What's Causing Widespread Lead Exposure in Developing Countries?

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Two decades on from the phase-out of leaded petrol,* one in three children in low- and middle-income countries (LMICs) still have elevated blood lead levels (BLLs), threatening their cognitive development and long-term health. A recent swell of interest in the issue has raised the obvious question: where is the lead coming from? Unfortunately, the answer is extremely unsatisfying: we don't really know.

To be fair, we know a little bit. By volume, at least 85 percent of lead is now used for the production of lead-acid batteries, which are used in most vehicles and energy storage systems, including for the growing renewable energy market. Improper smelting and recycling of those batteries creates lots of local pollution, which may also disperse further afield. But because lead is relatively abundant and versatile, it also finds its way into a wide variety of other products and infrastructure in our homes, workplaces, and communities—despite its toxicity. Studies attempting to understand the primary drivers of exposure in the most affected countries have expanded the list of potential culprits to include spices, aluminum cast pots produced from scrap metal, and traditional cosmetics, on top of established sources such as paint and plumbing components.

Even in the absence of better data, all countries can start regulating lead, including through laws and enforcement measures that get lead out of paint and spices. But more broadly, the global movement to mitigate lead poisoning requires far better information on the relative importance of different sources and pathways in driving population exposure. Policymakers need to know where to focus limited financial and enforcement resources to make the most impact. Health systems need to explain individual cases or hotspots of lead poisoning in order to quickly remove sources and prevent further exposure. And for applications where there are no current alternatives to lead or lead products, establishing that the application is a key source may spur innovation into non-toxic alternatives.

Research to understand the sources of exposure—whether in an individual case of lead poisoning, in a local area, or among a large population—is known as *source assessment*. In a paper released today, and informed by a technical roundtable on the topic we held earlier this year, we provide a state-of-the-science review of source assessment for a policy audience. The paper provides scientific background for understanding the process of source assessment; presents a conceptual framework for the different objectives and subjects that it can encompass; and reviews the plethora of methods employed within it.

As we describe in the paper, most source assessment research has limited generalizability beyond the specific population(s) it studies, and there needs to be far more research carried out at the national and subnational levels. However, there are also clear patterns in exposure across countries, meaning that lessons from certain kinds of research can be shared. Our final section outlines some key knowledge gaps in understanding exposure at a global level, and puts forward potential avenues of research to address them.

Source assessment is viable in LMIC settings—with some necessary adjustments

Big picture, we find that there are a wealth of methods available for source assessment, many of which are suitable and affordable in LMIC contexts. Indeed, as we outline below, source assessment research can be fantastically cost-effective in the long term.

Nonetheless, cost can be a constraint to this kind of research. In particular, laboratory-based methods for measuring lead concentrations in environmental samples have large start-up and running costs. The dissemination of highly accurate portable XRF machines, which offer minimal marginal costs and far greater portability, has been a hugely important development in this respect. Further innovation in low-cost methods for lead detection would greatly facilitate certain forms of source assessment research, enabling more countries to evaluate the key drivers of exposure in their populations.

Another (solvable!) issue stems from the fact that the vast majority of past source assessment research has been conducted in high-income countries, especially the United States. Biokinetic modelling—a particularly useful tool to help understand the relative contributions of different sources—is therefore calibrated to a US setting. More specifically, biokinetic models combine measures of lead in different environmental media with assumptions regarding their *intake* (through inhalation and ingestion), and *uptake* by the blood once in the body. Default intake rates in biokinetic modelling come from research in the United States, and may differ to certain settings in LMICs, where dusty environments, poorer sanitation, and hand-to-mouth behaviour can be common. Validation research for biokinetic modelling in LMICs have found variable results, pointing to the need for further research to calibrate such modelling to these settings.

There are opportunities for research to have huge impact

In 2014, a Stanford PhD student called Jenna Forsyth began exploring a question that had puzzled other researchers: why did children and pregnant women in rural Bangladesh, situated away from industrial sites or other known sources, have such high blood lead levels? As we describe in the paper, she employed a number of methods to narrow down potential sources, but ultimately found strong evidence that a key driving factor was the consumption of turmeric, adulterated with lead chromate. Further market analysis showed that lead chromate was added at the polishing stage to act as a pigment and command a higher price, with polishers often unaware of its toxicity. This made it highly amenable to intervention. A national campaign to end adulteration was remarkably successful, with the proportion of market samples containing detectable lead falling from 47 percent in 2019 to 0 percent in 2021. This campaign has been linked to the moderate decline in lead exposure in the country since then, with large implications for child development and public health.

The total cost of the source assessment research? $250,000, with the intervention costing a further $300,000. Truly peanuts relative to its impact.

This story, while not entirely typical, indicates the potential value of source assessment research. In the paper we call for more investment in this research, both at a local level and to plug the knowledge gaps we outline with relevance for sources globally. Tracking down the key sources of lead exposure will take us one step closer to achieving a lead-free future for every child.

**With the exception of a few hold-outs; Algeria was the final country to ban leaded petrol in 2021*.