safe (Lanphear et al., 2005; Aizer et al., 2018; Grönqvist et al., 2020), and most of the children with elevated blood lead live in low- and middle-income countries (Ericson et al., 2021; Larsen and Sánchez-Triana, 2023). Until 2025 the evidence for Bangladesh came from small and local samples (Kaiser et al., 2001; Mitra et al., 2009; Forsyth et al., 2018; Forsyth et al., 2019{b}; Chowdhury et al., 2021). The 2025 Multiple Indicator Cluster Survey measured lead in venous blood from a national sample of children aged 12 to 59 months (Bangladesh Bureau of Statistics and UNICEF Bangladesh, 2026).

Three facts from that survey are already established and are the starting point here, not the contribution. The survey report shows that 38 percent of children are at or above 5 µg/dL and that levels are highest in Dhaka division and in urban areas. The report and a preprint show that children in richer households have

more lead than those in poorer ones, the reverse of the usual pattern (Bangladesh Bureau of Statistics and UNICEF Bangladesh, 2026; Hossain, 2026). And a preprint reports that children with more lead are shorter for their age in a national regression (Hassan et al., 2026), as two earlier local studies had found (Gleason et al., 2016; Raihan et al., 2018). Appendix Table A1 reproduces the basic distribution from the microdata.

This paper asks what lies behind those facts. It uses the survey microdata, including the measurements of arsenic, cadmium and mercury in the same blood samples, the arsenic tests on household water and the blood tests on pregnant women, and links the survey to four other sources: district employment by industry from the Quarterly Labour Force Survey, the Department of Environment's monthly river monitoring, modelled air pollution from the Copernicus reanalysis, and measurements of lead in river water around Dhaka.

The first result concerns wealth. The positive national gradient is entirely a matter of location. Children in the richest fifth of households have 31 percent more lead than those in the poorest fifth nationally, no more within districts, and 10 percent less within the same survey cluster. Within a neighbourhood the better-off are less exposed, as elsewhere in the world; they have more lead in the aggregate because they live where lead is highest.

The second concerns the nature of the excess around Dhaka. In Dhaka, Gazipur and Narayanganj the geometric mean is 7.9 µg/dL, against 4.0 elsewhere, and 84 percent of children are at or above 5 µg/dL. The excess is specific to lead. Blood arsenic and mercury are lower in the three districts, and blood arsenic follows the arsenic in each household's own water while lead does not, so the measurements behave as they should where the pathway is known. Pregnant women show the same geography as children.

The third is a set of tests of what might explain it. The sources the survey asks about account for about a tenth of the excess. The industrial composition of employment in a district does not account for it, and nor does modelled ambient air pollution: fine particles, nitrogen dioxide and sulphur dioxide do not track blood lead once greater Dhaka is set aside. One measure does. Across 33 districts with a monitored river, children's blood lead rises with an index of river pollution, including outside greater Dhaka. The index reflects the load of untreated organic waste and cannot be attributed to industry in particular.

The fourth concerns growth. The association between blood lead and height-for-age holds within neighbourhoods, where children share the local environment and most of the variation in lead that comes from location. A doubling of blood lead is associated with a height-for-age z-score lower by 0.10 and a probability of stunting higher by 2.4 percentage points. The coefficient is larger with neighbourhood effects than without them, it is graded across the range of blood lead, and it is not shared by arsenic, cadmium or mercury. There is no association with haemoglobin or with a caregiver-reported index of developmental milestones.

The paper relates to work in economics on the consequences of early lead exposure (Aizer and Currie, 2019; Billings and Schnepel, 2018; Ferrie et al., 2012; Crawfurd et al., 2025) and on the sources of exposure in Bangladesh, where lead chromate in turmeric, informal recycling of lead-acid batteries and cookware have been identified (Forsyth et al., 2019{a}; Forsyth et al., 2023; Weidenhamer et al., 2017; Sargsyan et al., 2024). Its results are associations in a cross-section. Blood lead is measured once and at the same time as height; undernourished children absorb more lead; and the district-level comparisons rest on a few dozen districts. I report how the estimates move as controls are added and do not interpret them as effects.

2 Data

2.1 The survey and the blood module

The Bangladesh Multiple Indicator Cluster Survey (MICS) 2025 was carried out by the Bangladesh Bureau of Statistics with UNICEF between late February and June 2025. The sample is 62,980 households, twenty in each of 3,149 census enumeration areas, which I refer to as clusters or neighbourhoods, and is representative of the 64 districts and the city corporations (Bangladesh Bureau of Statistics and UNICEF Bangladesh, 2026). In each household with an eligible child, venous blood was collected from one child aged 12 to 59 months and analysed for lead, arsenic, cadmium, mercury and haemoglobin; soil at the home was measured for lead and arsenic with a portable X-ray fluorescence analyser. The children's file contains 24,680 children under five, of whom 17,124 were aged 12 to 59 months and selected for blood collection. A valid laboratory result is recorded for 10,622 of them (62 percent; the survey report tabulates 10,661 children, including a small number whose results the released file marks as not valid), in 2,985 clusters and 67 districts and city corporations, an average of 3.6 children per cluster. All estimates use the survey's weight for the blood-lead sample.

Children without a valid result differ somewhat from those with one. Among the selected children, those tested are less often urban (25 against 31 percent), less often in the richest fifth of households (12 against 23 percent) and about four months older. The survey weight for the blood sample is designed to correct for non-response, but if untested urban and better-off children resemble tested ones, who have higher blood lead, the national prevalence figures here are, if anything, conservative. The comparisons within neighbourhoods on which the later sections rest do not depend on the weights.

2.2 Measures

Blood lead is measured in micrograms per decilitre (µg/dL). I report the shares at or above 3.5 µg/dL, the reference value used by the United States Centers for Disease Control and Prevention since 2021 (Ruckart et al., 2021), 5 µg/dL, the level at which the World Health Organization recommends that the source of exposure be identified (World Health Organization, 2021), and 10 µg/dL. Regressions use the natural logarithm of blood lead.

Height-for-age, weight-for-age and weight-for-height z-scores are those computed by the survey from measured height and weight against the WHO growth standards; I drop flagged values. A child is stunted if the height-for-age z-score is below −2. Haemoglobin is from the same blood sample, and a child is counted as anaemic below 11 g/dL. For children aged 24 to 59 months the caregiver answers twenty questions about developmental milestones (motor, language, early literacy and numeracy, and social and emotional behaviour); I use the share of milestones reached, standardised within each month of age.

Household wealth is the survey's asset-based wealth index, in fifths of the national household distribution and as a continuous score. The caregiver's questionnaire for the blood module asks about possible sources of lead: whether vehicle batteries are made, recycled or repaired near the home, whether anyone in regular contact with the child does such work, whether jewellery is made, electronic waste recycled or vehicles repaired nearby, whether the child uses surma (kohl) or wears an amulet, whether the child eats soil, clay or paint chips, and whether a smoker is in regular contact. The household questionnaire records whether the dwelling is painted and the condition of the paint, the cooking fuel and the floor material.

3 Place

Differences in blood lead across places are much larger than differences across groups of children (Appendix Table A1). In the districts of Dhaka, Gazipur and Narayanganj, including the two Dhaka city

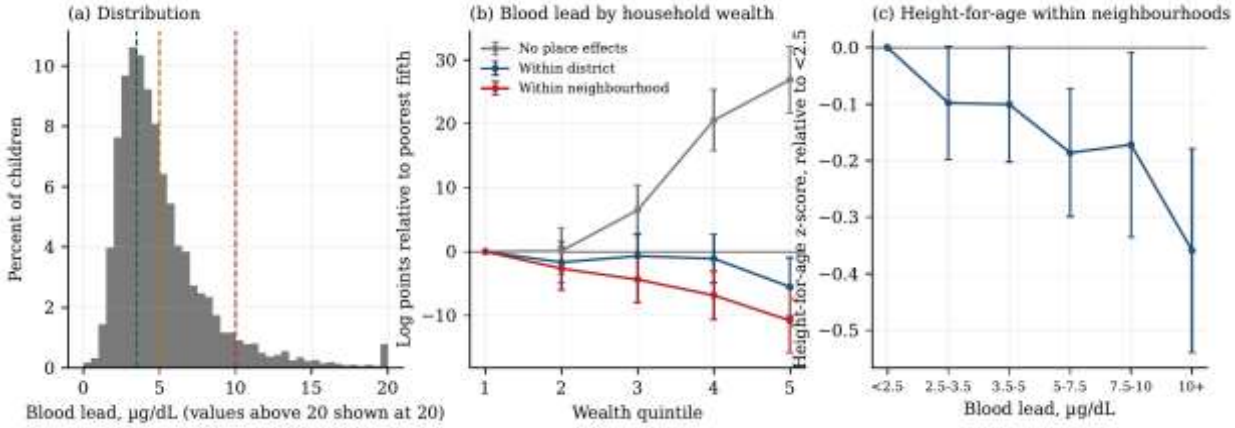
corporations, the geometric mean is 7.9 µg/dL, 84 percent of children are at or above 5 µg/dL and 29 percent at or above 10. In the three adjoining districts of Narsingdi, Munshiganj and Manikganj the geometric mean is 5.7. In the rest of the country it is 4.0, and 31 percent are at or above 5. Appendix Table A2 lists the ten districts with the highest and lowest levels and Appendix Figure A1 shows all of them. District geometric means range from 2.3 to 9.6 µg/dL; in 12 districts more than half of children are at or above 5 µg/dL, and in 6 fewer than a tenth are.

Conditional on wealth, age and sex, children in Dhaka, Gazipur and Narayanganj have blood lead 62 log points higher than children outside the six districts (standard error 9, clustered by district), and children in the three adjoining districts 35 log points higher. Living in an urban area adds 7 log points once these districts are accounted for. Most of the urban excess is therefore an excess in greater Dhaka, not a general feature of towns.

Districts account for 22 percent of the variance of log blood lead, and clusters for 37 percent, measured by the intraclass correlation, which removes the between-group variance that sampling alone would produce with three or four children per cluster. Where a child lives carries far more information about blood lead than any characteristic of the household examined below.

Pregnant women were tested in the same survey. Their levels are lower, with a median of 2.0 µg/dL among the 1,932 with valid results, but the geography is the same: blood lead is 82 log points higher in Dhaka, Gazipur and Narayanganj, and across districts the correlation between the mean log blood lead of women and of children is 0.86. The exposure is shared by adults and children in a place, which points to sources in the local environment and away from those specific to young children.

Figure 1: Blood lead: distribution, wealth gradient and height-for-age



Notes: Panel (a): weighted distribution; dashed lines at 3.5, 5 and 10 µg/dL. Panel (b): coefficients on wealth fifths from regressions of log blood lead with age and sex controls and, in turn, no place effects, district effects and cluster effects (Table 1). Panel (c): coefficients on blood-lead categories from a regression of the height-for-age z-score with age-in-months and cluster effects and controls for sex, wealth fifth and mother's schooling. Bars are 95 percent confidence intervals, standard errors clustered by survey cluster.

4 Wealth

In most settings poorer children carry more lead. In Bangladesh as a whole the opposite holds, as the survey report shows: 30 percent of children in the poorest fifth of households are at or above 5 µg/dL, and

52 percent in the richest fifth.

Table 1 and panel (b) of Figure 1 show that this is a fact about location. Without place effects, log blood lead in the richest fifth is 27 log points above that in the poorest (column 1). Comparing children within the same district, the difference is −6 log points (column 2). Comparing children within the same cluster, it is −11 log points, with a standard error of 3, and the gradient is monotonic across the fifths (column 3). A one standard deviation higher wealth score is associated with 10 log points more lead nationally and 4 log points less within clusters. The reversal arises because better-off households are concentrated where lead is highest: 33 percent of children in the richest fifth live in Dhaka, Gazipur or Narayanganj, against 0 percent of those in the poorest.

Mother's schooling behaves differently. Children whose mothers have completed secondary schooling have 8 log points less lead nationally and 6 less within clusters. Its association with lower exposure is visible with or without place effects.

Within a neighbourhood, then, more resources go with somewhat less lead, as elsewhere. But the within-neighbourhood gradient is small beside the differences between places: moving from the poorest to the richest fifth within a cluster lowers blood lead by about a tenth, while living in greater Dhaka nearly doubles it.

Table 1: Household wealth, mother's schooling and blood lead

	Log blood lead			At or above 5 µg/dL		
	(1)	(2)	(3)	(4)	(5)	(6)
Second wealth fifth	0.001	−0.017	−0.027	0.003	−0.009	−0.019
	(0.018)	(0.017)	(0.017)	(0.017)	(0.016)	(0.017)
Middle fifth	0.065***	−0.007	−0.044**	0.065***	0.008	−0.018
	(0.020)	(0.017)	(0.018)	(0.018)	(0.017)	(0.018)
Fourth fifth	0.205***	−0.011	−0.068***	0.170***	0.004	−0.035*
	(0.024)	(0.019)	(0.019)	(0.020)	(0.018)	(0.020)
Richest fifth	0.269***	−0.055**	−0.108***	0.217***	−0.030	−0.081***
	(0.027)	(0.023)	(0.026)	(0.023)	(0.021)	(0.027)
Separate regressions:						
Wealth score (s.d.)	0.101***	−0.018**	−0.038***			
	(0.008)	(0.007)	(0.008)			
Mother has secondary schooling	−0.083***	−0.082***	−0.056***			
	(0.014)	(0.012)	(0.013)			
Place effects	None	District	Neighbourhood	None	District	Neighbourhood
Children	10,622	10,622	10,241	10,622	10,622	10,241

Notes: Columns 1–3: log blood lead; columns 4–6: indicator for blood lead at or above 5 µg/dL. The omitted category is the poorest fifth. The rows for the wealth score and for mother's schooling are from separate regressions that replace the wealth fifths. All regressions control for age group and sex and use the blood-sample weight. Standard errors clustered by survey cluster. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5 Reported sources

Table 2 relates log blood lead to the possible sources recorded by the survey. A fifth of caregivers report that vehicle batteries are made, recycled or repaired near the home, 24 percent that the child uses surma, and 11 percent that the child eats soil, clay or paint chips.

Across the country (column 1), blood lead is higher where battery work is reported nearby (5 log points), where the child uses surma (6), wears an amulet (5) or eats non-food items (7), and where a smoker is in regular contact (5). The elasticity with respect to lead in the soil at the home is 0.17. Households that cook with solid fuel have much less lead (−26 log points), which reflects the fact that they are rural and far from Dhaka: within clusters the coefficient is −3.

Within clusters (column 3) little remains. Eating non-food items is associated with 7 log points more lead, wearing an amulet with 4 and contact with a smoker with 3; battery work, surma, paint and soil lead at the home have coefficients that are small and not distinguishable from zero. Adding all fifteen measures raises the within-cluster R^2 by 0.7 percentage points. The reported sources also do little to account for the geography: controlling for them lowers the excess in Dhaka, Gazipur and Narayanganj from 63 to 57 log points, or by 10 percent.

Two readings are possible. The questions may measure sources poorly: whether batteries are recycled "near the home" is a coarse and subjective report, and soil was sampled at one point. Or the main pathway in greater Dhaka may be one that households in the same neighbourhood share and that the questionnaire does not capture, such as lead in air and dust or in widely consumed foods and spices. The similarity of the geography for pregnant women and the size of the cluster-level correlation fit the second reading, but the survey cannot distinguish them.

Table 2: Reported sources and log blood lead

	Share (%)	(1)		(2)		(3)	
Vehicle batteries made, recycled or repaired near home	20	0.048**	(0.023)	0.004	(0.022)	0.009	(0.024)
Regular contact with a battery worker	4	0.023	(0.037)	−0.034	(0.032)	0.011	(0.035)
Jewellery made or recycled near home	42	−0.069***	(0.023)	−0.039**	(0.019)	−0.022	(0.025)
Electronic waste recycled near home	18	0.048*	(0.026)	0.023	(0.026)	−0.054	(0.034)
Vehicle repair near home	42	0.035	(0.022)	0.060***	(0.021)	0.032	(0.025)
Child uses surma	24	0.061***	(0.016)	0.030**	(0.014)	0.018	(0.016)
Regular contact with sindoor	15	−0.027	(0.022)	−0.007	(0.018)	0.004	(0.019)

Wears an amulet	13	0.050**	(0.021)	0.022	(0.020)	0.044**	(0.022)
Eats soil, clay or paint chips	11	0.069***	(0.024)	0.035	(0.023)	0.068***	(0.026)
Smoker in regular contact	52	0.045***	(0.014)	0.040***	(0.013)	0.026*	(0.013)
Painted walls, windows or doors	46	0.030	(0.019)	−0.022	(0.018)	−0.021	(0.018)
paint peeling or cracked	13	0.016	(0.023)	0.046**	(0.020)	0.011	(0.021)
Cooks with solid fuel	75	−0.265***	(0.022)	−0.060***	(0.020)	−0.030	(0.023)
Earth floor	46	−0.033	(0.021)	−0.022	(0.019)	−0.011	(0.020)
Log soil lead at home (mg/kg)	–	0.168***	(0.025)	0.114***	(0.024)	0.045	(0.029)
Place effects		None		District		Neighbourhood	
Children		9,723		9,723		9,723	

Notes: Each numbered pair of columns is one regression of log blood lead on all the measures shown, wealth fifths, age group and sex. “Share” is the weighted percentage of children for whom the item is reported. Standard errors clustered by survey cluster. *p < 0.10, **p < 0.05, ***p < 0.01.

5.1 Industry

A natural suspect for the excess around Dhaka is industry. The public file does not locate clusters, but districts can be characterised by what their residents do. From the 2022–2024 rounds of the Quarterly Labour Force Survey I compute, for each of the 64 districts, the share of employed people working in garments, textiles, basic and fabricated metals, other manufacturing, vehicle sale and repair, transport and construction, and the urban share of the population. Table 3 relates children’s log blood lead to these shares, each in standard deviations across districts.

Taken one at a time, most are associated with higher blood lead: a district one standard deviation higher in garment employment has 11 log points more, and the figure for metals is 10. Entered together, none of the industry shares is significant and only the urban share is. Outside Dhaka, Gazipur and Narayanganj none of them, including the urban share, predicts blood lead, and across the other 61 districts the correlation between mean log blood lead and the manufacturing share of employment is 0.17. Controlling for the industry mix does not reduce the coefficient on the three Dhaka districts. The industrial structure of a district, as measured by employment, does not account for the geography of lead; the three districts are the most industrial in the country, but there are too few of them to say which activity, if any, is responsible.

Table 3: District industry mix and children’s log blood lead

District share of employment in	One at a time		Together		Together, excluding	
(standard deviations)					Dhaka, Gazipur, Narayanganj	
Garments	0.106**	(0.049)	0.039	(0.025)	0.062	(0.069)
Textiles	0.071*	(0.036)	−0.000	(0.029)	−0.000	(0.043)
Basic and fabricated metals	0.097***	(0.026)	0.030	(0.029)	−0.004	(0.041)
Other manufacturing	0.071	(0.044)	0.007	(0.035)	0.010	(0.035)

Vehicle sale and repair	0.073*	(0.040)	0.010	(0.030)	0.030	(0.035)
Transport	0.072*	(0.043)	0.035	(0.028)	0.022	(0.026)
Construction	0.002	(0.033)	−0.018	(0.034)	−0.019	(0.031)
Urban share of population	0.143***	(0.019)	0.087**	(0.036)	−0.008	(0.048)
Children			10,622		10,049	

Notes: Regressions of log blood lead on district employment shares from the Quarterly Labour Force Survey 2022–2024 (city corporations assigned to their district), with controls for urban residence, wealth fifth, age group and sex. Each share is standardised across districts. Standard errors clustered by district. *p < 0.10, **p < 0.05, ***p < 0.01.

5.2 River pollution as a marker of the local waste load

Employment shares say what people in a district do, not what is discharged there. A more direct, if still indirect, marker is the state of the district's rivers. The Department of Environment monitors about thirty rivers each month and publishes the readings in its annual water quality reports. From the reports for 2019 to 2023 I take dissolved oxygen, biochemical oxygen demand and chemical oxygen demand in the dry season at each monitoring station, assign each station to a district, average within districts, and combine the three measures into a standardised index of pollution. Stations were assigned from their names, and the place names were then looked up in OpenStreetMap: of 72 places, 61 were found, and all of them lie in the assigned district.[1] The index covers 33 districts, 170 stations and 3,687 dry-season readings. Rivers are not proposed as a route by which lead reaches children; the index is a measure of how much untreated waste a district discharges.

Table 4 reports the result. Across the 33 districts the correlation between the river index and children's mean log blood lead is 0.73. In a regression at the level of the child, with controls for urban residence, wealth, age and sex, a district one standard deviation higher on the index has blood lead higher by 20 log points (standard error 4, clustered by district). Unlike the employment shares, the association survives the removal of greater Dhaka: it is 14 log points excluding Dhaka, Gazipur and Narayanganj, and 12 excluding the three adjoining districts as well. Reassigning the index at random among districts gives permutation p-values of 0.001 and 0.023 in those two samples. With one observation per district and heteroskedasticity-robust standard errors the coefficients are 22, 18 and 15 log points, each more than three standard errors from zero. No single district is responsible: dropping each in turn, the coefficient ranges from 16 to 23 log points in the full sample and from 13 to 17 without the three Dhaka districts. The index is unrelated to blood cadmium and is not positively related to arsenic or mercury.

What the index measures is less clear than that it predicts lead. Biochemical oxygen demand, which rises with sewage and other organic waste as well as with industrial effluent, carries the association (33 log points per log point). Chemical oxygen demand, which responds more to industrial chemicals, is reported for only 11 districts and is unrelated to blood lead among them; with both measures entered, the coefficient on chemical oxygen demand is negative. This does not favour a specifically industrial reading. On the other hand the association is not simply one with poor sanitation. The share of households in a district whose drinking water contains E. coli, measured by the survey, is uncorrelated with children's blood lead (−0.06) and with the river index, and controlling for it leaves the coefficient on the index at 19 log points. Controlling for the manufacturing and urban shares of the district reduces it to 13, and with all of these

[1] One of the 61 is returned under a variant spelling of the same district. The places not found are assigned from the station name alone. Stations whose location could not be established from the name are dropped.

controls together it is 11 (standard error 6). The index therefore appears to capture the density of activity that generates organic waste, part of which is urban and industrial concentration and part of which those measures miss.

Lead is present in the rivers themselves. In the 2017–2021 measurements of the REACH observatory on the rivers around Dhaka, the median concentration of lead in river water was 3.8 parts per billion, 17 percent of 280 samples exceeded 10 parts per billion, and the highest reading, on the Shitalakhya at Narayanganj, was 460.

These results rest on 33 districts and on one cross-section. They show that children's blood lead is higher where rivers carry a heavier load of untreated waste, inside and outside greater Dhaka, in a way that the industrial composition of employment does not capture. They do not show which activities are responsible, and the pattern across the components of the index gives no support to the view that industrial effluent in particular is the marker.

Table 4: River pollution in the district and children's blood metals

	Log blood metal		Lead ≥ 5 µg/dL		District	Permutation	Districts	Children
					correlation	p-value		
All districts with a monitored river	0.199***	(0.043)	0.146***	(0.030)	0.73	0.000	33	5,247
Excluding Dhaka, Gazipur, Narayanganj	0.143***	(0.041)	0.094***	(0.033)	0.56	0.001	30	4,674
Also excluding Narsingdi, Munshiganj, Manikganj	0.122***	(0.040)			0.43	0.023	27	4,353
Controlling for manufacturing and urban shares	0.127**	(0.050)					33	5,247
Controlling for E. coli in household water	0.186***	(0.052)					33	5,247
Controlling for all of these	0.108*	(0.062)					33	5,247
Controlling for greater-Dhaka indicators	0.093**	(0.042)					33	5,247
Components, all districts: dissolved oxygen (mg/L)	−0.108***	(0.022)						5,100

log biochemical oxygen demand	0.331***	(0.066)						5,247
log chemical oxygen demand	−0.023	(0.105)					11	1,714
Other metals, all districts: cadmium	0.058	(0.044)						
arsenic	−0.042*	(0.025)						
mercury	−0.106***	(0.037)						

Notes: The river index is the standardised average of dry-season dissolved oxygen (reversed), log biochemical oxygen demand and log chemical oxygen demand at the monitoring stations in the district, from Department of Environment monitoring for 2019–2023. Columns 1–4 report the coefficient on the index, or on the component named, in regressions for children with controls for urban residence, wealth fifth, age group and sex and standard errors clustered by district. The district correlation is between the index and the district's mean log blood lead, and the permutation p-value is from 5,000 random reassignments of the index among districts. *p < 0.10, **p < 0.05, ***p < 0.01.

5.3 Air pollution

Lead from smelting and combustion travels in air, and Dhaka's air is among the most polluted in the world, so ambient air pollution is another candidate marker. I take annual mean concentrations of fine particles, nitrogen dioxide, sulphur dioxide, carbon monoxide and dust for the twelve months before the survey from the Copernicus atmospheric reanalysis, at the main town of each of 62 districts.[2]

Table 5 shows that modelled air pollution does not follow the geography of lead. Fine particles are unrelated to children's blood lead across all districts and negatively related outside greater Dhaka, because the highest concentrations are in the north and west of the country, where air arrives from the Indo-Gangetic Plain and blood lead is lowest. Nitrogen dioxide and sulphur dioxide, which are more local in origin, are positively related to blood lead across all districts (10 and 8 log points per standard deviation), but only because both are highest in Dhaka: outside the three Dhaka districts the coefficients are −1 and −8. Entered alongside the river index, none of the pollutants has a positive coefficient distinguishable from zero, while the river index is little changed. Controlling for the three pollutants does not reduce the excess in Dhaka, Gazipur and Narayanganj.

At this resolution, then, lead exposure is not a by-product of general air pollution. That does not rule out airborne lead from particular sites, which a 40-kilometre model cannot see; it does mean that the regional haze that dominates Bangladesh's air quality statistics is not what distinguishes the places where children have the most lead.

[2]Retrieved through the Open-Meteo air quality service. The reanalysis is a model constrained by observations, with a resolution of about 40 kilometres, so adjoining districts share values and local sources are not resolved. Two districts could not be located by the geocoder and are omitted.

Table 5: Modelled air pollution in the district and children's log blood lead

Pollutant (log, standardised across districts)	All districts		Excluding Dhaka, Gazipur, Narayanganj		District correlation All	District correlation Excluding
Fine particles ($PM_{2.5}$)	−0.031	(0.037)	−0.098***	(0.022)	−0.28	−0.44
Nitrogen dioxide	0.100**	(0.048)	−0.012	(0.026)	0.15	−0.12
Sulphur dioxide	0.079	(0.057)	−0.075*	(0.042)	0.03	−0.28
Carbon monoxide	−0.001	(0.047)	−0.079***	(0.027)	−0.22	−0.40
Dust	−0.106***	(0.037)	−0.130***	(0.020)	−0.46	−0.57
With the river index, districts with a monitored river:						
Nitrogen dioxide	0.044	(0.047)	−0.026	(0.034)		
river index in the same regression	0.178***	(0.047)	0.154***	(0.042)		
Sulphur dioxide	0.039	(0.047)	−0.061	(0.060)		
river index in the same regression	0.184***	(0.041)	0.147***	(0.038)		
Fine particles	−0.028	(0.050)	−0.077**	(0.029)		
river index in the same regression	0.203***	(0.042)	0.120***	(0.040)		

Notes: Upper panel: each row is a pair of regressions of children's log blood lead on the district's annual mean concentration of the pollutant (log, standardised across districts), with controls for urban residence, wealth fifth, age group and sex; the correlations are between district mean log blood lead and the pollutant. Lower panel: the pollutant and the river index of Table 4 entered together. Standard errors clustered by district. *p < 0.10, **p < 0.05, ***p < 0.01.

5.4 A benchmark: the other metals

The other metals measured in the same blood samples show what a different pathway looks like (Table 6). Arsenic in Bangladesh reaches people mainly through groundwater. For the 1,092 tested children whose household water was also tested, the elasticity of blood arsenic with respect to arsenic in the household's source water is 0.14 (standard error 0.02) within districts, and children whose water exceeds 50 parts per billion have 101 percent more arsenic in their blood. Water arsenic does not predict blood lead. Blood arsenic is more strongly clustered than lead within survey clusters, as would be expected when neighbours share an aquifer, but varies much less between districts, and it is lower, not higher, in greater Dhaka, as is mercury. Lead is essentially uncorrelated with arsenic and mercury across children.

Two conclusions follow. The survey's blood measurements behave as they should where the pathway is known, which gives some confidence in the lead measurements. And the excess in greater Dhaka is specific to lead and, to a smaller degree, cadmium; it is not a general elevation of contaminants in the city's children or an artefact of how samples from the capital were handled.

Table 6: Four metals in children's blood

Metal in blood (log)	Intraclass correlation		Dhaka, Gazipur, Narayanganj		Wealth score, within cluster		Correlation with lead
	District	Cluster					
Lead	0.22	0.37	0.624***	(0.090)	−0.038***	(0.008)	1.00
Arsenic	0.10	0.57	−0.324***	(0.040)	−0.040***	(0.008)	−0.03
Cadmium	0.16	0.44	0.208***	(0.057)	−0.045***	(0.011)	0.21
Mercury	0.12	0.37	−0.400***	(0.087)	0.069***	(0.010)	−0.02

Notes: Children with valid results for all four metals. Intraclass correlations are from a one-way analysis of variance of the log concentration. The third pair of columns is the coefficient on residence in Dhaka, Gazipur or Narayanganj, with controls for the three adjoining districts, urban residence, wealth fifth, age group and sex (standard errors clustered by district); the fourth is the coefficient on the standardised wealth score with cluster effects (clustered by survey cluster). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

6 Blood lead and children's growth

6.1 Specification

The relationship between blood lead and a child's outcome y is estimated as

$$y_{ic} = \beta \ln Pb_{ic} + X_{ic}'\gamma + \alpha_{a(i)} + \mu_c + \varepsilon_{ic}, \qquad (1)$$

for child i in cluster c, where α_a is an effect for each month of age, X contains sex, wealth fifth and mother's schooling, and μ_c is a cluster effect. With cluster effects, β is identified from differences between children living in the same enumeration area, who share the local environment, local prices, health services and, by the previous sections, most of the variation in lead that comes from location. Standard errors are clustered by cluster.

This is not a causal design. Blood lead is measured once, at the same time as the outcome, and reflects recent exposure more than exposure over the child's life. Children within a neighbourhood who have more lead may differ in ways that also affect growth, such as diet, care or how much time they spend on the ground. And growth could itself affect blood lead, since undernourished children absorb more of the lead they ingest. The estimates are conditional associations, and the specifications below are intended to show how sensitive they are to observable confounders.

6.2 Results

A national association between blood lead and height-for-age in this survey has been reported (Hassan et al., 2026). Table 7 shows what happens to it, and to six other outcomes, as children are compared with others who are progressively more alike, ending with children in the same neighbourhood. For the height-for-age z-score, the coefficient is −0.096 with only age effects, −0.132 with household controls, −0.144 with district effects and −0.141 (standard error 0.038) with cluster effects. Adding blood arsenic, cadmium and mercury gives −0.153. The estimate becomes larger in absolute value, not smaller, as place is controlled for, because the places with the most lead are also the better-off places, where children are taller. A doubling of blood lead is associated with a height-for-age z-score lower by 0.10, and the difference between the 10th and 90th percentiles of blood lead corresponds to 0.19. The probability of stunting rises by 3.5 percentage points per log point, on a mean of 26 percent. Weight-for-age is lower by 0.095 per log point, in line with the difference in height; weight-for-height shows no association.

Table 7: Log blood lead and child outcomes

Outcome	(1)	(2)	(3)	(4)	(5)	Mean	Children
Height-for-age z-score	−0.096***	−0.132***	−0.144***	−0.141***	−0.153***	−1.31	10,157
	(0.026)	(0.025)	(0.029)	(0.038)	(0.039)		
Stunted	0.031***	0.040***	0.040***	0.035**	0.038**	0.26	10,157
	(0.010)	(0.010)	(0.011)	(0.015)	(0.015)		
Weight-for-age z-score	−0.039*	−0.077***	−0.129***	−0.095***	−0.106***	−1.38	10,204
	(0.023)	(0.023)	(0.026)	(0.034)	(0.035)		
Weight-for-height z-score	0.029	0.010	−0.057**	−0.016	−0.024	−0.95	10,147
	(0.023)	(0.023)	(0.026)	(0.032)	(0.033)		
Developmental milestones (z), 24–59 months	0.065**	0.041	0.028	0.053	0.046	0.02	8,051
	(0.026)	(0.026)	(0.029)	(0.038)	(0.039)		
Haemoglobin (g/dL)	0.032	0.045*	−0.002	0.028	0.042	10.99	10,216
	(0.027)	(0.027)	(0.030)	(0.038)	(0.039)		
Anaemic	−0.029***	−0.031***	−0.016	−0.030*	−0.035**	0.47	10,216
	(0.011)	(0.011)	(0.012)	(0.015)	(0.015)		
Age in months effects	Yes	Yes	Yes	Yes	Yes		
Sex, wealth, mother's schooling	–	Yes	Yes	Yes	Yes		
Place effects	–	–	District	Neighbourhood	Neighbourhood		
Blood arsenic, cadmium, mercury	–	–	–	–	Yes		

Notes: Each cell is the coefficient on log blood lead from a separate regression of the outcome in the row, estimated with equation (1) and the controls indicated. "Mean" is the weighted mean of the outcome. Standard errors clustered by survey cluster. *p < 0.10, **p < 0.05, ***p < 0.01.

Panel (c) of Figure 1 replaces the logarithm with categories of blood lead. Relative to children below 2.5 µg/dL, height-for-age is lower by about 0.10 at 3.5 to 5 µg/dL, 0.19 at 5 to 7.5 and 0.36 at 10 µg/dL or more. The association is present at levels below those at which action is usually recommended.

The other three metals offer a comparison. If the height result reflected an unobserved household characteristic that raises exposure to contaminants in general, blood arsenic, cadmium and mercury should show it too. Their coefficients in the height regression are 0.075, 0.044 and 0.046, none negative.

Haemoglobin is unrelated to blood lead in every specification, and the probability of anaemia is, if anything, slightly lower at higher lead. The index of developmental milestones is also unrelated: the coefficient with cluster effects is 0.053 (standard error 0.038). The index is reported by the caregiver, covers children from 24 months, and is a coarse measure; the confidence interval excludes a negative association larger than about 0.02 standard deviations per doubling of blood lead. The survey therefore provides no evidence on cognition, which is the outcome for which the effects of lead are best established.

6.3 Robustness and heterogeneity

Appendix Table A3 reports the height-for-age coefficient with cluster effects in subsamples and with further controls. It is −0.139 without weights, −0.150 excluding Dhaka, Gazipur and Narayanganj, and −0.137 when the continuous wealth score, floor material, cooking fuel and paint are added. Controlling for whether the child eats non-food items, which could be both a consequence of undernutrition and a source of lead, leaves it at −0.137. The association is absent in the second year of life (0.072, standard error 0.152) and present from 24 months, which is consistent with the cumulative nature of both exposure and linear growth failure, though the youngest group is small. It is larger for girls (−0.230) than boys (−0.093) and in urban than rural clusters, differences that are not individually significant.

Adding the observable controls within clusters moves the coefficient from −0.177 to −0.135 while raising the within-cluster R^2 from 0.005 to 0.040. By the coefficient-stability calculation of Oster (2019), with a maximum R^2 of 1.3 times the controlled one, selection on unobservables would have to be about 10 times as strong as selection on these observables to reduce the coefficient to zero. That calculation is only as informative as the observables are, and the within-cluster R^2 is low in every specification.

7 Discussion

What the microdata add to the published tabulations is, first, the degree of concentration. A child's cluster accounts for more than a third of the variance in log blood lead, the three districts of greater Dhaka have twice the level of the rest of the country, and adults there are affected in the same proportion. Exposure of this kind is a feature of places, and the sources that households can report on (cosmetics, amulets, paint, a battery workshop nearby) leave most of it unexplained. That is consistent with pathways shared across a neighbourhood, though the survey cannot say which. The association with river pollution across districts points the same way: lead is higher where more untreated waste is discharged, though the data do not say what kind of activity produces it. The released file gives districts only; with cluster coordinates the excess could be related to distance from industrial areas, roads and recycling sites.

The reversal of the wealth gradient has a practical implication. Programmes that target poor households on the assumption that they carry the most lead would, in Bangladesh, miss the areas where exposure is highest. Within any neighbourhood the better-off are somewhat less exposed, but the difference is about a tenth, against a doubling between greater Dhaka and elsewhere. Mother's schooling, by contrast, goes with lower exposure everywhere.

The association with height is of a size that matters if it is causal: the difference between the 10th and 90th percentiles of blood lead corresponds to about 0.19 of a standard deviation of height-for-age, in a population where 26 percent of these children are stunted. It agrees in sign with the two earlier Bangladeshi studies (Gleason et al., 2016; Raihan et al., 2018). Its specificity to lead among four metals, its gradient across the distribution and its stability as household controls are added are what one would expect of an effect of lead, but each is also compatible with an unmeasured factor that raises lead intake and impairs growth together, such as time spent on contaminated ground or a diet low in calcium and iron, both of

which increase absorption. The absence of an association with the developmental index should not be read as evidence that cognition is unaffected; the index is coarse and reported by caregivers.

8 Limitations

The data are a single cross-section. Blood lead is measured once, alongside the outcomes, and has a half-life in blood of weeks to months, so it is a noisy measure of a child's exposure over the years in which height is determined; measurement error of that kind biases the association towards zero, while confounding within neighbourhoods and reverse causation through nutrition could bias it away from zero. The growth results are associations.

A valid blood result is available for 62 percent of the children selected, and untested children are more urban and better-off. The survey's weights adjust for non-response on observables only.

Cluster locations are not in the public file, so the analysis of geography is by district. The anonymised coordinates that the survey programme releases on request would allow distances to industrial sites, roads and battery-recycling operations to be measured, which is the natural next step for the unexplained excess in greater Dhaka.

The questions on sources are reports by caregivers. The developmental index is reported by caregivers and available only from 24 months. With three to four tested children per cluster, cluster effects absorb much of the sample's information, and the within-cluster estimates are correspondingly less precise than their counterparts without place effects.

9 Conclusion

The lead in Bangladeshi children's blood is a matter of place. The apparent tendency of richer children to have more of it disappears, and reverses, once children are compared with their neighbours. The excess around Dhaka is specific to lead, is shared by pregnant women, and is not explained by the sources households report, by the industries that employ a district's workers or by general air pollution; it does rise with the pollution of a district's rivers, inside and outside greater Dhaka. And within neighbourhoods, children with more lead are shorter for their age, an association specific to lead among the four metals measured and present below the levels at which action is usually recommended.

References

1. Anna Aizer and Janet Currie. Lead and juvenile delinquency: New evidence from linked birth, school, and juvenile detention records. Review of Economics and Statistics, 101 (4): 575–587, 2019. doi: 10.1162/rest_a_00814.
2. Anna Aizer, Janet Currie, Peter Simon, and Patrick Vivier. Do low levels of blood lead reduce children's future test scores? American Economic Journal: Applied Economics, 10 (1): 307–341, 2018. doi: 10.1257/app.20160404.
3. Bangladesh Bureau of Statistics and UNICEF Bangladesh. Bangladesh multiple indicator cluster survey 2025: Survey findings report. Technical report, Bangladesh Bureau of Statistics, Dhaka, 2026. URL https://www.unicef.org/bangladesh/en/reports/bangladesh-multiple-indicator-cluster-survey-2025-0.
4. Stephen B. Billings and Kevin T. Schnepel. Life after lead: Effects of early interventions for children exposed to lead. American Economic Journal: Applied Economics, 10 (3): 315–344, 2018. doi: 10.1257/app.20160056.

5. Kamal Ibne Amin Chowdhury, Syeda Nurunnahar, Mohammad Lutful Kabir, Mohammad Tauhidul Islam, Musa Baker, M. Saiful Islam, Mahbubur Rahman, M. Aziz Hasan, Arif Sikder, Laura H. Kwong, Gordon K. Binkhorst, Emily Nash, et al. Child lead exposure near abandoned lead acid battery recycling sites in a residential community in Bangladesh: Risk factors and the impact of soil remediation on blood lead levels. Environmental Research, 194: 110689, 2021. doi: 10.1016/j.envres.2020.110689.
6. Lee Crawfurd, Rory Todd, Susannah Hares, Justin Sandefur, and Rachel Silverman Bonnifield. The effect of lead exposure on children's learning in the developing world: A meta-analysis. The World Bank Research Observer, 40 (2): 229–260, 2025. doi: 10.1093/wbro/lkae010.
7. Bret Ericson, Howard Hu, Emily Nash, Greg Ferraro, Julia Sinitsky, and Mark Patrick Taylor. Blood lead levels in low-income and middle-income countries: A systematic review. The Lancet Planetary Health, 5 (3): e145–e153, 2021. doi: 10.1016/S2542-5196(20)30278-3.
8. Joseph P. Ferrie, Karen Rolf, and Werner Troesken. Cognitive disparities, lead plumbing, and water chemistry: Prior exposure to water-borne lead and intelligence test scores among World War Two U.S. Army enlistees. Economics & Human Biology, 10 (1): 98–111, 2012. doi: 10.1016/j.ehb.2011.09.003.
9. Jenna E. Forsyth, M. Saiful Islam, Sarker Masud Parvez, Rubhana Raqib, M. Sajjadur Rahman, E. Marie Muehe, Scott Fendorf, and Stephen P. Luby. Prevalence of elevated blood lead levels among pregnant women and sources of lead exposure in rural Bangladesh: A case control study. Environmental Research, 166: 1–9, 2018. doi: 10.1016/j.envres.2018.04.019.
10. Jenna E. Forsyth, Syeda Nurunnahar, Sheikh Shariful Islam, Musa Baker, Dalia Yeasmin, M. Saiful Islam, Mahbubur Rahman, Scott Fendorf, Nicole M. Ardoin, Peter J. Winch, and Stephen P. Luby. Turmeric means "yellow" in Bengali: Lead chromate pigments added to turmeric threaten public health across Bangladesh. Environmental Research, 179: 108722, 2019a. doi: 10.1016/j.envres.2019.108722.
11. Jenna E. Forsyth, Karrie L. Weaver, Kate Maher, M. Saiful Islam, Rubhana Raqib, Mahbubur Rahman,
12. Scott Fendorf, and Stephen P. Luby. Sources of blood lead exposure in rural Bangladesh. Environmental Science & Technology, 53 (19): 11429–11436, 2019b. doi: 10.1021/acs.est.9b00744.
13. Jenna E. Forsyth, Musa Baker, Syeda Nurunnahar, Shariful Islam, M. Saiful Islam, Tauhidul Islam, Erica Plambeck, Peter J. Winch, Dinsha Mistree, Stephen P. Luby, and Mahbubur Rahman. Food safety policy enforcement and associated actions reduce lead chromate adulteration in turmeric across Bangladesh. Environmental Research, 232: 116328, 2023. doi: 10.1016/j.envres.2023.116328.
14. Kelsey M. Gleason, Linda Valeri, A. H. Shankar, Md Omar Sharif Ibne Hasan, Quazi Quamruzzaman, Ema G. Rodrigues, David C. Christiani, Robert O. Wright, David C. Bellinger, and Maitreyi Mazumdar. Stunting is associated with blood lead concentration among Bangladeshi children aged 2–3 years. Environmental Health, 15 (1): 103, 2016. doi: 10.1186/s12940-016-0190-4.
15. Hans Grönqvist, J. Peter Nilsson, and Per-Olof Robling. Understanding how low levels of early lead exposure affect children's life trajectories. Journal of Political Economy, 128 (9): 3376–3433, 2020. doi: 10.1086/708725.
16. Rafid Hassan, Ahadul Hassan Bhuiyan Konok, Tanjina Akter, Masum Ali, Ruhul Amin, and Sanjib Saha. Lead exposure and nutritional status among Bangladeshi children: Analysing based on Bangladesh Multiple Indicator Cluster Survey. 2026.
17. Syed Toushik Hossain. Social patterning of elevated blood lead among children aged 12–59 months in Bangladesh: A national cross-sectional analysis of MICS7 2025. 2026.

18. R. Kaiser, A. K. Henderson, W. R. Daley, M. Naughton, M. H. Khan, M. Rahman, S. Kieszak, and C. H. Rubin. Blood lead levels of primary school children in Dhaka, Bangladesh. Environmental Health Perspectives, 109 (6): 563–566, 2001. doi: 10.1289/ehp.01109563.
19. Bruce P. Lanphear, Richard Hornung, Jane Khoury, Kimberly Yolton, Peter Baghurst, David C. Bellinger, Richard L. Canfield, Kim N. Dietrich, Robert Bornschein, Tom Greene, Stephen J. Rothenberg, Herbert L. Needleman, Lourdes Schnaas, Gail Wasserman, et al. Low-level environmental lead exposure and children's intellectual function: An international pooled analysis. Environmental Health Perspectives, 113 (7): 894–899, 2005. doi: 10.1289/ehp.7688.
20. Bjorn Larsen and Ernesto Sánchez-Triana. Global health burden and cost of lead exposure in children and adults: A health impact and economic modelling analysis. The Lancet Planetary Health, 7 (10): e831–e840, 2023. doi: 10.1016/S2542-5196(23)00166-3.
21. Amal K. Mitra, Akhlaque Haque, Manirul Islam, and S. A. M. K. Bashar. Lead poisoning: An alarming public health problem in Bangladesh. International Journal of Environmental Research and Public Health, 6 (1): 84–95, 2009. doi: 10.3390/ijerph6010084.
22. Emily Oster. Unobservable selection and coefficient stability: Theory and evidence. Journal of Business & Economic Statistics, 37 (2): 187–204, 2019. doi: 10.1080/07350015.2016.1227711.
23. Mohammad Jyoti Raihan, Emily Briskin, Mustafa Mahfuz, M. Munirul Islam, Dinesh Mondal, Md Iqbal Hossain, A. M. Shamsir Ahmed, Rashidul Haque, and Tahmeed Ahmed. Examining the relationship between blood lead level and stunting, wasting and underweight — a cross-sectional study of children under 2 years-of-age in a Bangladeshi slum. PLOS ONE, 13 (5): e0197856, 2018. doi: 10.1371/journal.pone.0197856.
24. Perri Zeitz Ruckart, Robert L. Jones, Joseph G. Courtney, Tanya Telfair LeBlanc, Wilma Jackson, Mateusz P. Karwowski, Po-Yung Cheng, Paul Allwood, Erik R. Svendsen, and Patrick N. Breysse. Update of the blood lead reference value — United States, 2021. MMWR. Morbidity and Mortality Weekly Report, 70 (43): 1509–1512, 2021. doi: 10.15585/mmwr.mm7043a4.
25. Aelita Sargsyan, Emily Nash, Gordon Binkhorst, Jenna E. Forsyth, Barbara Jones, Gabriel Sanchez Ibarra, Sarah Berg, Andrew McCartor, Richard Fuller, and Stephan Bose-O'Reilly. Rapid market screening to assess lead concentrations in consumer products across 25 low- and middle-income countries. Scientific Reports, 14 (1): 9713, 2024. doi: 10.1038/s41598-024-59519-0.
26. Jeffrey D. Weidenhamer, Meghann P. Fitzpatrick, Alison M. Biro, Peter A. Kobunski, Michael R. Hudson, Rebecca W. Corbin, and Perry Gottesfeld. Metal exposures from aluminum cookware: An unrecognized public health risk in developing countries. Science of the Total Environment, 579: 805–813, 2017. doi: 10.1016/j.scitotenv.2016.11.023.
27. World Health Organization. Guideline for Clinical Management of Exposure to Lead. World Health Organization, Geneva, 2021. ISBN 978-92-4-003704-5. URL https://www.who.int/publications/i/item/9789240037045.