Opportunities for the G7 to Address the Global Crisis of Lead Poisoning in the 21st Century: A Rapid Stocktaking Report

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This paper was prepared by Rachel Silverman Bonnifield and Rory Todd of the Center for Global Development – a non-profit, non-partisan, and independent think tank based in Washington, D.C. and London, United Kingdom. It is intended to inform the deliberations of the G7 Workshop on *Lead as a Major Threat for Human Health and the Environment – An Integrated Approach Strengthening Cooperation Towards Solutions*, to be held November 9-10, 2022, in Berlin, Germany. We are grateful to CGD colleagues Susannah Hares and Lee Crawfurd for their contributions to the overall findings and recommendations; to Maimouna Konate for excellent research assistance; and Givewell for their financial support of this work. We are grateful to the Steering Committee of the G7 Workshop on Lead and GIZ for their partnership and helpful guidance. We also thank the many experts, practitioners, and policymakers who contributed their views and experience to this paper; please see the Preamble for full acknowledgements. This is a product of the Center for Global Development; it does not necessarily represent the views of the G7 or the Steering Committee, nor does it represent a policy commitment by the G7 of any other party. All viewpoints, errors, and omissions are entirely our own.

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Preface: About this Report

This paper was prepared by Rachel Silverman Bonnifield and Rory Todd of the Center for Global Development – a non-profit, non-partisan, and independent think tank based in Washington, D.C. and London, United Kingdom. It is intended to inform the deliberations of the G7 Workshop on *Lead as a Major Threat for Human Health and the Environment – An Integrated Approach Strengthening Cooperation Towards Solutions*, to be held November 9-10, 2022, in Berlin, Germany.

The report is based on a rapid 6-week stocktaking exercise, informed by stakeholder and key informant interviews; a review of the academic and grey literature; and some prior research and analysis on the topic. Given the rapid timeline, the methodological approach was necessarily non-comprehensive; its findings and recommendations should be understood within that context. Comment and feedback on this initial draft will be gratefully received. We expect to revise the draft in late November and publish as a CGD Working Paper in December 2022 or January 2023.

We are grateful to CGD colleagues Susannah Hares and Lee Crawfurd for their contributions to the overall findings and recommendations; to Maimouna Konate for excellent research assistance; and Givewell for their financial support of this work. We are grateful to the Steering Committee of the G7 Workshop on Lead and GIZ for their partnership and helpful guidance. We also thank the many experts, practitioners, and policymakers who contributed their views and experience to this paper, including: Richard Fuller (Pure Earth), Drew McCartor (Pure Earth), Perry Gottesfeld (Occupational Knowledge International), Lucia Coulter (Lead Exposure Elimination Project), Jenna Forsythe (Stanford University), Jack Caravanos (New York University), Steve Binks (International Lead Association), Phyllis Omido (Centre for Justice, Governance and Environmental Action), Paromita Hore (New York City Department of Health and Mental Hygiene), Angela Mathee (South Africa Medical Research Council), Angela Bandemehr (U.S. Environmental Protection Agency), Andreas Manhart (OKO-Institut e.V.), Rachael Kupka (Global Alliance on Health and Pollution), and staff at UNICEF, UNEP, WHO, the World Bank, and G7 partner governments.

The report proceeds in six parts. In Part 1, we assess the harms and burden of lead in the global context, including the prevalence and severity of lead poisoning across LMICs, as well as pathways and evidence of harm from human lead exposure. In Part 2, we consider current sources of lead exposure and potential solutions, including lead-acid battery recycling; mining and smelting; contaminated spices; lead paint; cookware; cosmetics; toys and consumer goods; and other sources. In Part 3 we take stock of existing international efforts by G7 member countries and select international organizations to address the global burden of lead poisoning. In Part 4 we profile four LMICs—Bangladesh, Georgia, Mexico, and Zambia—and consider the local burden of lead poisoning and efforts to address the problem. We conclude with a discussion (Part 5) and recommendations for the G7 (Part 6).

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Executive Summary

The Harms and Burdens of Lead in the Global Context

Lead poisoning may be among the most pressing public health challenges faced by low and middle-income countries (LMICs), and is certainly one of the least recognized and most neglected. Lead exposure is estimated by the Institute of Health and Metrics to be responsible for 900,000 deaths per year (more than malaria), primarily as a risk factor for heart disease,[i] and both chronic and acute exposure can have debilitating effects on almost every body system. On a population level, much of its harm comes through its effects in impeding child neurological development: even low-level, subclinical lead exposure during pregnancy and early childhood has been shown to cause substantial and lifelong deficits in cognitive ability, as well as issues with attention and behaviour control.

In high-income countries (HICs), the phaseout of leaded petrol since the 1970s has led to dramatic decreases in levels of lead exposure. While levels have also fallen in many LMICs, they remain extremely high. There is a severe scarcity of data, but what does exist suggests that up to a half of children in LMICs have levels of lead exposure at which the WHO recommends public health intervention, and even levels below the WHO benchmark have been shown to carry significant risks. The effects of lead poisoning on cognition and behaviour, combined with its high prevalence, suggest that lead exposure is likely to have a substantial impact on overall educational attainment, crime, violence, and potentially economic growth in LMICs.

Sources of Lead Exposure and Potential Solutions

Since the phaseout of leaded petrol, no single source of exposure has dominated globally, and the key sources responsible for lead poisoning vary widely between and within countries. While our understanding of the primary contributors has improved, there is still limited research on the relative importance of sources at the global and local levels. Nevertheless, the following sources have been identified as a cause or potential cause of significant levels of lead poisoning in many LMICs: lead-acid battery recycling, mining and ore smelting, contaminated spices, lead paint, cookware, cosmetics, and toys and consumer goods. Other potentially important sources include lead pipes, residual pollution from leaded petrol, light aviation fuel, e-waste recycling, traditional medicines and ceremonial powders, and folkloric traditions involving lead.

Important steps governments and agencies within LMICs can take against lead poisoning include developing capacity for the measurement and monitoring of levels of lead exposure; assessments of exposed populations to identify key sources; strengthening health systems to diagnose and treat lead poisoning; improving nutrition to limit lead absorption; and informing key stakeholders and the public generally about the threat of lead exposure, and how to recognize and prevent it. Other key actions are source-specific and may depend upon the sources identified to be the most central within a country. These are detailed in parts 2 and 4, but include roles for increased regulation, improved enforcement capacity, land remediation, and engagement with industry stakeholders and manufacturers of affected consumer products. Interventions against some sources are at an early stage of development, and there is a shortage of research on their effectiveness.

Current Initiatives and Actions by the G7 and International Organizations Against Lead Poisoning

While most action against lead poisoning within LMICs must be taken by LMIC governments themselves, G7 countries and international organisations also have a vital role to play in efforts to end lead poisoning globally. Overall, our stocktaking of current actions and initiatives detailed in part 3, while not exhaustive given the rapid timeframe in which it was conducted, shows that current actions are fragmented, *ad hoc*, and relatively small in scale compared to the importance of lead poisoning as a global health, education, environment, and development issue.

In 1996 and 1997, OECD and G8 declarations (respectively) included commitments to reduce lead poisoning; however, the content of these declarations is no longer in line with up-to-date recommendations based on current scientific consensus. The Convention on Long-Range Transboundary Air Pollution contains a protocol limiting emissions of heavy metals, including lead. The Rotterdam convention requires that importing countries give prior informed consent to imports of certain lead compounds used as petrol additives. The Basel convention also requires prior informed consent from countries importing waste lead-acid batteries, which it classifies as hazardous waste.

A few G7 countries fund and/or implement programs aimed at building capacity for chemical and waste management in various low and middle-income countries, although few of these are directed specifically at lead poisoning. Besides this, many countries provide financial and technical support to the international organizations discussed below in their efforts against lead poisoning.

Several departments within the United Nations Environment Program (UNEP) publish guidelines supporting policymakers to address lead poisoning. They have also initiated a few programs supporting countries directly in introducing regulation, and more recently the United Nations Environment Assembly has agreed on the foundation of a science policy panel on pollution prevention. The World Health Organization (WHO) also provides technical advice for clinicians as well as policymakers to address lead poisoning. Together, UNEP, WHO, and the United States Environmental Protection Agency lead the Global Alliance to Eliminate Lead Paint, which promotes lead paint regulation globally. The World Bank has also increasingly incorporated action against lead poisoning within its lending operations and its analytical work, and is seeking funding for a multi-donor trust fund to improve chemical and waste management. UNICEF has also taken actions against lead poisoning through survey work in Georgia, and a global awareness-raising campaign. There is a relatively high appetite among international institutions to sustain and expand these initiatives.

Recommendations for the G7 and Its Member Countries

The report identifies a number of highly impactful actions that can be taken by G7 partners now to reduce the burden of lead poisoning. The recommendations are briefly summarised here, and detailed in full in section 6; while informed by our engagement with various stakeholders, they remain solely our own.

Reaffirm and elevate a collective G7 political commitment to a shared vision for a world free of lead poisoning. A strong, clear, and high-level statement is needed, referencing up-to-date international standards and evidence, and endorsed by the political leadership of G7 members, to elevate lead poisoning as a priority issue with independent standing as a pressing global challenge.

Support strengthened international cooperation–among G7 members and the broader global community–to progressively reduce the burden of lead poisoning worldwide. Specific actions for consideration include:

- Exploring the potential for expanded and more structured standards, potentially under the auspices of a voluntary or binding international agreement;
- Regular coordination and strategic alignment between G7 members and potentially the broader international community to address sources of lead poisoning;
- International standard-setting, monitoring, and reporting of lead poisoning via relevant technical agencies;
- Developing a Global Environment Facility proposal to address sources of lead poisoning;
- Expanding investments in reducing lead poisoning via other multilateral mechanisms and international organizations; and
- Expanding involvement by G7 members in international cooperation to reduce lead poisoning.

Expand use of Overseas Development Assistance (ODA) to invest in global and LMIC country-level capacity to monitor, prevent, and treat lead poisoning. G7 members, via their respective aid agencies, should elevate lead poisoning as a priority issue, and consider initiating or expanding the following activities:

- Supporting LMICs to conduct initial diagnostic exercises on the prevalence of lead poisoning and key sources of contamination;
- Strengthening in-country capacity for the routine monitoring of lead exposure;
- Increasing awareness among field-based staff on the problem of lead poisoning;
- Supporting civil society organisations advocating for action against lead poisoning;
- Assisting LMICs to establish and enforce limits on lead in consumer products;
- Funding research by local partners on the burden of lead poisoning, exposure sources, and interventions against it;
- Considering investments in R&D designed to address lead poisoning in low-resource settings.

Strengthen G7 leadership at home to protect G7 citizens from lead while contributing to a world free of lead poisoning. G7 members should consider the following actions to support the broader vision for a lead-free world:

- Ensure domestic regulatory standards on products and the environment are aligned with the most stringent, evidence-based levels recommended by the WHO and other technical bodies;
- Ensure compliance with the Basel convention and other existing international agreements on the cross-border movement of hazardous waste containing lead;
- Consider expanded domestic surveillance systems, including source analysis, full data publication, and follow-up actions to remove lead-contaminated products from supply chains;
- Conduct preliminary review of exports and imports of lead, products containing lead, and lead waste to inform potential measures to address lead poisoning through trade levers;
- Consider responsible sourcing regulations for G7-based importers of lead; and
- Consider regulations on the export of products containing lead, for example requiring that exporters guarantee a functioning end-use system.

Part 1: The Harms and Burden of Lead in the Global Context

Lead poisoning is responsible for an estimated 900,000 deaths per year, more than from malaria (620,000) and nearly as many as from HIV/AIDS (954,000).[ii] It affects almost every system of the body, including the gastrointestinal tract, the kidneys, and the reproductive organs, but has particularly adverse effects on cardiovascular health. According to the World Health Organization (WHO), it is responsible for nearly half of all global deaths from known chemical exposures.[iii]

Despite this massive burden, the effects of lead on bodily health may be relatively minor compared to lead's effect on neurological development in young children; the cognitive effects of lead poisoning on brain development are permanent, and most severe when lead exposure occurs between the prenatal period to the age of around 6 or 7.[iv] Even low-level lead exposure at this age has been conclusively shown to cause lifelong detriments to cognitive ability; though evidence is less definitive, there is also a very strong and compelling literature which links lead exposure to anti-social/violent behaviour, attention deficits, and various mental disorders.

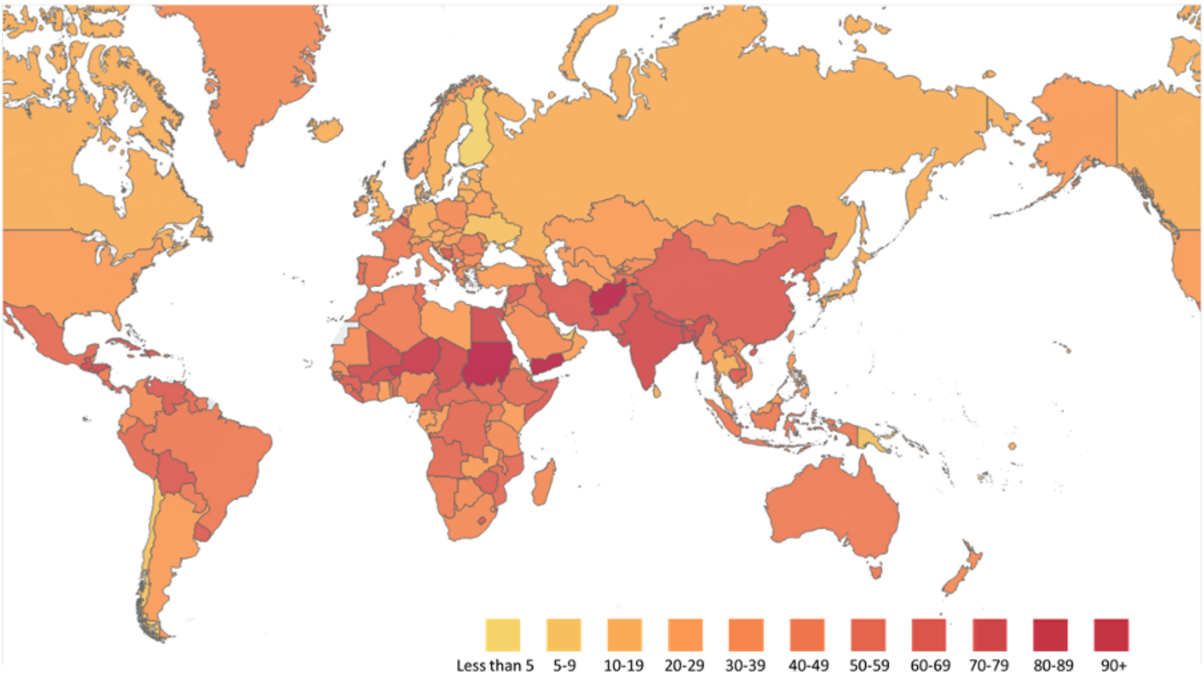
An estimated 800 million children[v]--nearly one in three globally, an estimated 99% of whom live in low and middle-income countries (LMICs) (Figure 1) --have blood lead levels (BLL) above 5 micrograms per decilitre (µg/dL), which the WHO uses as a threshold for recommending clinical intervention to mitigate neurotoxic effects.[vi] Effects on cognitive development have been demonstrated in BLLs significantly below this, however, and there is increasing evidence that there may be no threshold for neurotoxic effects at all--meaning that any exposure to lead in early childhood can cause permanent damage.[vii]

Though subclinical lead exposure is unlikely to have catastrophic effects for any individual child, the total population-wide impact is very large. A widely cited meta-analysis from 2005 estimated that having a BLL of 10 µg/dL - a high but far from uncommon level in LMICs results in an average deficit of 3.9 IQ points compared to a BLL of 2.4 µg/dL, which would itself be considered a high level within high-income countries.[viii] There is also evidence that the same increase in exposure at a lower baseline of blood lead has stronger effects than at higher levels; effectively, much of the damage may be done at relatively low exposures, which are almost ubiquitous across many LMICs.[ix] Compounded by its probable effects on violent behaviour and crime, lead poisoning may well be among the most pressing public health challenges faced by LMICs--and certainly one of the least recognized and most neglected.

Anecdotal and social awareness of acute lead toxicity dates to Ancient Rome, but the modern understanding of lead poisoning at the *subclinical* level has evolved substantially over the past few decades. The expanded evidence base linking low-level lead exposure to cognitive deficits, violence, and attention deficits—described in further detail below—has led to significant national and international efforts to reduce human lead exposure, most notably through the global phase-out of leaded petrol. Such efforts have led to dramatic reductions in lead exposure within the G7 and other high-income countries.[x] Yet lead poisoning remains a neglected and poorly understood issue across most LMICs, which continue to see high levels of population-wide lead exposure.

In this chapter, we consider the current burden of lead within LMICs, including the documented harms of lead poisoning and our (limited) understanding of current prevalence levels.

Figure 1: Population at risk of lead poisoning (% of population). (IHME, 2019)[xi]



The Prevalence and Severity of Lead Poisoning in LMICs

While evidence on levels of lead exposure in LMICs is extremely limited, overall it suggests that BLLs in LMICs have also seen significant declines as a result of banning leaded gasoline.[xii] However, declines have not been nearly so steep as in high-income countries, and evidence—also very limited—suggests levels may be plateauing in many of these countries,[xiii] which is intuitive given the likely diminishing returns from eliminating leaded gasoline as residual contamination decreases. What is beyond doubt is that existing levels of lead exposure in most LMICs are highly damaging, and that widespread lead exposure will not end in these countries without action against other sources.

Given its scale as an issue in LMICs, there is an extreme scarcity of data on current levels of lead exposure. To our knowledge, only two LMICs—Mexico and Georgia—have recent surveys of BLLs in children which can be described as representative and of a reasonable size. A 2021 systematic review found no recent data on BLLs for almost two thirds of LMICs.[xiv]

There have been two main attempts to estimate BLLs using what data exists. The Institute for Health Metrics and Evaluation (IHME) produces estimates for country level lead exposure, which it calculates through weighting and extrapolation from a limited group of studies deemed to be sufficiently representative, or where this is not available (likely the majority of LMICs) imputation using country-level characteristics.[xv] This is the source of the previously referenced statistic that 815 million children have BLLs above 5 µg/dL, including 96 million with levels above 10 µg/dL. 99% of these children are in LMICs, and 61% are in Sub-Saharan Africa.

Another study, published by Ericson et al in 2021, calculated new estimates for 34 LMICs using a wider range of sources, with no reliance on imputation.[xvi] They generally find blood levels to be higher than the IHME estimates, and for some countries dramatically so; overall, they estimate half of children in the 34 countries to have BLLs above 5 µg/dL.[xvii] This may indicate that the limited data used by IHME leads to underestimates of the problem, but also demonstrates that without better data, estimates of BLLs will vary drastically.

Pathways and Evidence of Harm from Human Lead Exposure

In this section, we briefly review causal pathways and evidence for the harms of lead poisoning for health and human welfare.

Lead Toxicity

Lead exposure can occur through inhalation or skin contact, but most prevalently comes through ingestion, especially of dust.[xviii] Children are more vulnerable, as their gastrointestinal tract absorbs around five times as much ingested lead as adults; they also consume and breathe more relative to their body weight, and through playing outdoors and hand-to-mouth behaviour may ingest significant quantities of soil and dust, especially if they engage in pica (eating non-food).[xix]

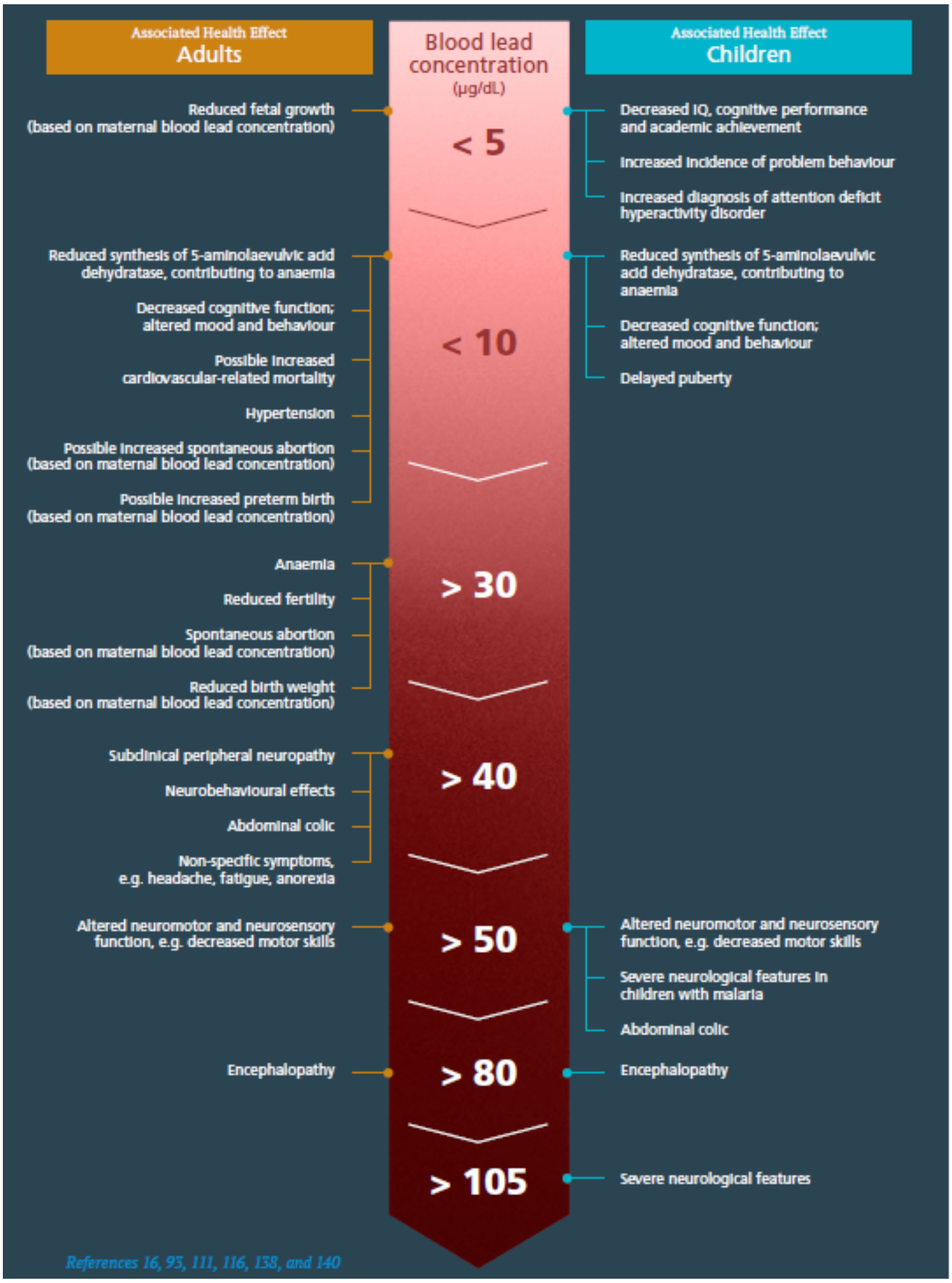
After lead is absorbed, it circulates in the bloodstream, which distributes it to soft tissues and bone.[xx] It accumulates in bone and can be stored for decades, although it is released as lead is excreted from the blood, as well as by various metabolic processes including those common during pregnancy and lactation, endangering fetuses.[xxi] Consequently, BLLs are used to measure recent and current exposure, while bone lead levels are used to measure lifetime exposure. The toxicity of lead is complex and varies depending upon the dose and organ, but an important route is its mimicry of biologically essential metals, especially calcium.[xxii] Deficiency in these metals therefore increases absorption of lead and aggravates its toxicity, and the WHO recommends iron and calcium supplementation as a preventative measure against lead poisoning.[xxiii]

Health Effects

The effects of lead on health vary with the duration and severity of exposure, as well as individual-specific factors (Figure 2).[xxiv] Acute lead poisoning can have immediate effects on the gastrointestinal tract and liver, and in the days and weeks after exposure cause kidney disease and neurological impairment.[xxv] In severe cases, this can lead to encephalopathy (brain dysfunction) and sometimes death.[xxvi] Effects from chronic exposure include, but are not limited to: gastrointestinal effects such as abdominal pain and nausea; often permanent neurological effects including behaviour change and sensory issues; kidney disease; anaemia; and cardiovascular effects, including hypertension, strokes, cardiovascular disease, and ischaemic heart disease—the leading cause of death globally.[xxvii][xxviii] A study based on the Third National Health and Nutrition Examination Mortality Follow-up Survey found that a decrease in blood lead from 6.7—the average level in some LMICs—to 1 µg/dL—the average in many HICs—would reduce mortality from ischaemic heart disease by 37.4%.[xxix] Exposure to even low levels of lead during pregnancy can stunt fetal growth, and has also been linked to preterm birth and preeclampsia.[xxx]

Besides calcium and iron supplementation, the WHO recommends gastrointestinal decontamination in some circumstances to remove lead objects and compounds from the gastrointestinal tract.[xxxi] It also recommends the use of chelating agents - pharmaceuticals that bind to heavy metals- for acute cases. Chelating agents carry their own risks, and are therefore unlikely to be appropriate for the low level lead exposure which affects a large proportion of children in LMICs.[xxxii]

Figure 2: Effects of lead poisoning. (WHO, 2021)[xxxiii]



Cognitive Effects

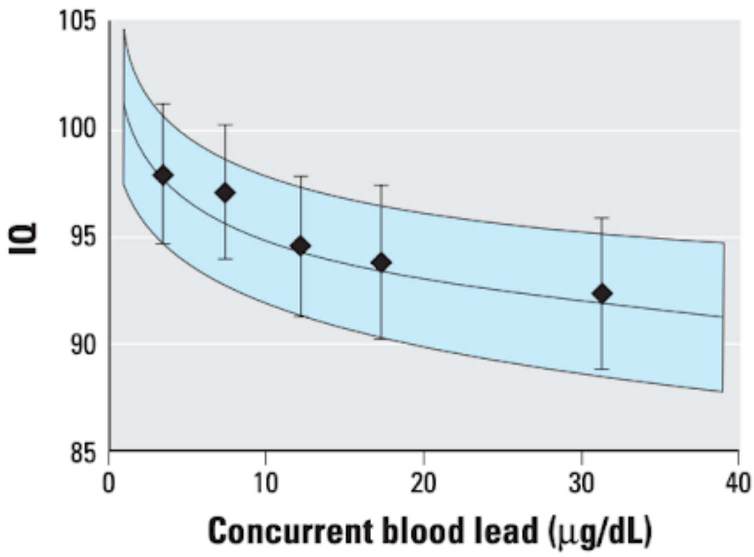
Lead passes the blood-brain barrier by mimicking calcium, and many of its neurotoxic effects are linked to displacement of calcium and disruption of its roles in the brain.[xxxiv]

A wealth of diverse studies have demonstrated that even low-level childhood lead exposure has significant adverse effects on cognitive development, and causes deficits in cognitive ability which persist into adulthood.[xxxv] The meta-analysis mentioned above pooled data from seven longitudinal studies, totalling 1,333 children. Two studies have independently reanalysed the data used by Lanphear et al, and found similar results.[xxxvi] Since that meta-analysis was published in 2005, many more studies have shown similar impacts, including a few which utilize administrative data, and therefore have sample sizes in the tens of thousands.[xxxvii] As discussed above, studies consistently show that the same marginal difference in blood lead has a greater effect on cognitive development at a lower baseline compared to at a higher baseline, meaning that even very low levels of exposure can have serious effects (Figure 3). While previously it had been thought that children were most vulnerable to the effects of lead on cognitive development before the age of 5, recent studies suggest that exposure at 6 or even older may be similarly detrimental.[xxxviii]

Similarly low-levels of lead exposure have been linked to a higher propensity for Attention Deficit Hyperactivity Disorder, or ADHD.[xxxix] In a national study in the United States, Tanya Froehlich and others found that children with a blood lead concentration in excess of 1.7 micrograms per deciliter were over two-times more likely to have ADHD.[xl]

More recently, a plethora of studies have demonstrated that the cognitive and attention deficits caused by lead exposure also impact academic achievement.[xli] A few studies in the US have found differences in lead exposures to explain a portion of the gap in academic achievement between White and Black students in the USA.[xlii] Some studies have compared the effects of lead exposure on both IQ and test scores and show effects are broadly similar in magnitude, although there is some evidence of reading ability being affected more strongly than mathematical ability.[xliii]

Figure 3: Dose-response function estimated in Lanphear et al, 2005. [xliv]



Violence and Crime

Lead exposure has also been consistently linked to anti-social, criminal or violent behaviour. A 2010 meta-analysis of 16 studies found a moderately strong relationship between lead exposure and conduct problems among children and adolescents; the magnitude of this association was very similar to that between lead exposure and IQ.[xlv] A number of studies have gone further and shown a relationship between lead exposure and violent/criminal behaviour, with some authors even attributing some of the macro-level rise in violent crime in the late twentieth century to increased lead exposure from leaded gasoline.[xlvi] One study from the US used the proximity of schools to roads to measure the effect of increased lead exposure on school suspension and juvenile detention, finding that a 1 µg/dL increase in blood lead increased the chance of detention by 6%.[xlvii] A systematic review is currently underway to summarise the evidence on this issue.[xlviii]

Economic Impact

Through its effects on cognitive development and behaviour, lead exposure can limit future earnings of individuals. A study from 2002 estimated the effect of phasing out leaded gasoline on children's IQ in the USA - which reduced BLLs by around 12 µg/dL- to improve average lifetime earnings by between 4 and 11%.[xlix] A large study in Sweden showed that through its effect on the likelihood of graduating from high school alone, having a BLL of 5 compared to 10 µg/dL increased lifetime earnings by around 4%.[l] Both of these studies only account for the effect on cognitive or academic ability, and do not factor in non-cognitive effects, which in the Sweden study were actually more significantly affected by lead exposure. [li]

Some authors have gone further and estimated the effect of lead exposure in decreasing human capital on national or global productivity. A 2013 modelling paper calculated the economic costs accrued from IQ deficits as a result of lead exposure to be $977 billion, or 1.2% of global GDP - including 4% of Africa's GDP.[lii] A recent update by the Lead Exposure Elimination Project (LEEP) revised this down to 0.68% of global GDP. [liii] These estimates are necessarily imprecise, but they do suggest that the effects of lead exposure on human capital may have a non-negligible impact on economic growth.

Part 2: Current Sources of Lead Exposure and Potential Solutions

Since the phaseout of leaded fuel, no single source of lead exposure has dominated globally. While our understanding of the primary contributors has improved significantly, the data is still insufficient to draw conclusions about their relative importance at the global level—or even, in most cases, from country to country. Indeed, the recent 'discovery' of aluminium pots as a contributor –detailed below— implies we may still be missing other potential sources. Fully understanding the sources of lead poisoning would require far more national and sub-national data than is currently collected.

The presence of so many different sources, each with its own market dynamic and at-risk populations, makes preventing lead poisoning an increasingly complex challenge. The interventions required to prevent exposure are primarily source-specific, and implementing them involves radically different stakeholders across multiple sectors. These are detailed in this section. However, there are actions which governments and agencies can take that would help to support action against lead poisoning in general.

To support targeting of action and intervention:

- **Conduct initial diagnostic surveys to measure the national prevalence of lead poisoning.** Policymakers are unlikely to devote attention and financing to reducing lead exposure without the scale of the problem being demonstrated. Existing national health surveillance surveys such as Demographic and Health Surveys (DHS) and Multi Indicator Cluster Surveys (MICS) present a potential opportunity for such testing to be implemented quickly.[liv]

- **Develop capacity for routine monitoring of blood lead levels at national and subnational levels**. Governments need to be able to pinpoint high-risk areas, and to track trends in lead poisoning.

- **Carry out source apportionment assessments for exposed populations**. Far more data is required to understand the relative importance of sources in different contexts and areas. Source apportionment must consider not just the presence of lead in the physical environment, but the bioavailability of lead objects as potential sources of human exposure. (Many objects contain lead, but not all will become bioavailable through typical use.)

- **Strengthen health systems to diagnose and treat lead poisoning**. This will help to identify hotspots or outbreaks of lead poisoning, as well as facilitate the use of chelation therapy for acute cases.

To directly reduce the burden of lead poisoning:

- **Improve nutrition**, in particular children's intake of calcium, vitamin C, and iron, which help to limit lead absorption.

- **Educate the population** about the risks of lead exposure, how to prevent it, and how to recognize its symptoms. In most cases, neither exposed children nor their parents are aware they were at risk of lead poisoning, or are even familiar with it. Workers in at-risk professions are also often unaware of their risk of lead exposure. Informing people can help to prevent exposure directly as they will take steps to reduce their own risk, as well as empower communities to take action against sources of contamination (see ULAB recycling section). Especially important audiences are children and pregnant mothers, so informing teachers and healthcare workers may be an effective intermediate step. The public at large should be aware of the problem, so public education campaigns using existing media resources can also play an important role.

A recurring theme through many sources is the role of occupational exposure. This is a particular issue in relation to ULAB recycling, e-waste recycling, and mining, but product-based sources also risk occupational exposure to those manufacturing them. Other workers at risk are those in construction, abatement, demolition, those that work with glass or metal, painters of industrial equipment and steel structures, and those who repair or renovate buildings.[lv] Importantly, this exposure poses risks not just to workers themselves, but also to their families and others with whom they have physical contact.

Lead-Acid Battery Recycling

While lead has a number of industrial applications, at least 80% now goes into the production of lead-acid batteries.[lvi] Lead-acid batteries are used in motor vehicles (electric and traditional), back-up power supplies, and green energy storage; demand for all of these is growing rapidly - especially in LMICs- and the market price of lead has in turn roughly doubled in the last 20 years.[lvii] Under normal conditions, a car battery lasts about three to five years,[lviii] but batteries can degrade more quickly due to poor manufacturing or the hot and humid climates common to many LMICs.[lix] Almost all of the lead within old batteries can be harvested and sold for later use–making used lead-acid battery (ULAB) recycling a lucrative economic activity.

ULAB recycling involves breaking down batteries, draining the electrolyte solution, and smelting the lead components for reuse; all of these processes require significant safety precautions to prevent environmental contamination or occupational exposure. These precautions are generally in place within G7 member states, where ULAB recycling is highly regulated.[lx] But in many LMICs, such environmental and occupational standards are often either absent or unenforced. Manual destruction of batteries without protective equipment, uncontrolled smelting, and dumping of waste into waterways and soils are common. Studies show high blood lead levels in children living near lead battery manufacturing and recycling facilities and in workers, and high levels of airborne lead in battery facilities and acute exposure to workers and their families.[lxi] Environmental contamination is exacerbated by the fact that recycling plants–unlike most ore smelters in mining areas–are often located in proximity to major urban centers, where ULABs are easily accessible.

In some contexts, ULAB recycling is conducted by informal operators, often in backyard smelters. Adequate safety measures in this context are impossible, and the tendency for operations to move frequently in order to avoid sanction also leaves behind many more contaminated areas. However, licensed battery recycling plants may be no more safe, and their higher capacity brings the risk of more scaled environmental contamination.

There are no reliable statistics to quantify the extent of ULAB recycling as a contributor to the global burden of lead poisoning. Anecdotally, Pure Earth and GAHP report finding informal ULAB sites in all major LMICs where they have searched for them, with a particularly high concentration in Sub-Saharan Africa. Pure Earth's Toxic Site Identification Program has thus far identified 529 informal ULAB recycling sites in LMICs, putting 1.2 million people at risk;[lxii] however, further research shows this is a very incomplete sample.[lxiii] One modeling paper estimates that there are between 10,000 and 30,000 such sites across 90 LMICs, exposing between 6-17 million people with very high average[1] blood-lead levels of 21 µg/dl in adults and 31 µg/dl in children under 5.[lxiv] This would suggest that ULAB recycling is a major contributor to severe/acute lead poisoning in the surrounding communities, but one of many sources that contribute to the global *prevalence* of lead poisoning—which is estimated to affect well over a billion people.

To ensure batteries remain within the formal sector, many countries have imposed extended producer responsibility on battery manufacturers through take-back schemes. India, for example, has mandated that battery manufacturers collect a minimum of 90% of the batteries they sell; in practice, however, this does not occur.[lxv] Studies in both India[lxvi] and Kenya[lxvii] show that consumers offload batteries to the informal market because of a lack of awareness about regulation and laws, inadequate enforcement, and the lower price and additional inconvenience associated with contracting official recyclers. Penalising manufacturers who fail to collect batteries presents one potential solution. Another is providing a financial incentive to consumers to return batteries to retailers, for example by mandating a deposit system where customers receive a discount for a new battery when exchanging an old one.

Ensuring that batteries go to certified recyclers is not a guarantee of safe recycling, however, given the widespread contamination caused by many formal recycling plants. Stronger regulations on ULAB recycling may be needed; several suggested standards for operating procedures in ULAB recycling plants have been published to support governments with drafting legislation for this purpose.[lxviii][lxix] Emission controls are particularly important to prevent environmental contamination. Legal drafting assistance, as is provided through the UNEP/WHO-coordinated Global Alliance to Eliminate Lead Paint, may be helpful in fostering action to reduce lead exposure from battery recycling as well. Enforcement agencies need both resources to conduct regular audit of recycling plants and authority to financially sanction non-compliant facilities. Community advocacy and legal action can play a role in this process. In Mombasa, Kenya, for example, a mother affected by lead poisoning from a nearby smelter campaigned against it; persuaded the government health centre to carry out blood tests; and used this data to force the closure of the smelter and the cleanup of the site, as well as secure $12 million in damages for the community (currently under appeal). Importantly, community advocacy is by its nature localized and grassroots; it does not necessarily offer a systematic assessment of relative contamination levels across locations, but instead reflects the concerns of a specific individual community. China also requires plants to be of a minimum capacity,[lxx] a useful step as introducing the required safety standards is only economical when volumes are sufficiently high.[lxxi]

Exports of used lead-acid batteries are subject to various international agreements including the 1992 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, generally requiring prior consent from countries importing hazardous waste. Nonetheless, there continue to be multidirectional flows of used batteries and refined lead between high-income countries – including G7 member states – and LMICs which lack adequate systems for environmentally sound recycling. For example, the US exports large numbers of ULABs to Mexico and elsewhere, where according to the Commission for Environmental Cooperation, responsible recycling cannot be guaranteed.[lxxii] A series of studies in Africa have also found that lead recycled from substandard facilities is frequently exported to countries in Europe[lxxiii] with no formal certification of safe recycling practice. There is a lack of understanding about exact volumes and the exchange is not clearly reflected in COMTRADE data, as these flows can be subject to export misclassification by some traders to

[1] All BLL averages refer to the geometric mean, unless stated otherwise.

circumvent trade restrictions.[lxxiv] This suggests a potential opportunity to improve ULAB recycling safety via import regulation and enforcement in G7 members, though the magnitude of this opportunity remains unclear.

Battery recycling can only be done safely through regulated and formalized recycling within at-scale, dedicated facilities. While long term-structural reforms are being put in place to enable such safe and sustained practices, there are some potential stopgap measures to reduce (but not eliminate) the harm of substandard recycling in the immediate term. Such strategies are not rigorously evaluated; they may include relocation of recycling operations to industrial areas/non-urban environments; provision of personal protective equipment for informal workers; or worker education to reduce the risk of personal and environmental exposure stemming from ULAB operations.

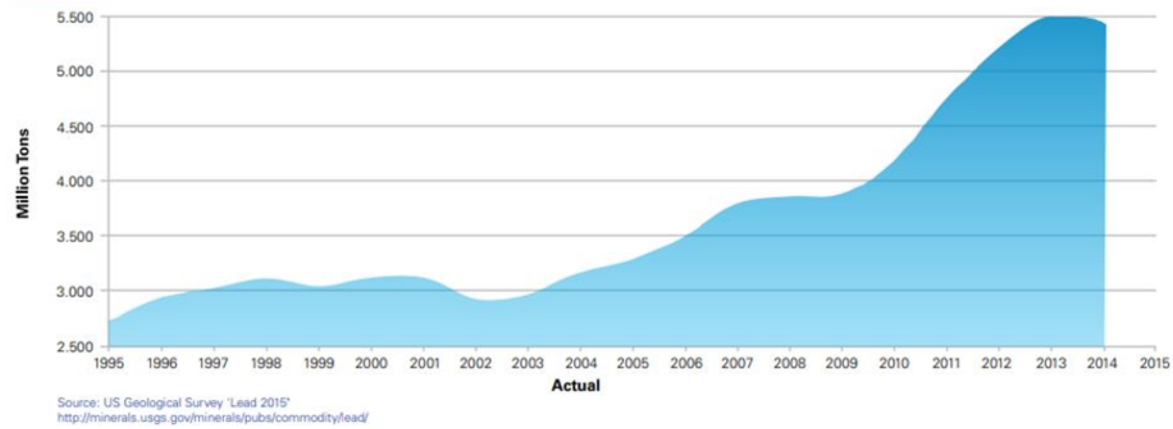
Mining and Smelting

The increase in the value of lead has also catalyzed the growth of lead mining, with the US geological survey estimating primary production of lead to have doubled between 1994 and 2019 (figure 4).[lxxv] Where lead mining - typically accompanied by zinc extraction- occurs without adequate safety precautions, it can cause widespread occupational exposure and environmental contamination, particularly through uncontrolled smelting to extract lead from ores, and the unsound handling of waste. Residual contamination often endures even after the polluting activity has ended, putting additional generations at risk. Probably the largest example globally is the lead mine in Kabwe, detailed in the Zambia country brief, which has led to universal lead poisoning among 90,000 local children, and continues to expose children even after its closure (although artisanal mining continues[lxxvi]) and a $53 million World Bank remediation operation.

A second, and possibly larger risk of lead exposure globally, is posed by mining of other metals, including gold, nickel, and platinum. Exposure is especially common in artisanal or small-scale mining, which employed at least 40 million people in 2017 - compared to just 7 million in industrial mines- including significant numbers of child labourers.[lxxvii] Artisanal gold mining in Zamfara state in Nigeria, for example, led to the deaths of more than 400 children from acute lead poisoning in the space of six months in 2010, as a result of workers grinding ores within villages.[lxxviii] Lead poisoning from mining is frequently accompanied by contamination by other heavy metals and toxicants. In Southeastern Brazil, historic lead mining has led to significant arsenic exposure in neighbouring communities.[lxxix] Mercury poisoning is a particular threat from artisanal gold mining.[lxxx]

Efforts to reduce exposure include providing alternative livelihoods along the supply chain such as gemstone cutting and polishing, formalising the sector to discourage artisanal mining through streamlining and supporting licensing processes, and introducing certification schemes to encourage responsible sourcing.[lxxxi] Programs have also been implemented to lessen the harm from artisanal mining. A pilot project by Doctors Without Borders and Occupational Knowledge International in Northern Nigeria has had some success in reducing lead exposures by teaching safer mining practices.[lxxxii]

Figure 4: Primary lead production over time. (Toxic Truth, 2020) [lxxxiii]



Toxic Site Remediation

ULAB recycling, mining, e-waste recycling (detailed in the 'other sources section) and other sources can leave extreme levels of contamination even after polluting activities have been curtailed. Toxic sites can continue to cause exposure for years or decades after. Although the most important step is to stop present polluting activities, in the long-term residual contamination from sites must also be addressed to end lead poisoning.

To prevent exposure from toxic sites, we must first know where they are. Pure Earth's Toxic Sites Identification Program attempts to map contaminated areas globally, and has so far identified 1646 toxic sites where lead is the primary pollutant. A study in Ghana, however, estimated that the program had identified less than a seventh of sites in the country, indicating that a comprehensive program of that kind would require significant funding.[lxxxiv]

After contaminated sites have been identified, immediate steps must be taken to prevent exposure to the surrounding population. Ideally, areas should be cordoned or fenced off to preclude access. Informing the community - especially children- about the risks of exposure is critical, and a number of media resources exist to get the message out.[lxxxv]

Ideally, contaminated sites should be cleaned-up via remediation strategies. Ex-situ remediation, which involves transporting and treating contaminated soil away from sites, comes at great expense and therefore only makes sense where contamination is most severe or future site-use is impossible to avoid, at least for LMICs in the short-term. [lxxxvi] More cost-effective methods include capping contaminated soil with grass, woodchips, mulch, or concrete, and bio-remediation techniques to reduce lead bioavailability. [lxxxvii][lxxxviii] There is a severe shortage of evidence on effectiveness in remediation; a review in 2021 found just five reliable studies on soil remediation - all in North America- which had mixed results.[lxxxix]

Remediation efforts can be quite costly, especially for large sites, and has sometimes attracted international financing. By far the largest such effort, at present, is an ongoing $66 million World Bank operation in Zambia to remediate environmental pollution at Kabwe and other mining areas.[xc] Pure Earth has conducted small-scale clean ups of several such sites with funding from USAID, the European

Commission, UNIDO, and others, including a village in Bihar, India (cost of $35,000);[xci] a soccer field in Indonesia adjacent to the local primary school (cost of $115,000);[xcii] and an old mine in Kyrgyzstan (cost of $79,000).[xciii]

Contaminated Spices

Though the extent of the problem is still not fully understood, an increasing body of evidence points to lead-adulterated spices as a significant driver of widespread lead poisoning, particularly in South and Central Asia. For turmeric and other spices with bright yellow/orange colors, lead chromate is typically added during the polishing stage to increase pigmentation and reduce polishing time (which also increases the weight of the final product batch); the bright pigmentation characteristic of lead chromate is considered a sign of high quality,[xciv] and adulteration therefore allows producers to command a higher price point for their products. Lead may also be inadvertently introduced in smaller concentrations to a broader range of spices—for example oregano, thyme, ginger, or paprika—via contaminated soil, airborne pollution, or cross-contamination at a factory,[xcv] though this is likely to be a relatively small part of the overall problem.

Via global supply chains, contaminated spices can drive lead poisoning far beyond their countries of origin—and pose a real threat even within G7 members. In the US, where roughly 95% of spices are imported,[xcvi] a Consumer Reports investigation found detectable levels of lead or other heavy metals in one third of sampled spices;[xcvii] in New York City, investigations of elevated blood lead levels frequently identify lead adulteration in spices purchased abroad as a likely source, with the highest concentrations of lead found in spices from the countries Georgia, Bangladesh, Pakistan, Nepal, and Morocco.[xcviii][xcix]

The practice of adulteration may in part be borne of unfamiliarity; in South Asia, unpublished research shows that many producers are unaware of the health harms of lead, and some cease adulteration once informed of the impact of their actions.[c] Consumers too are largely unaware of the danger, including the ability of lead-chromate to mimic the bright pigmentation of high-quality spices. This suggests an important role for both consumer and producer education, as well as better-equipped consumer safety bodies, including the use of practical detection technologies such as x-ray fluorescent analyzers[ci] to easily identify contaminated substances in marketplace or household settings. Another potential but untested intervention might be supporting turmeric producers to purchase drying machines, which can help improve natural pigmentation and reduce demand for color additives.[cii]

Interventions to address lead in spices may be extraordinarily cost-effective given the broad reach of the supply chains, and the small direct costs to stopping lead adulteration. Though not rigorously evaluated, the limited interventions already conducted to reduce lead in spices have had impressive results. In Georgia, a Pure Earth pilot project identified spices as a major source of childhood lead poisoning; in partnership with the Georgian government, this source of contamination was drastically curtailed over a two-year time span via new regulation and enforcement; producer awareness along the entire supply chain; and consumer education.[ciii][L] Long-term monitoring will confirm whether this reduction persists. Actions taken abroad likely also contributed towards the decline in the number of children with elevated blood lead levels among New York City children with Georgian ancestry.[civ] In Bangladesh, a baseline market analysis in 2019 found that 50% of turmeric samples were lead-tainted. A subsequent intervention involved: 1) fining lead wholesalers and confiscating contaminated merchandise; 2) more broadly screening turmeric samples for lead, and warning sellers about the possibility of fines; and 3) a broad public awareness and education campaign. Measurements in 2021 and 2021 found no samples containing lead;[cv] test data on the effect of these interventions on BLLs is expected early 2023.[cvi]

Lead Paint

Despite their danger being established for decades, lead paints remain legal in the majority of countries, and are widely used for residential coatings and decorative purposes in most LMICs, and for industrial purposes in many high-income countries. Lead additives are primarily in solvent-based paints, and may be added to paint to improve durability, drying capacity, and corrosion prevention, as well as in the form of pigments - especially lead chromate- to enhance color.[cvii] It can cause occupational exposure as workers inhale dust during manufacture, application and removal, or exposing their families through take-home contamination. Children are exposed primarily through ingestion of chips and dust, which can occur throughout the life cycle, but may be exacerbated as paint ages as well as during application and removal.[cviii]

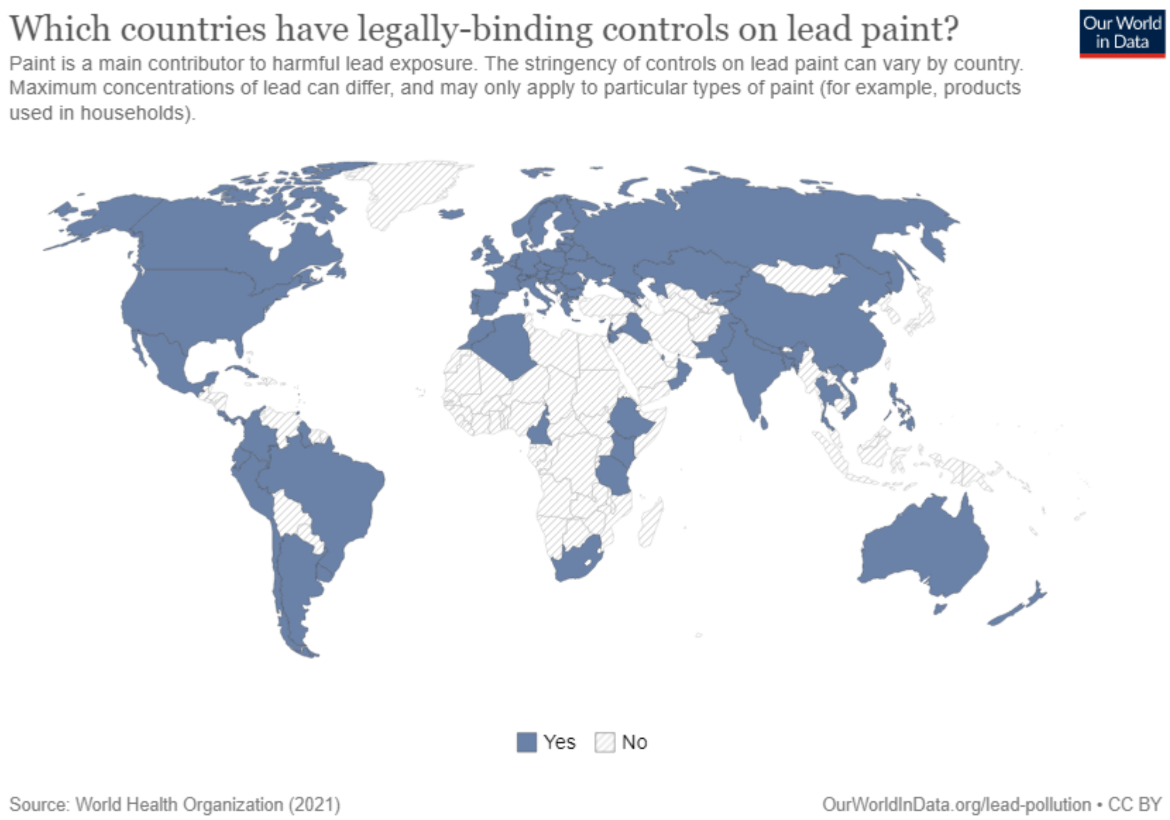
Lead paint is an avoidable source of exposure, and there are safe and cost-effective alternatives to lead additives.[cix] One important way to prevent exposure is for countries to establish legally binding regulatory measures prohibiting the addition of lead to paint. Over the last six decades, better recognition of the health risks[cx] has prompted considerable effort to phase out lead in paint. According to the WHO, 87 countries have laws in place to limit the production and sale of lead paint,[cxi] including all G7 members except Japan,[cxii] although exposure via older layers of paint in residential buildings remains a significant exposure risk. Many of these countries often allow for exceptions, however, such as for 'industrial' paint, which can cause severe exposure to workers and their children, as well as the population through use on road marking, bridges, and even playground equipment.[cxiii] It has also been found in consumer markets.[cxiv] Most importantly however, 55% of countries still have no confirmed regulation on lead paint (figure 5),[cxv] and high lead levels have been found in paints in more or less every country where this is the case, across Asia, Africa, Latin America, and Eastern Europe.[cxvi]

The Global Alliance to Eliminate Lead Paint—a voluntary partnership led by the WHO and UNEP, and guided by an advisory council chaired by the US EPA— was founded in 2011, to promote the phase out of lead paint. As part of this initiative, UNEP have published a model law and guidance for regulating lead paint[cxvii], and other partners have created tools to promote and track regulation.[cxviii] The WHO also organises International Lead Poisoning Prevention Week, which in 2021 involved 104 associated events in 56 countries. The Global Environment Facility also funded a five-year project under the SAICM secretariat ending in June 2022,[cxix] a key component of which was enhancing the work of the alliance. Under this project, various partners of the Alliance and other organizations worked with over seventy countries to provide technical support on drafting lead paint laws, including through national consultations, and published detailed information to assist with legal drafting and develop lead paint law compliance and enforcement systems. They also published guidance on paint reformulation,[cxx] and implemented pilot demonstration projects with paint manufacturers in eight countries to reformulate their paint production processes and phase out the use of lead in paint. Though the project has ended, partners of the Alliance continue to engage with policymakers and paint manufacturers as resources allow.

The Global Alliance to Eliminate Lead Paint claims at least partial credit for the steady increase in countries with regulations on lead paint, which rose from 52 in 2012 to 87 in 2022.[cxxi] Advocates of regulation point to the success of bans on leaded gasoline,[cxxii] which dramatically reduced blood lead levels. The few studies which have measured the effect of regulations on quantities of lead in paint have found that they do bring down lead levels, although more effectively when accompanied by active enforcement and direct engagement with manufacturers.[cxxiii] Considering the relatively low cost of such policy engagement - the GEF project component involved $3 million of GEF funding and $10 million of co-financing- this kind of initiative is likely to be a strong investment and should be considered for other sources of lead exposure as well.[cxxiv]

Evidence on the effectiveness of abatement interventions to prevent exposure from existing lead paint is mixed,[cxxv] and abatement requires adequate waste management systems to ensure waste is handled soundly:[cxxvi] it is therefore unlikely that such measures would be immediately cost-effective in most LMIC contexts. A strong argument for focusing on lead paint regulation is to limit the ongoing influx of lead into residential,[cxxvii] public[cxxviii] and commercial spaces at minimal cost, thereby averting future need for expensive *ex-post-facto* remediation.

Figure 5: Countries with Legally-Binding Controls on Lead Paint. (Our World In Data, 2022). [cxxix]



Cookware

There are two main types of cookware with the capacity to pass lead into food, and therefore cause elevated blood-lead levels. The first (and better established) risk is from artisanal, lead-glazed ceramics. Lead-based glazes are used to control moisture and add shine. When lead-glazed ceramics are fired at insufficient temperatures, often in wood-fired kilns, the glaze does not properly seal; as a result, lead can leach and contaminate food and drink during cooking, storage, or serving. Use of lead-glazed pottery thus represents a broad health threat to people who cook and eat with these products; their manufacture also creates a severe health risk to potters and their families, who risk severe lead poisoning.[cxxx][cxxxi][cxxxii]

Lead-glazed ceramics are popular in central Mexico, where they are primarily produced by indigenous communities, and are commonly used in restaurants for cooking and serving. They have been identified as a primary cause of elevated blood lead levels in the country,[cxxxiii] where 22% of children aged 1 to 4 years have blood lead levels above 5 µg/dL.[cxxxiv] But they are also used elsewhere in Latin America, North Africa, and South Asia, and may be a significant source of exposure. Lead-glazed pottery has also been identified as the source of severe lead poisoning cases in G7 member states:[cxxxv] often these are acquired during visits abroad, but they have also been found on sale within countries.[cxxxvi]

The use of leaded glazes is already illegal in Mexico, but the prohibition is not enforced, due in part to the traditional and economically important role of lead-glazed pottery in indigenous communities.[cxxxvii] One intervention may be educating artisans about the dangers of lead glazes; supporting substitution to unleaded glazes, or supporting artisans to shift to higher temperature kilns. Efforts are made more difficult by the small-scale of most pottery workshops; it is estimated that there are 10,000 potters using lead glazes in Mexico alone.[cxxxviii] On the demand side, interventions can educate consumers to recognize the danger of lead glazes and demand unleaded alternatives; however, without suitable detection equipment or reliable certifications, consumers may be unable to distinguish between leaded and lead-free products.[cxxxix] A Pure Earth project[cxl] in Mexico combines these approaches: it engages potters directly while also educating restaurant workers to demand lead-free pots. Another efficient intervention may be targeting the manufacturers of lead glazes themselves, who are likely much fewer in number, and supporting them to shift to lead-free glazes that effectively mimic the desirable properties of leaded versions.[cxli]

More recently, alumnium pots and other cookware produced from scrap metal—used by poor families in LMICs across all regions—have been found to frequently contain lead and other heavy metals.[cxlii][cxliii] Studies suggest that this can also contaminate food, particularly when cooked at high temperatures and with highly acidic foods.[cxliv][cxlv] Lead-contaminated aluminum cookware has also been found in resettled Afghan populations within the US, potentially explaining the high blood lead levels observed among Afghan refugee children.[cxlvi] The overall scale and geographic distribution of this source of lead exposure remains unknown but could be quite substantial given the ubiquity of artisanal aluminum cookware across many LMICs.

The intervention space here is challenging and at a nascent stage given the relatively recent recognition of the problem. Pot manufacturers are usually operating at very small-scale, often in private residential settings, making regulation of the supply chain or even direct engagement difficult. Potential technical interventions include incorporating an additive to the aliminium melt that would bind any lead to the metal amalgam,[cxlvii] or coating pots with a fluoropolymer spray,[cxlviii] which almost entirely eliminates the bioavailability of lead, although has been shown to pose its health risks. Implementation of such approaches at scale, however, may be hampered by the highly fragmented production and supply chains of these products. As an initial step, interventions might target the large pots and pans used for school feeding programs - some of which have been found to contain lead-[cxlix] given the large reach of school meals to school-aged children, and the relative ease of identifying and reaching school facilities.

Cosmetics

Cosmetic use of lead sulfide (PbS), known as galena, has origins in ancient Egypt. The use of galena-based Kohl (known as *surma* in India and *tiro* in Nigeria) (figure 6) is important in cultural and religious traditions across the Middle East, South Asia and North Africa—including for babies and young children.[clcli] While safe, lead-free substitutes exist, traditional leaded Kohl—with up to 98% lead content—is still common across the world, and frequently found in G7 member states[cliiicliii] despite strict *de jure* regulations.[clivclv] Routine use of Kohl has been associated with extremely high blood-lead levels, including in young children and adults in G7 member states.[clviclviiclviiiclixclx] Lead has also been found within non-Kohl cosmetics including henna[clxi] and lipsticks,[clxiiclxiii] though usually in lower concentrations.

The cultural and sometimes religious customs associated with the use of kohl and henna in South Asia and Africa, coupled with lack of enforcement capacity, can make bans less effective in these regions. Indian regulations, for example, formally limit lead concentrations in cosmetics to 20 ppm; however, a 2013 study found average lead content of up to 32% among market samples.[clxiv] Consumer education and local activism may be helpful to increase awareness of the potential health harms of these products and encourage use of non-leaded alternatives, but evidence on the effectiveness of such interventions remains limited.

Figure 6: Woman in village in Tamil Nadu, India, applying kohl to her child. (Etan Doronne, 2011) [clxv]

Toys and Consumer Goods

Lead is also found in other consumer goods, particularly toys and jewelry. Use of lead in toys is typically to add pigment/color, including via lead paint on surfaces[clxvi] and lead pigment in crayons, sidewalk chalk, and other art supplies; lead is also used to heat-stabilize plastic molecules, though it is not clear that lead in plastic would be bioavailable.[clxvii] Lead-containing toys are of particular concern because they are used by young children, who may also suck or chew on lead-coated surfaces. Jewelry can also have very high lead content,[clxviii] and may be particularly dangerous if mouthed or ingested by young children.[clxix]

The extent of lead poisoning via toys is difficult to quantify, but lead is frequently found in toys distributed via international supply chains. In China, 36% of toys purchased from major shopping platforms had lead levels exceeding US and EU standards as of 2018.[clxx] In New York City, investigations of lead poisoning have revealed significant lead content in a broad range of toys, jewelry/amulets, and other novelty items, often originating in East and South-East Asia.[clxxi]

Measures taken to limit lead poisoning from exposure to toys mainly concern government regulations on toy manufacturers/importers, recalls, and awareness campaigns. US legislation from 2008 introduced much stricter limits on lead in children's products (e.g., childhood jewelry and toys intended for children and infant products); revised (stricter) EU standards also entered into force as of October 2018.[clxxii] Some HIC regulatory frameworks may leave gaps for products widely used by children but also marketed to adults, and thus not covered in prohibition of lead in children's products, e.g. fidget spinners.[clxxiii]

Other Sources

Researchers have documented lead exposure through several other channels, though the attributable burden of lead poisoning to these sources remains unknown. We offer a non-comprehensive list of these exposure channels:

Lead-Contaminated Water*:* Historically, lead was commonly used in water mains and pipes; lead pipes can still be found in older buildings/neighborhoods and may leach lead into drinking water, particularly if the water is highly corrosive. Lead-contaminated water is one of the most common sources of lead poisoning within G7 member states, but it is not clearly documented as a major source of lead exposure at the global level or within LMICs. One recent study from three countries in West Africa finds that lead concentrations in water are similar to those found in HICs; given the far higher BLLs found in LMICs, this would suggest that lead pipes may be a relatively minor source of exposure in the studied contexts.[clxxiv] Lead contamination of drinking water may also occur via the water table in areas with contaminated soil.

Residual Pollution from Leaded Petrol: Though leaded petrol is now banned worldwide—a major public health victory—residual pollution from decades of emissions remains in the soil and continues to cause lead exposure.[clxxv] The problem is more pronounced in dense urban areas, near transit arteries, and in countries with relatively recent bans on leaded petrol.

Light Aviation Fuel: Prohibitions on lead additives to gasoline contain exceptions for avgas, used for piston-driven airplanes, and leaded varieties remain widely used. Several studies have shown this to be a significant source of exposure in high-income countries, particularly to children living near to airports.[clxxvi]

E-Waste Recycling*:* Across many LMICs, economically and socially vulnerable people support themselves by scavenging and hand-recycling electronic waste—for example, used and discarded televisions, appliances, computer monitors, and cellular phones. These products contain valuable raw materials for resale—but also lead and other toxic substances. Lead and other dangerous metals can be released into the air and soil during the recycling process, potentially causing severe lead exposure and other illnesses among workers and in the surrounding communities.[clxxvii]

Traditional Medicines and Ceremonial Powders: Very high concentrations of lead have been found in a range of traditional medicines and ceremonial powders, primarily originating from and used within East and South Asia; litargirio, a traditional remedy from the Dominican Republic used for skin problems and as a deodorant, can also contain high levels of lead.

Folkloric Traditions*:* Lead is used in several folkloric traditions—most notably molybdomancy, in which molten lead is poured in water as a form of fortune-telling. Historically, molybdomancy has been popular across Europe, including in German-speaking countries where it was practiced as a popular New Year's tradition. As of 2018, the use of lead in this practice is banned across the EU;[clxxviii] however, molybdomancy using lead remains common in the Balkans and Turkey.

Part 3: International Engagement on Lead by the G7 and International Organisations

In this section, we present the results of a rapid stocktaking exercise intended to assess the extent of international engagement to measure, prevent, or treat lead poisoning, including international agreements, plus individual actions by G7 members and selected international organisations. Given the rapid and non-systematic nature of this exercise—and our limited ability to reach key informants during its short duration—the results below cannot be considered a comprehensive accounting, but rather an indicative and illustrative overview of selected actions.

International Treaties, Conventions, and Initiatives

There are several lead-related international agreements and initiatives which include most or all G7 members:

- With the exception of Japan, all G7 members are signatories of the Convention on Long-Range Transboundary Air Pollution; a protocol within the Convention limits emissions of heavy metals, including lead.

- A 1996 OECD Declaration on Risk Reduction for Lead calls for a broad range of national and international efforts to reduce lead exposure and related risks, including phase down of lead in paint; exposure via ceramics and crystal; and limits on air emissions.[clxxix]

- The 2002 World Summit on Sustainable Development resulted in a Plan of Implementation, which includes a commitment to "phase out lead in lead-based paints and in other sources of human exposure, work to prevent, in particular, children's exposure to lead and strengthen monitoring and surveillance efforts and the treatment of lead poisoning."[clxxx]

- All G7 members have a designated focal point within the Strategic Approach to International Chemicals Management (SAICM), a policy framework which aims to support international cooperation on chemicals management.

- The 2009 International Conference on Chemicals Management resulted in "widespread support…for establishing a global partnership on lead in paint,"[clxxxi] leading to establishment of the Global Alliance to Eliminate Lead Paint, a voluntary partnership formed by UNEP and the WHO and chaired by the US EPA.

- With the exception of the USA,[2] all G7 members have ratified the Basel and Rotterdam conventions. Exports of waste containing lead that are controlled under the Basel Convention are prohibited without prior informed consent of importing countries and any transit countries.[clxxxii] Twenty-nine African countries are also subject to the Bamako convention, which

[2] Exports and imports of waste containing lead (e.g, spent lead-acid batteries) regulated as hazardous waste under the U.S. Resource Conservation and Recovery Act are subject to U.S. hazardous waste export and import requirements, which included prior informed consent requirements consistent with those established under the Basel Convention.

contains stronger prohibitions on imports of hazardous waste. Tetraethyl lead and tetramethyl lead–both additives to fuel–are classified as hazardous chemicals under the Rotterdam convention, and therefore all parties must give prior consent to imports.[clxxxiii]

- In 2022, the G7 Climate, Energy, and Environment Minister's Communique reaffirmed a commitment to reduce lead exposure in vulnerable communities, encouraged domestic regulation of lead, and laid out ambitions for a G7 workshop on lead under the German Presidency to "take stock of G7 activities and develop possible options for future work and cooperation on sources of lead to reduce lead exposure in developing countries."[clxxxiv]

United States of America

The US government's response to lead poisoning, domestically and internationally, is coordinated by the Lead Exposures subcommittee of the President's Task Force on Environmental Health Risks and Safety Risks to Children (Task Force),[clxxxv] which covers the work of 18 separate federal agencies and White House Offices. In December 2018, the Task Force released the Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts (Federal Lead Action Plan), which serves a blueprint for reducing lead exposure and associated harms through collaboration among US federal government agencies and with a range of stakeholders.[clxxxvi] Much of the internationally-relevant work is conducted by the Environmental Protection Agency (EPA), which chairs the advisory council of The Global Alliance to Eliminate Lead Paint.[clxxxvii] The EPA has also provided strategic, technical, and legal drafting support to a global lead paint project funded by the Global Environmental Facility (GEF), and continues to work with WHO to develop campaign materials for the International Lead Poisoning Prevention Week of Action.[clxxxviii][clxxxix] Other activities relevant to the international context include the Food and Drug Administration (FDA)'s Closer to Zero action plan[cxc] to reduce levels of lead and other toxic elements in foods consumed by babies and young children, as well as engagement within the FAO/WHO Codex Alimentarius Commission to establish international standards for lead concentrations in food and feed.[cxci] The Consumer Product Safety Commission monitors lead in paint, toys and children's products and engages with foreign government agencies and other organizations to ensure compliance with US standards.[cxcii] The CDC also plays a significant role in setting guidance on childhood lead poisoning, and historically supported WHO and other international partners in responding to lead poisoning. Finally, the New York City Department of Health collects and publishes useful information about the causes of elevated blood levels in the city from imported goods.[cxciii] Research on the propensity for elevated blood levels among children with Georgian ancestry, and the subsequent discovery of high levels of lead in Georgian spices, was instrumental in UNICEF Georgia's inclusion of blood testing to the 2018 MICS[cxciv]; this found very high rates of elevated blood lead levels and spurred the government to implement a number of successful interventions to reduce lead exposure.

Canada

Responsibility for lead in Canada is shared between the environment and health ministries (Environment and Climate Change Canada and Health Canada, respectively). Canada is an active participant in the Global Alliance to Eliminate Lead Paint, and holds events during the WHO-coordinated International Lead Poisoning Prevention Week. Also, as a WHO Collaborating Centre for Environmental Health, Canada works with the WHO on chemicals-related guidelines, including lead.[cxcv] Canada also contributes to the development of other relevant programs under the WHO, including the protection of women's and children's health.[cxcvi] In some circumstances, Health Canada will actively reach out to foreign suppliers to promote compliance with Canadian regulations.[cxcvii]

United Kingdom

Much of the UK's international action against lead poisoning is conducted by the UK Health Security Agency (UKHSA). The UKHSA has collaborated with the National Centre for Disease Control in Georgia to document the effectiveness of interventions aimed at reducing exposure to lead across the country[cxcviii] and in the identification and ranking of importance of lead sources to prioritise further interventions. The UKHSA delivers capacity building programs such as the International Health Regulations (IHR) Strengthening Project,[cxcix] a bilateral UK program that provides technical assistance to partners in Africa, Asia, and the Eastern Mediterranean to meet the WHO IHR, with a focus on improving surveillance and national poisoning systems. This includes training, development of standard operating procedures, capacity-building in clinical toxicology, and harmonisation across different stakeholders. The UKHSA also participates in programs to enhance the sound management of chemicals and their associated wastes in Eastern Europe[cc] and Southeast Asia.[cci]

France

The French Fund for the Global Environment (FFEM)'s helped to fund a capacity building project in Bangladesh, implemented by Pure Earth, which aims to improve ULAB recycling in the country.[ccii] France has partnered with the WHO to host events in support of the International Lead Poisoning Prevention Week, including two events in 2020.[cciii] The country is also a member of the World Coatings Council.[cciv]

Germany

Germany provides financing to the Global Environmental Facility (GEF) and offers technical support to the WHO and UNEP in their formulation of guidelines concerning chemicals and waste management.[ccv] Some GIZ development projects may also support capacity building to improve chemical and waste management in LMICs.[ccvi]

European Union (EU)

EU REACH legislation at least partially restricts the sale of products containing most lead compounds, and EU legislation also imposes restrictions on lead in petrol, electronic equipment, cosmetics, toys, occupational exposure, and industrial emissions. Lead jewelry and lead-pouring kits - used in a German New Year's Eve tradition - are now banned, and a new process has started to ban lead in bullets and fishing weights.[ccvii] A lawsuit brought by Sweden also led to an expansion of the scope of REACH legislation to cover lead chromate pigment in paint.[ccviii] Countries adjacent to the EU may also match EU REACH legislation.[ccix] There are indications that that bans on these products may affect production for markets elsewhere; despite an exemption for lead ammunition, German armed forces and police have reported difficulties sourcing it, suggesting there may in future be an insufficient market for manufacture.[ccx] The European Commission (EC) also funds capacity building to improve chemical and waste management in LMIC through the CBRN Centres of Excellence Initiative, although this is primarily focused on chemical, biological, radiological, and nuclear risk mitigation, with limited direct focus on lead. A recently completed project supported 10 countries in Africa with chemical management, and projects are currently underway supporting countries in Eastern Europe, Central Asia, North Africa and Sahel, and Southeast Asia.[ccxi] This includes support with legislation, prevention, environmental protection, detection through laboratory procedures, preparedness, response, recovery, and remediation.[ccxii]

Italy

N.B.: As the authors were unable to reach informants from Italy, the information presented here is likely to be incomplete.

As discussed in the case study on Georgia, the panel test included in the 2018 MICS survey was dependent upon the Italian National Institute of Health's agreement to carry out the testing,[ccxiii] as Georgia had no laboratory sufficiently equipped to do so.

Japan

Actions against lead poisoning internationally have primarily been conducted by the Environmental Health department, within the Ministry of Environment. The Ministry is co-chair of a thematic working group on chemical waste and health in the Asia-Pacific region forum on Environment and Health. In this role it organised a webinar on the sound management of lead, attended by officials from 13 countries in the region. It shares this chairing role with the Thailand Ministry of Health, and the department has advocated for more intersectoral engagement between health and environment in SAICM. The department also runs the Japanese Environment and Children's study (JECS), a long-term and large-scale survey initiated in 2010, which has provided data on the long-run effects of lead.[ccxiv] Under this initiative, the department brought together other researchers studying the effects of environmental risks on children's health through the JECS International Liaison Committee.[ccxv]

World Health Organisation (WHO)

Lead is identified by the WHO as one of the ten chemicals of major public health importance. Responsibility for lead at the WHO is housed at the Chemical Safety and Health Unit within the Department of Environment, Climate Change, and Health. This unit publishes normative guidelines on a range of issues around lead, including clinical management of acute exposure; norms and standards for exposure to lead in air, water, and food; and standards for preventing exposure, including via regulation of leaded paint.[ccxvi] It also raises awareness among both the public and policymakers through publications and events. Many of these activities occur during the WHO-run International Lead Poisoning Prevention week, which takes place every year in the third week of October; in 2021, there were 104 associated events in 56 countries.[ccxvii] Along with UNEP, the WHO also leads the Global Alliance to Eliminate Lead Paint, and in this position played an important role in the GEF project supporting governments to introduce regulations on leaded paint. The Global Health Observatory maintains a list of countries which have introduced controls on leaded paint.[ccxviii] WHO also gives priority to addressing lead in the context of its work on children's environmental health and is in the process of developing several e-learning courses for health professionals on lead exposure, diagnosis and management. WHO is collaborating with UNICEF in this regard and a joint e-learning course is planned for launch in early 2023. UNICEF and WHO are also in the process of implementing a pilot project in Indonesia for implementing the WHO Guidelines for the Clinical Management of Exposure to Lead. This work is led by country offices of both UNICEF and WHO.

World Bank

Responsibility for lead at the World Bank comes under the Environment, Natural Resources and Blue Economy Global Practice. The World Bank has recently started to increase its actions against lead poisoning through its lending operations in LMICs. An ongoing project in Zambia aims to remediate mining areas including Kabwe; support capacity building to stop exposure from mining; and reduce health risks through localised health interventions.[ccxix] A recently completed project in Lao PDR also aimed to strengthen pollution monitoring and management,[ccxx] including sucessful regulations on ambient standards, lead paint, and toys.[ccxxi] In addition to project work, the World Bank also conducts analytical work on sub-national, country[ccxxii] and global level,[ccxxiii] including technical briefs to support countries in researching and addressing lead exposure.[ccxxiv] They have recently proposed and are seeking funding for a multi-donor trust fund called PROCLEAN, which aims to improve chemical and hazardous waste management, with a significant focus on lead exposure.[ccxxv] This would help fund country-level analytical programs to understand and demonstrate the impact of lead exposure, as well as technical assistance and financing to support a range of interventions against exposure.

United Nations Environment Program (UNEP)

Several departments of UNEP have work related to global lead poisoning and mitigation:

- To support countries to meet the conditions of the Basel Convention, its secretariat (housed within UNEP) produces technical guidelines on the sound management of ULAB recycling[ccxxvi], and supports capacity development through online courses, workshops, and projects.[ccxxvii] It also provides assistance in case of emergencies caused by exposure to waste containing lead.

- Historically, the Partnership for Clean Fuels and Vehicles–the secretariat of which is housed within UNEP–coordinated many efforts to eliminate lead from gasoline.[ccxxviii]

- As a core founder and partner of the Global Alliance to Eliminate Lead Paint, UNEP has published model laws on lead paint,[ccxxix] and suggested steps[ccxxx] for governments to introduce regulations as well as guidance on compliance and enforcement.

- The SAICM secretariat, also administered by UNEP, coordinates regulations against lead products between countries, and also launched the GEF project to promote and support lead paint regulation globally.[ccxxxi] This included financial support and workshops for policymakers, the publication of paint reformulation guidelines,[ccxxxii] and direct engagement with paint manufacturers. It additionally provides technical and financial support to countries to build capacity to manage chemicals and waste.[ccxxxiii]

- More recently, UNEP has established projects in Bangladesh, Tanzania, and Burkina Faso to support the introduction of regulations on ULAB recycling.[ccxxxiv] UNEP publishes expert guidance to inform the international community on environmental issues, such as through the Global Chemicals Outlook II,[ccxxxv] and the Assessment Report on Issues of Concern,[ccxxxvi] both of which have identified lead as a priority in the near future.

- The United Nations Environment Assembly (UNEA) agreed on the foundation of a science policy panel on chemicals, waste, and pollution prevention under UNEP, which will play a similar role to that of the IPCC with respect to climate change.[ccxxxvii] They convened an ad hoc open-ended working group to prepare proposals for the panel, the second session of which will be held in Bangkok from 30 January to 3 February 2023. UNEA also requested that UNEP work with countries to establish and strengthen legal frameworks for controlling lead paint and recycling of lead acid batteries.

UNICEF

Responsibility for lead poisoning within UNICEF comes under the Healthy Environment for Healthy Children unit of the Health program. UNICEF and Pure Earth's 2020 global report on childhood lead poisoning—"The Toxic Truth"—generated significant media attention on the issue.[ccxxxviii] They have targeted lead as a key issue in the near future, and as a route to gain traction on other environmental issues with effects on children.[ccxxxix] The most important work thus far has been conducted by the country office in Georgia, which implemented a panel test for exposure to different chemicals in the 2018 Multiple Indicator Cluster Survey. This found that 41% of children aged 2 to 7 had blood lead above 5 µg/dL, including 85% of children in the western region of Adjara.[ccxl] Seed money from UNICEF subsequently helped build a laboratory and to design a surveillance system for ongoing monitoring. As discussed above, the effort in Georgia was dependent upon in-kind contributions from the Italian government. There are no other country-level projects to measure lead exposure planned, although there is hotspot measurement and intervention research currently underway in Ghana and Bangladesh.[ccxli] UNICEF is also part of the Protecting Every Child's Potential campaign, in conjunction with Pure Earth and the Clarios Foundation.[ccxlii] While initially including environmental and regulatory work, this is currently in transition to an advocacy campaign.[ccxliii] In addition, UNICEF is scaling up its engagement on childhood lead poisoning in 14 countries, including the Indonesia partnership with WHO described above.

Other Organisations

There is insufficient space to cover all organisations involved in actions against lead poisoning internationally. Other relevant non-governmental and intergovernmental organisations include the FAO, ILO, UNIDO, OECD, UNITAR, and UNDP, all of which are partners in the Inter-Organization Programme for the Sound Management of Chemicals; regional multilateral development banks, including the ADB, AfDB and IADB; NGOs including Pure Earth, Occupational Knowledge International, LEEP, Vital Strategies, Oeko Institute, and GAHP; donors including Givewell, OpenPhil, and the Clarios Foundation; networks of public sector and charitable organisations in LMICS working to implement environmentally sound management, including IPEN and RECPnet; and academic research groups including those at Stanford Woods Institute for the Environment and NYU School of Public Health.

Part 4: Selected LMIC Profiles

In this section, we offer short profiles of lead poisoning within four selected LMICs: Bangladesh, Georgia, Mexico, and Zambia. These countries were selected to showcase a range of national experiences across regions and common sources of lead exposure; they are not necessarily intended to serve as exemplars among the broader community of LMICs.

As is the case throughout this report, these profiles are the result of a rapid stock-taking exercise, intended as background for an international audience. Given time and resource constraints, the profiles may not offer a comprehensive view of all actions, policy measures, and relevant evidence within each country.

Bangladesh

There is no reliable data on the number of children in Bangladesh with elevated blood lead levels; however, estimates suggest a very high overall burden, with about 60% of children exceeding the 5 ug/dl reference level[ccxliv] and about 45% of children exceeding the higher 10 ug/dl threshold.[ccxlv] Older studies suggest levels of lead poisoning are particularly high in Dhaka (compared to rural areas), with a mean BLL measured at 13.5 ug/dl in a 2007-2009 BLL survey.[ccxlvi] There are many potential sources of lead exposure in Bangladesh, and the relative burden caused by different exposure channels remains poorly understood.

At the industrial level, ULAB recycling is a common source of hazardous emissions in urban and semi-urban areas. In 2018, the World Bank reported 148 known ULAB recycling sites–but estimated 1,100 in total, putting roughly one million people at risk.[ccxlvii] Once abandoned, defunct ULAB recycling sites still pose a hazard to surrounding communities–sometimes even after intensive remediation. One study found initial median BLL levels of 22.6 ug/dl in children near a former recycling site; remediation efforts resulted in a 30% drop in median BLL (to 14.8 ug/dl) after 14 months–somewhat better, but still far too high.[ccxlviii] ULAB recycling is also extraordinarily dangerous for workers, including the child laborers that comprise about a quarter of the ULAB workforce.[ccxlix] A 2014 study in Dhaka found a mean BLL of 65 ug/dl[3] among ULAB workers, with many reporting at least one symptom of acute lead poisoning.[ccl]

In 2018, Bangladesh banned leaded paint exceeding 90 ppm at the urging of civil society activists; however, compliance and enforcement remain spotty. A 2021 study by IPEN-ESDO found that 30% of paints sold in Bangladesh exceeded the 90 ppm standard, and about 10%--all yellow–still contained very high lead concentrations (>10,000 ppm).[ccli] Local NGOs, including the Environment and Social Development Organisation (ESDO),[cclii] continue to mobilise in support of stronger controls and enforcement against leaded paint.[ccliii]

Lead may also be found in local cosmetics like *kajal*, cultural or religious powders such as kohl (surma) and especially sindoor,[ccliv] traditional health remedies, and amulets/jewelry. Though lead adulteration of these substances is anecdotally documented, including in Bangladeshi exports detected abroad,[cclv] there is limited evidence about the extent of lead contamination or the relative contribution to the national burden of lead poisoning.[cclvi] One study has also linked elevated blood lead levels in pregnant

[3] It was not possible to confirm whether this was a geometric or arithmetic mean, which tend to be larger due to the skewed distribution of BLLs.

women to a variety of potential sources including herbicides, pesticides, rice-grinding mills, and lead-soldered cans.[cclvii] In an older study, high BLLs were also associated with use of iron or lead faucets; proximity to industry; use of melamine plates; and some indigenous medical treatments.[cclviii]

Recently, adulteration of spices–particularly turmeric–has attracted local and international attention. A 2019 study led by Stanford University and ICCDR,b identified widespread and intentional adulteration of turmeric with lead chromate in Bangledesh to enhance color, and thereby increase perceived quality and market price;[cclix] a companion study used isotopic analysis to demonstrate a link between turmeric adulteration and observed elevated blood levels.[cclx] In the years since, the Bangladesh authorities have taken strong response measures, including an aggressive public awareness campaign and fines to offending turmeric wholesalers.[cclxi] Measurements in 2020 and 2021 indicate that less than 5% of turmeric samples now contain lead, down from 50% in 2019.[cclxii] Remedial actions taken in Bangladesh may have global implications; unpublished New York City data from lead poisoning investigations suggest that spice samples purchased in Bangladesh with detectable lead has declined from nearly 90% in 2018 to 10% in 2022.[cclxiii]

Georgia

Georgia–a small country of 3.7 million in the Caucuses–is a recent exemplar among LMICs for its rapid and apparently successful effort to understand and mitigate the burden of childhood lead poisoning.

Prior to 2018, Georgia had limited information on the prevalence or severity of lead poisoning within its borders. Georgia itself had no laboratory capacity to detect and measure lead poisoning; IHME had estimated average blood lead levels of 2.4ug/dl, with about 6% of children above 5 ug/dl.[cclxiv] Nevertheless, there were some indications of a more serious problem. Small-scale surveys (2015) by Georgia's National Center for Disease Control and Public Health (NCDC), with support from the U.S. CDC, had found that about 30% of kids had BLL above 5 ug/dl in Tblisi, Bolnisi, and Dmanisi.[cclxv] In New York City, investigations of lead poisoning cases in Georgian expats had identified very high lead concentrations in some spices originating in Georgia;[cclxvi] these data were then shared with the Georgian Ministry of Health and National Food Agency via the Consulate General of Georgia in New York. Triggered by these communications, Georgian food safety authorities conducted further investigations in Georgia, which found similarly high lead levels in spices available for sale in Georgian spice markets and groceries.[cclxvii][cclxviii] In addition, 2018 research found high levels of lead in paint within schools and kindergartens.[cclxix]

At the request of the Government of Georgia, UNICEF agreed to include blood lead testing in children aged 2-7 within the nationally representative 2018-2019 Multiple Indicator Cluster Survey (MICS). Samples were collected using venous blood draws and sent to the Italian Institute of Health for analysis.[cclxx] Results suggested that 41% of Georgian children had BLL above 5 ug/dl, and 16% exceeded 10 ug/dl; in some regions in the West, up to 85% of children had elevated blood lead levels.[cclxxi]

Following publication of these findings, the Government of Georgia invited Pure Earth to conduct further investigation of the problem in 2020 with funding from Clarios Foundation.[cclxxii] Pure Earth tested potential sources of lead exposure within 25 homes and four spice markets, including cookware, paint, soil, spices, toys, dust, water, and other media.[cclxxiii] Their results suggested very high levels of lead contamination within select spices–particularly *kviteli kvavili*, *svanuri marili*, and *khmeli kharcho*–

and only negligible lead exposure via other channels.[cclxxiv] Further investigation found that the contamination was occurring during processing by large importers and wholesalers.[cclxxv]

The Government of Georgia has taken a number of important steps to stem the burden of lead poisoning. Under the leadership of the Prime Minister an Inter-sectoral Coordination Council was established and Multisectoral Long-term Action Plan was elaborated to combat the problem of lead poisoning. In 2019, the government introduced testing and treatment recommendations for all children with BLL above 5 µg/dl; it also introduced technical regulations on lead in toys in 2020, and follow-up rules on lead in paint the next year. With funding from Clarios Foundation, in 2021 UNICEF equipped Georgia's NCDC with laboratory capacity to detect lead and other heavy metals in both blood and environmental samples.[cclxxvi]

On the issue of spices specifically,. Georgia passed regulations limiting the levels of lead in spices, and began an aggressive enforcement campaign.[cclxxvii] It also conducted a public information campaign, providing advice to parents about how to prevent lead exposure from dietary habits. According to Pure Earth, unpublished follow-up testing at spice sellers in 2022 has shown a dramatic reduction in levels of lead contamination.[cclxxviii] Remedial actions taken in Georgia likely had broader impact. Based on NYC blood lead surveillance data, between 2017 and 2020 there was an almost 60% estimated decline in the number of children with elevated blood lead level among NYC children with Georgian ancestry. Similarly, between 2017 and 2020, there was a decline in the percentage of samples from Georgia with detectable lead."[cclxxix]

Mexico

Mexico is one of the few LMICs with a recent (2019) national survey of blood-lead levels (excluding major cities of 100,000+ people),[cclxxx] enabling relative (though far from complete) confidence in the prevalence, severity and distribution of lead poisoning within at least rural areas within the country. The 1400-person survey, conducted by the National Institute of Public Health (INSP), found that 22% of children had elevated BLLs, placing it in the low to middle end of LMICS, according to Ericson 2021.[cclxxxi]

The survey results also pointed to lead-glazed pottery as a highly significance source of exposure in rural Mexico; 43% of children in households which frequently used lead-glazed pots had elevated BLLs, compared to 13% among families who did not use lead-glazed cookware. Variation in the use of lead-glazed pottery also explains the geographic and ethnic distribution of lead poisoning across Mexico. 26% of children in the south had elevated BLL, compared to just 10% in the north; and children speaking an indigenous language had a 40% higher likelihood of having elevated BLLs than their Spanish-speaking counterparts, after controlling for other factors. Many of the most acute cases of lead poisoning occur among potters or their families, with one recent study estimating a median BLL of 17.8 µg/dL among potters who used lead glazes. Use of lead-glazed ceramic ware from Mexico has also been associated with elevated blood lead levels, as high as 53 ug/dL, in New York City (USA) and other G7 members. Often individuals may hand-carry such ceramic ware from Mexico during their travel, but such lead-containing ceramic ware are also widely available in US stores increasing the risk of lead exposures for users.[cclxxxii][cclxxxiii]

Limits on lead in pottery in Mexico were introduced in 1993, but these are not consistently enforced due partly to the sensitivity of policing practices in indigenous communities. As discussed above, efforts to change practices by NGOs are hampered by the diffuse nature of manufacturing: there are at least

10,000, and possibly up to 40,000 potters using lead glazes in Mexico alone.[cclxxxiv] A Pure Earth project, Barro Aprobado, has provided workshops for potters to switch to an alternative to lead-glazes, produced from Boron, and has worked on the demand-side to raise awareness among consumers and restaurants which use lead-glazed cookware. There is a lack of evidence on the reach and effectiveness of this program.

The presence of high BLLs–even in households without lead-glazed pottery (13% prevalence)--suggests the existence of other significant channels of exposure within Mexico, but these are not well understood. Lead paint is one potential cause; current regulations only require paint with lead content above 600 ppm to have a label forbidding residential use, or use where children may be exposed.[cclxxxv] A 2018 study found that 28% of sampled paints had levels greater than 10,000 ppm.[cclxxxvi] There are efforts underway to further reduce the regulatory standard to 90 ppm – on par with the United States – but that had not yet occurred as of December 2021.[cclxxxvii]

Another concern is ULAB recycling, which has grown rapidly in recent years due in part to exports from the USA, which sends between 75-95% of its ULAB exports (by weight) to Mexico.[cclxxxviii] These exports grew markedly after the lowering of U.S. air quality standards in 2009, an example of the potential negative consequences of improving regulations in G7 members when not accompanied by adequate export regulations.[cclxxxix] A report by the secretariat of the Commission for Environmental Cooperation found severe faults in regulations and enforcement on ULAB recycling in Mexico: ambient air standards are 10 times as high as in the USA, and occupational standards are minimal.[ccxc] There is a lack of current data on the environmental performance of recycling plants and other lead-polluting industrial operations, but there have been a few high-profile cases of widespread contamination. Widespread lead exposure was discovered in 2001 in Torreon silver-zinc-lead smelter, prompting new environmental controls; nevertheless, children living nearby still had mean blood lead levels of 11 µg/dl in 2011.[ccxci] It has been reported that airborne lead emissions from recycling plants in Mexico are approximately 20 times higher than from comparable sized facilities in the U.S.[ccxcii]

In 2019, the General Health Council of Mexico published an action program to reduce lead exposure in the country, including general initiatives to monitor and treat lead exposure, and several actions to incentivize and promote the switch to non-lead glazes on the producer and consumer side.[ccxciii] The results of the program remain to be seen.

Zambia

Lead poisoning in Zambia is most closely associated with Kabwe, its fourth largest city. Kabwe has been branded “the world’s most toxic town”[ccxciv] due to extraordinarily high levels of lead contamination from a now-abandoned state-owned lead smelter, which previously operated for almost a century (1904-1994). Lead dust and debris is still ubiquitous in the surrounding air and soil, leading to very high levels of lead in children’s blood; small-scale scavenging and mining still takes place within the large waste dump adjacent to the site, known as “black mountain.”[ccxcv] A 2015 study found that 100% of children under 7 in this region had elevated blood-lead levels (above 5 µg/dL), and almost all had levels above 10µg/dL. In one neighborhood, median BLL in children was recorded at 75 µg/dL; individual BLLs exceeded 150 µg/dL in several cases.[ccxcvi]

Kabwe has attracted significant international attention from the media and human rights groups, as well as international financing to support remediation, including the following initiatives:

- The World Bank-financed Copperbelt Environment Initiative, which was a $53 million operation running from 2003 to 2011.[ccxcvii] Within Kabwe, the Initiative's objectives included "the treatment of lead-exposed children and remediation of lead contamination in their living, play and learning environments."[ccxcviii] A recent Human Rights Watch report is critical of the operation, suggesting a patchwork of small-scale and largely unsustainable remediation efforts versus a comprehensive remediation approach, plus an absence of systematic testing and treatment.[ccxcix] Recent data collection suggests that Kabwe continued to experience severe lead poisoning after the project's closure.

- In 2015, *terre des hommes Deustschland* – the German branch of an international NGO confederation – funded a Pure Earth partnership with Environment Africa and the Kabwe Municipal council, which remediated 120 households and launched environmental clubs in several local schools.[ccc]

- A research partnership between the Japan International Cooperation Agency, University of Zambia, and the Government of Zambia, starting in 2016, to investigate the extent of lead poisoning in the area and possible remediation approaches.[ccci]

- A new World Bank operation,[cccii] starting in late-2017 and now projected to extend through 2024, has committed $65.6 million to reduce health and environmental harms associated with mining, including lead contamination in Kabwe. The operation has experienced substantial implementation delays, in large part associated with the COVID-19 pandemic; the delays also led to an extension of the expected closure date, which was originally anticipated in late-2022. In 2020, 10,000 children were tested for lead under the initiative, identifying 2,500 children with blood lead levels above 45 µg/dL who could qualify for chelation therapy. As of June 2022, the World Bank reports that it has treated 2,000 people with high blood lead levels (end target: 7,000); reached 800 local children with awareness campaigns (end target: 30,000); and remediated 2 hectares of highly contaminated land (end target: 10).[ccciii] The project has been extended until June 2024.[ccciv]

- Zambia's Ministry of Mines and Minerals Development has begun discussions to adapt the Responsible Mineral Development Initiative (RMDI) to Zambia's context. The initiative is supported by United Nations/UNDP and conducted in close collaboration with the Chamber of Mines; it involves multi-stakeholder dialogue to define and advance a vision for responsible mineral development in Zambia in line with the Africa Mining Vision.

Beyond mine-adjacent communities, the extent of lead poisoning in Zambia is poorly understood. A recent systematic review found no relevant studies from Zambia on BLLs;[cccv] IHME, in turn, estimates that roughly 14% of Zambian children have elevated BLL, though the estimate is highly uncertain.[cccvi] Lead contamination has been documented in the food and livestock produced in areas with high rates of lead exposure, which may put people at risk if supply chains extend across the country.[cccvii][cccviii][cccix] As of late 2021, Zambia had not passed laws restricting the use of lead paint; however, according to the Global Alliance to Eliminate Lead Paint, it had established a voluntary standard of 90 ppm and is in the process of formulating a mandatory standard at the same level.[cccx] A 2017 IPEN study of paints on the Zambian market found that 36% exceeded the 90 ppm standard, while 18% had dangerously high lead concentrations above 10,000 ppm.[cccxi] Some local authors have also suggested ULAB as a potential source of local contamination, but this has not been documented in the literature.[cccxii] Studies from neighboring countries also point to artisanal aluminum cookware as a potential source of exposure, but that has not been studied directly in the Zambian context.

Part 5: Discussion

The findings of this stocktaking report suggest that global lead poisoning is a complex, poorly understood, and neglected crisis, affecting billions of adults and children around the world. Evidence on the adverse health and cognitive effects of lead exposure is well-established and robust. Yet in many LMICs, the average child has elevated blood lead levels that would merit medical intervention in any G7 country. Widespread, uncontrolled lead exposure is a society-wide tax on children's potential to learn and thrive; on adults' longevity and quality of life; and countries' overall prospects for economic and social development.

As described across the report, however, our findings are hampered by a lack of data, which also constrains efforts to directly address lead poisoning at the national and international levels. Cross-country estimates suggest an exceptionally high overall prevalence of elevated blood-lead levels, but the extrapolations are not reliable at the country level. Most LMICs have no locally representative evidence on blood lead levels, and their governments remain largely unaware of the prevalence, severity, or sources of lead poisoning that affect their citizens. To begin systematically addressing the global burden of lead poisoning, a step change is required in global surveillance, monitoring, and reporting—both on blood lead levels and lead concentrations in consumer products and in the environment.

The dearth of data is particularly problematic given the evolving nature of global lead exposure. Rather than a single primary source applying across all countries—as was (largely) the case for leaded petrol prior to the global phase-out—we find there are now many different sources of lead exposure with different regional patterns of relative importance. Even within a given country (e.g. Bangladesh), there can easily be 10 or more potential sources of exposure—none of which are clearly or systematically documented, nor ranked in importance. Sources of lead exposure within LMICs often differ from those that are well-known within the G7 and require different intervention approaches. There is thus no single "quick fix" from one product or source at the global level; while all reductions in lead contamination are useful, a comprehensive approach at the country level requires a thorough diagnostic exercise, source analysis, and locally tailored interventions that are responsive, feasible, cost-effective, and acceptable within the local community.

However, despite insufficient data to quantify the impact on BLLs, there are measures, some already taking place, that can and should be sustained and expanded to address sources of lead. At both the country and international levels, there is still an unfinished agenda to ban lead within consumer products and enforce consumer safety standards across the supply chain; the G7 can provide helpful assistance by supporting the drafting of policy and legal frameworks to this end. Leaded paint is the most obvious candidate here and has thus far received a significant portion of international attention; we note that while lead paint is banned across most G7 member states (except Japan), the sale of lead chromate pigment generally remains legal. Kohl cosmetics and lead-based religious powers/traditional medicines are also highly concerning given the potential for extremely high lead concentrations, use by young children, and direct application to the face; however, these sources have not yet been clearly documented outside of anecdotal reports and there are questions about their bioavailability as sources of lead poisoning.

Given the inherent methodological limitations of this rapid stocktaking exercise, we do not claim that its contents represent a complete census of all G7 international actions and investments related to global lead poisoning, nor a comprehensive assessment of the relative risks. Nevertheless, our findings—informed by interviews with representatives from almost all relevant countries and institutions—suggest a relatively small scope of international intervention, financing, and action, at least relative to the very large magnitude and severity of lead exposure as a health, education, environment, and development issue. We note that many NGOs and international organizations in this sector have received a substantial source of all lead-related funding from industry and affiliated philanthropies (e.g. the Clarios Foundation), and increasingly from Effective Altruism-affiliated funders, further highlighting the general scarcity of ODA and traditional philanthropy in this space.

Notwithstanding the relatively small amount of current funding, we identified relatively low-cost, high-value investments that could be made by G7 aid agencies to help address the problem (further enumerated in the next section), suggesting that the lack of international financing commensurate with the scale of the issue is *not* due to a lack of fundable opportunities. We also note a relatively high appetite among existing international institutions to sustain and expand lead-related activities (funding permitting), e.g. via the WHO, UNEP, and the World Bank's proposed PROCLEAN trust fund. Our overall impression is that lead poisoning is relatively neglected as a potential target of ODA and international cooperation, with substantial absorptive capacity for immediate, productive, and high-value investments by the G7, other bilateral and multilateral donors, and private philanthropy.

As a final point of caution, we note that this report is written to inform deliberations at a G7-sponored workshop and is thus targeted specifically to an audience of G7 policymakers. However, it is essential to recognize that LMICs governments and communities themselves are the most important stakeholders and must spearhead efforts to address the burden of lead poisoning within their own borders; G7 member states, necessarily, can play only a supportive role in the internal affairs of other sovereign nations. We urge the G7 and participating countries to expand discussion and cooperation on lead poisoning with the broader community of affected nations, including via the OECD, G20, Quad Grouping, and United Nations General Assembly.

Part 6: Recommendations for the G7 and Its Member Countries

Based on the findings of this stocktaking report, we urge the G7 and its constituent countries to consider the following recommendations:

1. Reaffirm and elevate a collective G7 political commitment to a shared vision for a world free of lead poisoning.

As highlighted in this stocktaking report, some or all G7 members are signatories to a range of declarations, international agreements, and other commitments that in part, obliquely, or indirectly reference lead. A 1997 G8 declaration also called "for further actions that will result in reducing blood lead levels in children to below 10 micrograms per decilitre",[cccxiii] while a recent G7 Environment Ministries' declaration affirmed a "strong commitment to reduce lead in the environment [and] to reduce the disproportionate lead exposure in vulnerable communities"[cccxiv]. However, a stronger, clearer, and higher-level statement is needed to define a shared vision for a world free of lead poisoning, referencing up-to-date international standards and evidence, and endorsed by the political leadership of G7 members. G7 members should therefore elevate lead poisoning as a priority issue with independent standing as a pressing global challenge, and re-affirm a collective, explicit, and high-level political commitment to a shared vision for a world free of lead poisoning.

2. Support strengthened international cooperation–among G7 members and the broader global community–to progressively reduce the burden of lead poisoning worldwide.

In line with a commitment to a world free of lead poisoning (Recommendation 1), G7 members should strengthen international cooperation to address this globally relevant issue. Specific actions for consideration include:

- In partnership with international bodies, the G20, OECD, and broad community of nations, as well as the relevant international entities, explore the potential for expanded and more structured standards, interventions, cooperation, capacity building, and monitoring to address the global burden of lead poisoning, potentially under the auspices of a voluntary or binding international agreement.

- Promote regular coordination and strategic alignment between G7 members to address sources of lead poisoning in G7 member states and in LMICs, with the potential for expanded participation from the broader community of nations.

- Encourage international standard-setting, monitoring, and reporting of lead poisoning via the relevant technical agencies, including:

    - Encourage the WHO to add national statistics on childhood blood lead levels to the Global Health Observatory database and World Health Statistics annual report;

    - Encourage the OECD to add national statistics on childhood blood lead levels to the OECD's Health Statistics database.

- Work with GEF implementing agencies to develop a GEF proposal aiming to address sources of lead poisoning, such as lead acid batteries, cookware, foods, and lead paint, building on the progress achieved on lead paint under the SAICM Global Environment Facility (GEF) Project and taking note of the UNEA Resolution (3/9) on LABs and lead paint.
- Consider expanded investments in reducing lead poisoning via other multilateral mechanisms and international organizations, potentially including the WHO, UNEP, and World Bank, including the proposed World Bank PROCLEAN trust fund.

- Expand involvement by G7 members in international cooperation to reduce lead poisoning, such as the Global Alliance to Eliminate Lead Paint.

3. Expand use of Overseas Development Assistance (ODA) to invest in global and LMICs country-level capacity to monitor, prevent, and treat lead poisoning.

As documented in this stocktaking report, G7 member states and international organizations, institutions, and mechanisms have supported bilateral and/or multilateral investments to monitor, prevent, or treat lead poisoning in LMICs. However, these initiatives have been largely indirect (e.g. focused broadly on waste management and national poison control systems), ad hoc, and small in scale relative to the importance of lead poisoning as an education, development, environment, and health challenge. G7 members, via their respective aid agencies, should elevate lead poisoning via their internal prioritization mechanisms and consider a range of potential investments within LMIC partners to respond.

Specifically, G7 aid agencies should consider initiating or expanding the following activities and investments within LMICs:

- Support LMICs to conduct initial diagnostic exercises about the prevalence of lead poisoning and relevant sources of contamination, including via nationally representative baseline surveys, potentially integrated within planned Demographic and Health Surveys (DHS) or Multi-Indicator Cluster Surveys (MICS). This may include in-kind support, e.g. the use of Italian laboratories to analyse blood samples collected via the Georgia MICs.

- In partnership with LMICs governments, support programs to strengthen in-country laboratory capacity, surveillance systems, and point-of-care detection (including relatively affordable handheld XRF devices) to enable sustained, systematic monitoring of blood lead levels and exposure pathways, including integration of lead within existing laboratory strengthening programs for health and environment.

- Increase awareness among institutional staff about the problem of lead poisoning within LMICs, including its development relevance as a health, environment, human rights, and education challenge. This could include, for example, mandatory or optional training programs for field-based staff, or guidance to integrate a lead poisoning lens as a cross-cutting theme across ODA-financed health, environment, nutrition, and education programs in LMICs.

- Support grassroots civil society organisations to advocate for lead-free air, water, food, and soil; safe housing; and non-toxic paint and consumer goods – and to educate their local communities about how to better protect themselves from some common hazards.

- Assist LMICs to establish and enforce domestic requirements or limits on lead in consumer products–e.g., toys, foods, cookware, and paint. This may include capacity-building for policy, regulatory and institutional capacity, including regulatory drafting assistance building on the success of the approaches taken in the Partnership for Clean Fuels and Vehicles and the Global Alliance to Eliminate Lead Paint

- In partnership with local universities and research institutes, fund additional research into the burden of lead poisoning; sources of lead poisoning and source-specific interventions; and the contextual LMIC harms of lead poisoning, including on educational and health outcomes, and considering potentially relevant mediating factors, for example malaria, anemia, and malnutrition.

- Consider investments in R&D to address the burden of lead poisoning that are adapted to low-resource settings, including better chelation therapy; more reliable and affordable point-of-care BLL measurement tools; and practical detection technologies to quickly and affordably detect lead contamination in consumer products.

4. Strengthen G7 leadership at home to protect G7 citizens from lead while contributing to a world free of lead poisoning.

Most lead poisoning is local–and in most cases, the opportunities to address lead poisoning will require action within LMICs themselves and by G7 members as well to protect citizens against lead poisoning while also contributing to progress against the global burden. More specifically, G7 members should consider the following actions to support a broader vision for a lead-free world:

- Lead by example by ensuring domestic regulatory standards for lead in food, paint, consumer products, and the environment are aligned with the most stringent, evidence-based levels recommended by the WHO and other technical bodies. G7 members should also consider more aggressive restrictions–or even outright bans–on the manufacture or use of lead-based compound without essential industrial application, such as lead-chromate pigment.

- Ensure compliance with the Basel convention and other existing international agreements on the cross-border movement of hazardous waste containing lead, for example waste lead-acid batteries.

- Consider expanded domestic surveillance systems following the model set by New York City, which should include source analysis, full data publication, and follow-up actions to remove lead-contaminated products from the local and global supply chains.

- Conduct a preliminary review of exports and imports of lead, products containing lead, and lead waste to inform potential measures to address the burden of lead poisoning through trade levers.

- Consider responsible sourcing regulations for G7-based importers of refined lead products–e.g., require importers to ensure lead is sourced from companies and facilities with robust safety and environmental standards, as well as their own responsible sourcing practices for unrefined lead.

- Consider regulations on the export of products containing lead, such as lead-acid batteries, for example requiring that exporters guarantee a functioning end-use system, possibly funded as part of an export license.

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