Proposal to GiveWell Foundation
Lead (Pb) in the Kitchen

June 8, 2021

Background

Today, one third of the world's children have lead poisoning.[1] The vast majority of these children live in low-and middle-income countries (LMICs). The implications for health, economic growth, the environment, and societal violence are profound. More than 800 million children globally have a concentration of lead in their blood above 5 micrograms per deciliter (ug/dL) – resulting in permanent brain damage and the loss of 3 to 5 IQ points. Lead exposures also result in approximately 900,000 premature deaths annually—a toll approximately equal to that of HIV/AIDS and greater than that of malaria.[2] Further, lead damages the brain's frontal cortex, reducing a person's capacity for empathy and self-control, and increasing their tendency to commit violent crime. It's these impacts to children's potential that make lead not just an environmental and health issue, but a critical and under-recognized impediment to development and stability.

Historically, lead exposures were driven primarily by the use of leaded gasoline and lead-based paint. Today, in LMICs, key exposure sources include unsafe recycling of used lead-acid batteries (ULABs), adulterated spices, and contaminated metal and ceramic cookware. Each of these sources has its own prescribed set of interventions related to the collection, dissemination, and use of exposure data; regulatory design and enforcement; economic incentives; and education and awareness. Over the past 20 years, Pure Earth has trialed many exposure-reduction interventions and has developed a strategic approach based on successes, setbacks, and lessons learned. This is not to say that solutions are easy, as they require substantial government buy-in, and the mobilization of private sector actors, development agencies, NGOs, and communities, but the path forward is clear.

Strategic Approach

Pure Earth's Global Lead Program follows a strategic approach based on three components, designed to ensure that our work is informed by the best possible information, that such information is shared broadly, and that activities to reduce exposure are replicable, sustainable, and result in measurable improvements in blood lead levels (BLLs).

1. **Data Collection:** Collect information on the scope, severity, demographics, impacts and sources of lead exposure in selected geographies to increase the efficacy and efficiency of

[1] Rees, N.; Fuller, R. (2020). The toxic truth: children's exposure to lead pollution undermines a generation of future potential. https://www.unicef.org/media/73246/file/The-toxic-truth-children%E2%80%99s-exposure-to-lead-pollution-2020.pdf
[2] Institute for Health Metrics and Evaluation (IHME). (2020). Global Burden of Disease (GBD) 2019 dataset.

subsequent intervention design and implementation. This component includes conducting baseline and endline BLL assessments, conducting rapid baseline and endline marketplace surveys or home-based source analyses to identify main sources of lead, conducting value or supply chain tracking of lead containing products, reviewing current regulatory frameworks and gaps, creating a case studies, and other activities to monitor progress and outcomes.

2. **Influence:** Share results of BLL, marketplace/source analyses, case studies, and relevant guidance with local, national, and international stakeholders to: develop educational materials for consumers, develop education and/or training materials for producers, sensitize governments to potential intervention strategies and develop joint action plans, activate resources and partners, and increase the effectiveness of lead exposure reduction programs.

3. **Intervention/Impact:** Implement lead exposure prevention and source control measures for priority sources with local partners to reduce lead exposures from identified sources and decrease baseline blood lead levels (BLLs): provide technical assistance (training, communications, joint investigations) to governments to enforce regulations and roll out public/consumer education and producer training programs.

Pure Earth's activities and interventions are intended to significantly reduce the BLLs of children. Intervention design is informed by an understanding of the main, or contributory, sources of exposure in a country or region. More details are available in Appendix A and B.

Lead in the Kitchen

While battery recycling contaminates entire neighborhoods and results in acute exposures and high BLLs (over 20 ug/dL for those within 1 km of the source), exposures are geographically limited to regions or towns in which ULABs are recycled. Lead in the kitchen is more pervasive and lead to chronic exposures, as local culinary customs may result in the ubiquitous use of lead contaminated or adulterated products. Sources of lead most commonly found in LMIC kitchens include pottery made with lead-based glazes, aluminum cookware, spices adulterated with lead for color/weight, medicines and perhaps leaded paint. Each country or geographic area can have a somewhat unique combination of lead sources that cause exposures and contribute to elevated BLLs.

Exposures from kitchen-based sources generally result in lower average BLLs at the individual level than exposure from ULAB recycling, but likely contribute more to national average BLLs due to the high number of people exposed. Daily use of contaminated spices may result in 6 - 10 ug/dL rise; lead-glazed pottery used weekly, 2 ug/dL, based on a _**preliminary**_ assessment of BLLs from exposure to a variety of lead-containing products, calculated using IEUBK modeling tools,[3] as presented in Appendix C.

[3] https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

Focusing on specific kitchen-based interventions we believe will have the largest effect with respect to reducing BLLs across a large area. The key step is to determine the sources of lead in the kitchen by conducting a source analysis. This analysis is done in the houses of children with elevated BLLs, and thus must follow a baseline blood lead study to identify appropriate households. Those sources of lead that have a large impact (based on that analysis) will be targeted for interventions. A much quicker, less expensive assessment—a marketplace analysis—can help to identify countries with likely large exposures, and give an indication of likely sources. This is an important step in fostering source control and exposure reduction efforts by governments and other actors in countries where a BLL survey is infeasible in the near-term (e.g., NYC Dept. of Health analyses identifying contaminated spices from Bangladesh prompted Stanford University and its local partner to initiate spice interventions in Bangladesh).

Interventions, while following the strategic approach outlined above, will vary depending on the type of source as well the existing regulatory framework and the socio-political context. For example, a response to contaminated spices or aluminum cookware may focus mainly on regulation and education, and be simply and rapidly effected. The complexities tend to be in supply or value chain tracking, and in government coordination. For glazed pottery, our experience in Mexico indicated that a regulatory response is not possible, as the indigenous potters are a high-value political constituency. The response needs to be educational in nature, with additional assistance around alternatives to lead-based glazes. This may not be the case in all countries that use leaded glazes. In each country, Pure Earth will design the intervention, or set of interventions, to respond to the specific local conditions. Appendix B provides an overview for a successful spice intervention that could serve as a model for other countries.

Pure Earth proposes a portfolio of lead exposure assessment and reduction activities focused on lead-contaminated products over a three-year period, conducted sequentially in target countries according to marketplace data and source apportionment results. Specifically, Pure Earth will:

- Conduct Regional Rapid Marketplace Screenings (RMS) in 20+ countries to identify lead-containing products and prioritize countries for future interventions (Year 1).
- Carry out lead exposure reduction interventions in countries where baseline BLL data and/or data on sources of lead exposure have already been collected (Bangladesh, India/Bihar), one additional Indian state to be determined, and the Philippines (Years 1-3).
- Design and launch interventions in an additional 2-3 countries, based upon the data collected from the RMS (Years 2 and 3).

See Appendix D for the project timeline.

Throughout all three years of the proposed project, Pure Earth will increase and enhance its internal monitoring, evaluation and learning (MEL) capacity through dedicated M&E staff, trainings, development of metrics, standards and protocols, and will include project-related M&E activities including, but not limited to:

- Baseline and endline spice sampling and BLL assessments
- Source analyses

- An ex-post market/source analysis (Kathgora, Bangladesh)
- An ex-post BLL analyses (Bangladesh)
- Monitoring of project outputs and outcomes

It has been the experience of both Pure Earth and our implementing partner, Global Alliance for Health and Pollution (GAHP), that targeted pollution research, source assessments and economic analyses not only provide the data required to determine appropriate interventions, but also motivate governments, civil society, and the public to act.

For example, integrating BLL testing into national health surveys (as has taken place in Mexico and Georgia) serves as a change agent. It:

- builds capacity of health workers to administer and analyze BLL tests, which is critical for the ongoing monitoring of lead levels and the impact of interventions
- empowers stakeholders such as the public, community, and civil society leaders with concrete evidence to hold relevant public and industry actors accountable to implement and monitor lead reduction interventions and policies.
- resulted in the development of national lead exposure strategies in Georgia and Mexico.

Pure Earth will also work with the GAHP to develop robust responses from other agencies and NGOs on this issue. A Global Lead Working Group will help to spread knowledge and interest in this problem within the UN system, multi-lateral development banks, NGOs, and affected country ministries of health and environment.

Regional Rapid Marketplace Screenings

The protocol for marketplace screenings will be informed by regional reviews of published literature on local lead sources to increase the likelihood of identifying “lead-positive” samples. For example, in the Caucasus region, sampling of spices containing yellow marigold flower is very important, but is less important in Latin America. In Latin America, there have been reports of contaminated chocolate, which may not be an issue in South Asia. Similarly, ayurvedic medicines from South Asia are a vast and varied product class and will require some formative research to ensure high-risk types are sampled.

Investigators will follow a protocol developed by Dr. Jenna Forsyth (Stanford University) and Dr. Petr Sharov, Pure Earth’s Director of Technical Excellence, that will include:

- 5 or 6 investigators chosen, one for each region.
- Initial desk review for likely sources.
- Coordination with local NGO/consultant to accompany investigator to marketplaces. Pure Earth-trained toxic site investigators are natural choices.
- Development of a simple online system to which investigators will upload all data from marketplace screenings.
- Implementation plan expected:
    - Visit country x (or state x for larger countries), visit 3 to 5 key markets
    - One day at each market, with local consultant supporting
    - Materials purchased taken back to office and screened by XRF

    - Data uploaded, including photos of all samples, sources (from vendor enquiry)
- Analysis conducted; multiple papers published.
- Results strategically communicated with affected countries.

In general, market screenings will sample the following types of products (specific countries will have specific sets of targeted sampling, determined by desk reviews):

- Spices
    - A focus on "loose" powdered or processed spices rather than unprocessed "whole" spices, roots or packaged spices
    - Turmeric, paprika, chili powder, curry powders, Ras El Hanout, red pepper powers, coriander, garam masala, cumin, mustard powder, saffron, ginger powder, caraway seed powder, spices containing yellow marigold
- Chocolate and candy (particularly in LAC)
- Aluminum pots
- Ceramics
- Ayurvedic medicines (specific to country)
- Cosmetics (khol, sindor, etc.) especially in South Asia
- Potentially, house paints (likely latex) and pigments. High use paints - those used on window surrounds, walls.
- Toys

As a comparison, full source analysis of homes where high BLLs have been identified will generally focus on the same products as the market screenings, but also includes a variety of other media, including: water, indoor dust, outdoor soil, local playground soil, and painted playground equipment. Source analysis is much more definitive, but also much more expensive. The Rapid Market Screenings will give a strong indication of types of exposure, and will be followed up with full source analyses in countries with significant exposures in countries where interventions are planned. This grant will fund representative baseline and endline BLL assessments in 2 additional countries, determined by the results of the Rapid Market Screenings, and by which of the most likely countries can integrate BLL testing into existing national surveys, with assistance from Vital Strategies.

Rapid Market Screenings are proposed in the following regions and countries, based on best estimates of countries with high childhood BLLs:

- South Asia: India (Jharkhand, Uttar Pradesh, Tamil Nadu and West Bengal states), Nepal, Pakistan
- Central Asia: Tajikistan
- Southeast Asia: Indonesia, the Philippines, Cambodia
- North Africa: Morocco, Egypt, Algeria
- West Africa: Nigeria, Ghana, Burkina Faso, Mali, Cote d'Ivoire, Liberia, Guinea
- Southern Africa: Zimbabwe, Lesotho, Mozambique, Namibia
- Latin America: Bolivia, Cuba, Haiti, Dominican Republic, Peru, Mexico

Country Intervention Plans

Bangladesh:
Estimated mean BLL (kids < 14): 7.5 ug/dL
Number of kids above 5 ug/dL: 35.5M
Number of kids above 10 ug/dL: 10M

Work is needed to validate a recently completed intervention that addressed turmeric adulteration in Bangladesh. That intervention reduced the prevalence of highly contaminated spice samples from a pre-intervention rate of 50% highly contaminated samples, to a post-intervention rate of 5% (90% reduction). However, the endline analysis only analyzed effects on lead concentrations in turmeric samples and did not analyze the effects on BLLs. To validate this intervention and understand the impacts on beneficiaries, an analysis of the endline BLLs is required. We propose doing this in three regions of Bangladesh where previous studies have been conducted. The first region encompasses three rural districts in northern Bangladesh's Mymensingh division where Stanford and iccdr,b researchers conducted a study of women and children. Blood samples were collected and stored for these women and children in 2014, and lead concentrations in these blood samples can now be tested to provide a baseline. The second region is Kathgora, a remediation site in Dhaka division where Stanford, iccdr,b, Pure Earth, and Dhaka University conducted BLL assessments among 70 children. The third region is in Munshiganj (near Dhaka), where a 2014 study tested over 300 children, of which 78% had elevated BLLs over 5 ug/dL. Such BLL analyses will inform all subsequent work on spice adulteration, particularly with respect to anticipated beneficiary impacts. Pure Earth considers this a crucial M&E activity with implications for many countries and activities.

<u>Scope of work:</u>

- Baseline BLL analysis on stored blood and endline blood collection and BLL analysis using atomic absorption spectrometry among 500 pregnant women and 500 children living in three rural districts of Bangladesh: Mymensingh, Kishoregani, and Tangail. Turmeric sampling also.
- Follow-up post-intervention BLL assessment among 150 children in Munshiganj.
- Publication and dissemination of results.
- Follow-up with turmeric producers and food safety regulators to ensure no further adulteration.
- Follow-up post-intervention BLL assessment among 70 children at the Kathgora remediation site. (A baseline exists, but a smaller site remediation follow-up assessment is needed to determine long term effectiveness.)

<u>Benefits:</u>

Published results on intervention impacts on BLLs will give credibility to the intervention and increase the justification for, and likelihood of replication of such interventions, and will help future implementors predict costs and benefits. Pure Earth already works collaboratively with Stanford University and icddr,b — the principal implementing partners. The researcher associated with the 2014 study in Munshiganj have also agreed to share data/detailed location information for follow up testing. These organizations are willing (and excited) to collaborate, share and publish data, and complete this final missing phase of analysis and M&E.

Risks:
Bangladesh is experiencing a spike in COVID cases, and, as of May 2021, is in full lockdown. Depending on the duration of the pandemic and Bangladesh's caseload, delays are possible.

Bihar State, India:
Estimated mean BLL (kids < 14): 14.8 ug/dL
Number of kids above 5 ug/dL: unknown
Number of kids above 10 ug/dL: unknown

India has approximately one third of the world's lead poisoned children. Pure Earth has worked on lead exposure in the Indian state of Bihar since 2016. In 2018, Pure Earth implemented a project to remediate a lead-contaminated neighborhood in suburban Patna, Bihar, and did not see the anticipated reduction in BLLs. In response, Pure Earth conducted a combined BLL and home-based source analysis in 136 homes across Patna to establish a BLL baseline and to identify other major exposure sources. The study confirmed extraordinary BLLs across the city (mean BLL of 14.8 ug/dL with 85% above 5 ug/dL) and a high prevalence of contaminated spices, particularly turmeric, but also coriander and chili powder. Among turmeric samples, 53% were above 100 ppm, and 28% were above 1000 ppm. For reference, the Bureau of Indian Standards sets an allowable level of lead in turmeric powder of 10 ppm. Interestingly, a rapid assessment of spices from other Indian states did not show similar results nation-wide, but spice contamination challenges in neighboring states of Jharkhand, Uttar Pradesh, and West Bengal as well as in Tamil Nadu (from our previous work in this state) are expected. Pure Earth now believes that the neighborhood remediation project in Patna described above did not reduce BLLs as much as expected because much of the children's exposure was from spices.

Scope of Work:

- Representative baseline BLL assessment by Vital Strategies
- Spice intervention.
- Endline BLL assessment by Vital Strategies and spice sampling.

Benefits:
GiveWell-supported work in Bihar will benefit not only from existing relationships with local organizations and government agencies, but also from existing data on baseline BLL and spice contamination. The existing understanding of exposure sources will allow Pure Earth to begin with direct intervention activities immediately. Bihar is one of the most densely populated places on Earth with about 1,106 people/km^2. The state has a population of approximately 100M. An intervention in Bihar has the potential to impact more people than the total population of many other countries. Furthermore, interventions in Bihar will inform and expedite similar interventions in one of the Indian states of Jharkhand, Uttar Pradesh, West Bengal or Tamil Nadu. Education materials and trainings can be replicated to achieve economies of scale. Ultimately, if the analyses show a similar pattern of high

BLLs and adulterated spices across the region, a multi-state intervention, based on the Bihar intervention, can be designed.

Risks:
Bihar is often regarded by Indians as a "backward" state due to extremely low development indicators and a reputation for poor government services and capacities. The success of the intervention will depend, in part, on the state government's willingness and ability to participate. Pure Earth has an existing relationship with the State Pollution Control Board, local health officials and a State hospital, all of which have participated in previous projects, but has not previously worked with the food safety agency. India is experiencing a spike in COVID cases as of May 2021. Depending on the duration of the pandemic and local caseloads, delays are possible.

Jharkhand, Uttar Pradesh, West Bengal, or Tamil Nadu, India:
As described above, prior assessments by Pure Earth found significantly elevated children's BLLs and spice-lead levels in the states of Tamil Nadu and Bihar. In the case of the latter, we suspect that these conditions do not stop at the state border but are regional, and could exist across three bordering states. To evaluate the need for interventions, Pure Earth will conduct Rapid Market Screenings in Tamil Nadu (pop.), Jharkhand (pop. 39M), Uttar Pradesh (pop. 231M), and West Bengal (pop. 100M). Depending on the results of the screenings, Pure Earth, with implementing partner Vital Strategies, will then conduct a baseline assessment of BLLs and lead sources in the homes of highly exposed children and design spice interventions likely similar to the approach implemented in Bihar (see Attachment B) in the selected state, implement the intervention, and then carry out an endline BLL survey and product sampling

Scope of Work:
- Representative baseline BLL assessment by Vital Strategies of selected state.
- Home-based source analysis.
- Spice intervention.
- Endline BLL assessment by Vital Strategies and product sampling.

The Philippines:
Estimated mean BLL (kids < 14): 5.3 ug/dL (to be updated with better data on completion of the national BLL study currently underway)
Number of kids above 5 ug/dL: 20M
Number of kids above 10 ug/dL: 1M

Pure Earth has assessed 150 contaminated sites throughout the country, but has not identified unsafe battery recycling as a major source of contamination. Pure Earth believes that lead-contaminated products are the drivers of the elevated lead levels estimated by IHME, but more data is needed. Recently, Pure Earth successfully advocated with the government of the Philippines to integrate BLL testing into its national health survey and secured funding from USAID and the Clarios Foundation, among others, and has engaged technical partners to facilitate this survey enhancement. Taking place in June 2020, the survey will measure BLLs of 3,200 children aged 6-9 and 320 pregnant women and inform us of the scale and geographic distribution of lead exposure, but not the sources. Pure Earth proposes to follow up this BLL survey with a home-based source analyses to pinpoint the primary drivers of exposure. This work will then be used to define an intervention to be undertaken beginning in Year 2.

Scope of Work:

- Analysis of government-conducted BLL survey with support from Vital Strategies
- Home-based source analysis among high BLL homes.
- Intervention(s) to be determined.
- National endline BLL survey with support from Vital Strategies, and product sampling.

Benefits:
Established in 2009, Pure Earth's Manila office has excellent connections with relevant health and environmental government agencies, as well as USAID Philippines. Further, Pure Earth Philippines will be partnering with the University of Philippines, Philippine General Hospital, and Vital Strategies in the analysis of the BLL survey and these partners are interested in participating in the source analysis, M & E and interventions as appropriate.

Risks:
Interventions must await the outcome of the source analysis.

International Coordination/Advocacy

Pure Earth will also work with GAHP to develop a robust global response to lead pollution and poisoning, with the aim to raise not only attention and awareness to the issue, but also to elevate it on the international development agenda and increase allocation, provision and access to resources to solve lead pollution at source.

GiveWell funds will support GAHP to:

1. Expand its global awareness raising and advocacy efforts particularly:
    a. With Ministries of Health and Environment of affected countries and donor/aid agencies in those countries to encourage development lead pollution prevention and reduction programming in affected LMICs.
    b. At High level political events/fora, such as the G20, UN General Assembly, the Strategic Approach to Chemicals Management (SAICM), the Basel Convention, and World Health Assembly, to encourage political support to address lead poisoning globally and action to address lead pollution through announcement, inclusion of targets around Pb pollution or poisoning or other efforts.
2. Global Lead Working Group. Coordinate with a diverse set of actors to develop and support a global response with GAHP members and network, especially the UN family
    a. Develop and host a global lead working group as a platform for knowledge exchange and to disseminate and spread knowledge and interest about this problem within the UN system, multi-lateral development banks, NGOs, and affected country ministries of health and environment, but more importantly to coordinate across agencies and

devise strategies to deal with the issue globally. The group will be modeled on Every Breath Counts Coalition (https://stoppneumonia.org/about-us/).

b. Develop and host a repository of data and efforts to eradicate lead poisoning, expanding public access to information lead pollution and lead poisoning through a reworking or reintegration of data found on www.lead.pollution.org and including results of PE Marketplace screenings.
c. Develop 1-2 regional plans of collaboration or strategies to address lead poisoning, with actions and targets. Draft and collate key case studies on successful efforts to address lead pollution and exposures.

GAHP's advocacy efforts have shown tangible results. For example, in May 2021, the European Union released its EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'. GAHP successfully lobbied to include in the document the development of a global imitative to address unsound lead acid battery recycling, which now includes this text:

> "…In particular, the increased use of cars, solar power and ICT technology has vastly expanded the use of lead acid batteries in developing countries. Their often-informal recycling exposes people, to harmful lead pollution with a major impact on children and their development. The Commission will explore a global initiative with international partners to end informal recycling of used lead acid batteries."

Monitoring, Evaluation and Learning

Pure Earth will undertake vigorous monitoring, evaluation and learning (M&E) during all three years of the proposed project, including developing metrics, standards and protocols; identifying and adopting best practices; M&E training for staff and partner organizations; monitoring key activities, budgets and project documentation, and evaluation of outcomes, impacts and achievements of the project overall. To build its capacity in MEL, Pure Earth is proposing to add full time M&E staff, engage consultants and create a working group to establish robust M&E protocols to support the proposed project.

The M&E protocols will include, but not limited to, the following key elements:

- Establishing data quality objectives for all facets of the project, including appropriate training of staff; proper collection and testing of representative samples; monitoring and maintenance of equipment; and proper data management and reporting.
- Ensuring appropriate design and implementation of statistically representative and replicable baseline and/or endline kitchen source and blood lead level data, including obtaining Institutional Review Board approval.
- Creating project-specific monitoring of expenditures and budgets, with periodic evaluation and reporting, to enhance Pure Earth's existing procedures.
- Establishing evaluation metrics to monitor the success and shortcomings of the proposed project, including impact on BLLs and kitchen sources through baseline and endline sampling of one or both in selected countries; uptake of awareness campaigns at the national and global level; and sustainability of the project outcomes.

Communications Programs

A regional public health communications consultant will be part of the eight Regional Rapid Marketplace Screening teams. This person will capture video and photos of all the project activities. They will observe and create documentation of relevant socio-economic, cultural, gender-norms, and other contextual factors that will be useful in when creating awareness-raising, outreach and educational materials in Phase 2 - Influence, and Phase 3 - Intervention/Impact of the project.

By adding this expertise to the field research team, Pure Earth will be building a network of regional public health communications capacity.

The media assets gathered can be crafted in multiple ways to deliver messages to a range of project stakeholders, targeting messages for different audience segments.

Budget Summary:

Total budget request for three years: $7,999,619
Please refer to Appendix E for detail.

Appendix A:

Lead in the Kitchen
Intervention process - spices, medicines, pottery, pots and pans

Either Marketplace Survey or Source Analysis indicates that spices, pottery, cookware, and/or medicines are adulterated/contaminated and are significant contributors to BLL.

Critical success factors	Non-critical success factors
• Government buy-in (the release of BLL data is often a catalyst for government interest and action) • Solid support network of local agencies/NGOs • Respected local implementing partner	• Support from WHO, WHA, FAO, UNEP

Program:

Data collection:
Conduct baseline BLL assessment
Conduct marketplace survey or full source analysis to assess priority lead sources
Review regulations related to priority sources to see if they already restrict lead use
Review current regulatory enforcement strength

Influence
Disseminate results of BLL testing and source analysis
Sensitize government to intervention strategies and develop joint plans for action
Develop education materials consumers
Develop education and/or training materials for product manufacturers

Impact/intervention:
Assist gov't enforcement action through training, comms and joint investigations
Roll out consumer education program
Conduct education and/or training for product manufacturers (can be substantial depending on product)
(Some actions may need to be repeated)

M&E:
Conduct market/source analysis after program is complete
Conduct BLL analysis two years after completion
Write up case study

Appendix B:

Bangladesh spice intervention

Researchers from Stanford University and icddr,b found that 31% of pregnant women in rural Bangladesh had elevated BLLs in 2014[4]. With no evidence of lead acid battery recycling or other industrial sources of exposure, they began investigating possible household sources. They hypothesized that adulterated turmeric was a major contributor and carried out an isotope fingerprinting study that confirmed the that lead in turmeric contributed to elevated BLLs among these rural women[5]. They continued to perform a supply chain investigation between 2016-2018 to determine how and why lead was ending up in the turmeric and to explore viable solutions. This involved a research team of 3-4 field investigators who traveled to the capital city and the 9 major turmeric-producing districts to collect samples and conduct interviews and observations with turmeric producers, processors, traders, and consumers. They also interviewed food safety officers and lead chromate traders. In total, more than 150 individuals were interviewed from across the supply chain and more than 500 samples of turmeric, pigments, dust, and soil were collected and analyzed for lead and chromium concentrations. The findings were published and disseminated, within approximately 9 months after the investigation[6].

Study results indicated that lead chromate was being added to turmeric by polishers, unaware of its neurotoxic effects, in order to satisfy wholesalers who are driven by consumer demand for bright yellow roots. People could no longer say that lead was an unavoidable problem from accidental lead contamination via soils or agrochemicals.

When the results of this research were published in early September 2019,[7] media coverage ranged from articles in *The Washington Post* and *The Scientist,* to headlines in the top national newspapers in Bangladesh. In December, the Bangladeshi Prime Minister announced plans to control the import of lead chromate. Stanford and icddr,b researchers met with the Bangladesh Food Safety Authority (BFSA) and developed a plan to raise widespread awareness via the distribution of 50,000 flyers and posters and one-on-one communication with notable wholesalers and turmeric processors responsible for adding lead chromate. The BFSA and icddr,b visited the major turmeric wholesale market in Dhaka to screen for lead chromate on-site using a portable XRF and to warn wholesalers of fines and other penalties. Subsequently, the BFSA held a mobile court[8] at the major market and fined two wholesalers 800,000 taka and confiscated 900 kg of adulterated turmeric. Stanford and icddr,b researchers conducted baseline turmeric lead assessments at this main market, as well as follow-up monitoring 3- and 12-months later. The investigation revealed that the prevalence of lead-tainted turmeric reduced by 90%, from 50% of samples to less than 5%. The research team conducted BLL assessments among 30 turmeric polishing mill workers in 2019 before the intervention and again in

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[4] https://www.sciencedirect.com/science/article/pii/S0013935118302196

[5] https://pubs.acs.org/doi/10.1021/acs.est.9b00744

[6] https://www.sciencedirect.com/science/article/pii/S0013935119305195#:~:text=Most%20commonly%20they%20used%20the,(%E2%80%9Cjackfruit%E2%80%9D)%20color.

[7] https://www.sciencedirect.com/science/article/pii/S0013935119305195

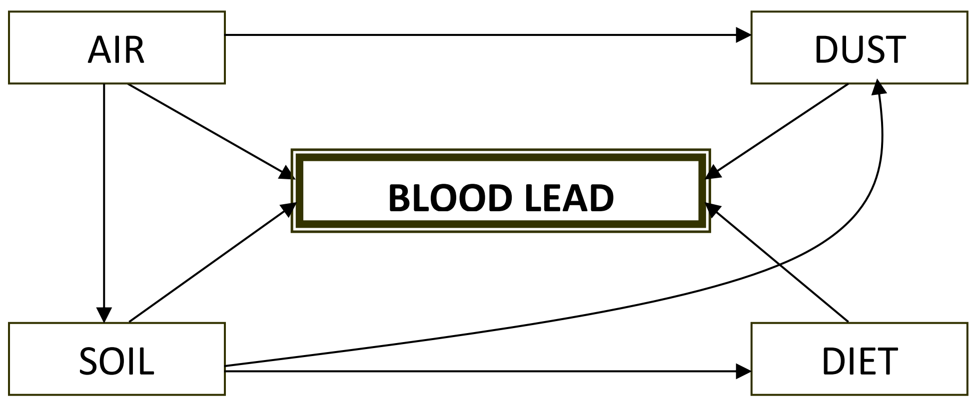
[8] https://vimeo.com/368098499

2020. Mean BLLs among these workers decreased from 9.5 mcg/dL to 5.0 mcg/dL after the mill ceased adding lead chromate.

The total cost of this intervention including the time of the field research team, lab tests and site visits was approximately $250,000.

Appendix C:

Estimates of BLL impact of various sources of lead



Each source of lead exposure listed below will be accompanied by tables showing concentrations of lead in the environment and most likely blood lead level (BLL) calculated using Integrated Exposure Uptake Biokinetic (IEUBK) model.

The IEUBK Model was developed in the United States in order to predict blood lead concentrations in children exposed to lead. This software combines estimates of lead intake from lead in air, water, soil, dust, diet, and other ingested media, with an absorption model for the uptake of lead from the lung or gastrointestinal tract, and a biokinetic model of lead distribution, and elimination from a child's body, to predict the likely distribution of blood lead for children of ages 6-84 months exposed to lead in these environmental media. The model was made to provide estimates for children since they are most sensitive to lead exposure and their health damages are most severe. The model cannot predict exact concentrations. For a given scenario the model provides results as a range of possible BLLs, geometric mean of most likely concentration and percentage of children above selected standard level.

Air is often one of the main sources of lead exposure. If air lead concentration is above 5 µg/m^3 more than 50% of exposed children are likely to have blood lead levels (BLL) above the “safe” standard of 5 µg/dl. The project does not aim to assess air pollution but inhalation of lead should be considered as an important pathway of exposure.

1. Industrial lead air pollution is usually associated processing and smelting metals, particularly production of lead, zinc and copper. But any facility that may use fuels containing lead could be a source of lead air pollution, including waste incinerators, power plants, cement plants and so on.
2. Used lead acid battery (ULAB) recycling, if it involves dismantling the batteries and heating up lead to produce ingots would cause high levels of air pollution. Children could be exposed to this pollution if they visit the ULAB recycling working area or live there or near.
3. Production of lead glazed pottery involves baking final products which may produce fumes containing lead. It could result in very high BLLs in anybody coming near the oven and inhaling those fumes.
4. Tobacco smoking could contribute to increased BLLs. In families with smoking family members children are more likely to have elevated BLLs.
5. Burning of scented materials as part of religious or other practices could be another source of lead exposure if the burned materials contain lead. In some cultures it could be big problem.

6. Leaded gasoline today is phased out in most countries, but historically it was one of the main sources of lead exposure worldwide. Today lead is still used on some aviation fuels. Because of that children living near airports servicing small (piston-engine) aircraft may have elevated blood lead concentrations.

Description	**Concentration, µg/m3**	**Geometric Mean (GM) BLL, µg/dl**	**Range, µg/dl**	**Children above 5 µg/dl, %**
USEPA Regional Screening Level (RSL) for air	1.5	**2**	1-8	3.7
Moderately polluted air	5	**5**	1-18	50
Highly polluted air in a residential area near smelter	15	**12**	3-35	97
Fumes from baking lead glazed pottery	27	**19**	4-50	99

Food could be the main or even only source of exposure to lead in an environmentally clean area. There are many ways how food could be contaminated:

1. Use of lead glazed pottery for cooking and serving food results in contaminating food with lead and increases lead exposure. This problem is well documented for Mexico. This problem could also exist in other parts of the world. For example, lead was detected in glazed pottery in Caucasus and Central Asia. Investigators should test pottery and find out if it is used for cooking.

2. Use of pots made with scape metals containing lead. The alloys used for making cookware are not supposed to include toxic metals. But some recycled metals could be contaminated with lead and used for producing pots and pans. More studies are needed to determine the scale of this problem.

3. Cooking with spices containing high concentrations of lead. In some countries lead chromate is used to improve color of some spices. The problem was confirmed in Bangladesh and Georgia and adulterated spices were found in other countries. Investigators should collect spices in local markets and use XRF to test for lead. The samples containing lead should be tested in a certified laboratory to confirm.

   Modeling using Integrated Exposure Uptake Biokinetic (IEUBK) model suggests that if a spice (e.g. turmeric) contains 1000 mg/kg lead then consumption of only 2 grams of the spice daily would result in 80% of children having BLLs above 5 µg/dl. Modeling using latest data from Georgia shows that consumption of local contaminated spices with lead concentrations of 1800 mg/kg would result in 96% of children having BLLs above 5 µg/dl and the geometric mean (most likely concentration) would be 12 µg/dl. The modeling results correspond with lead health risk assessment studies involving testing spices and blood for lead concentrations.

4. Food produced in lead contaminated areas. Soil lead contamination and air pollution may result in high concentrations of lead in plants. Animals eating those plants would be exposed to lead. Therefore, any plant or animal products could contain lead. Most countries have standards for maximum concentrations of lead in different foods.

IEUBK modeling shows that if a child consumes daily 160 g (typical 2 servings for 1 year old) of food with lead concentration 0.1 mg/kg it is likely to cause an increase of BLL by 2 µg/dl.

Testing all food in a given country is not possible. But investigators could collect some food samples if there is information that certain foods could be contaminated with lead.

5. Canned food could be a source of lead in some countries. Historically lead solder was used for food cans and caused lead poisoning. For example, in the US lead solder for food cans was prohibited only in 1995. Solders containing lead could still be used in some countries. Also, some cans may contain lead from tin-lead alloy coating. It could lead to increased concentrations of lead in canned food.

Description	**At Concentration, mg/kg (ppm)**	**Geometric Mean (GM) BLL, µg/dl**	**Range, µg/dl**	**Children above 5 µg/dl, %**
Baby food, 160 g/day	0.1	**2.4**	0.5-8	6
Cereals, 100 g/day	1	**8**	2-26	86
Eggs, 30 g/day	10	**19**	4-50	99
Spice - Turmeric, 2 g/day	1000	**8**	2-25	85
Spice - Svanuri Marili, 2 g/day	2766	**12**	3-40	97
Spice - Khmeli Suneli, 1 g/day	5100	**13**	3-40	98

Lead glazed pottery exposures

Using lead-glazed pottery	**Geometric Mean (GM) BLL, µg/dl**
1 time per week	**2.5**
3 times per week	**3.6**
7 times per week	**6.3**

(non IEUBK analysis. From Mexico ENSANUT study)

Soil lead contamination is often a result of air pollution from smelters, from crumbling leaded paint, or historical use of leaded gasoline. Soil could be also contaminated as a result of mining, metal and ore processing activities and spills of lead containing materials. In USA the Regional Screening Level for lead in soil is 400 mg/kg. According to IEUBK modeling such concentration may result in 35% of children having BLLs above 5 µg/dl.

Investigators should use XRF to test soil for lead concentrations. Clean soil usually has lead concentration 20-40 mg/kg. If the concentration is higher it means that soil is contaminated and adds to exposure of people to lead. Roughly every increase of soil lead concentration by 100 mg/kg may result in an increase of BLL by 0.5-1 µg/dl.

Description	At Concentration, mg/kg (ppm)	Geometric Mean (GM) BLL, µg/dl	Range, µg/dl	Children above 5 µg/dl, %
RSL for residential soil	400	**4**	1-15	41
RSL for industrial soil	800	**7**	2-24	81
Contaminated soil in a residential area near a source of lead pollution	1000	**9**	2-30	89
Highly contaminated soil in a residential area near a source of lead pollution	3000	**19**	4-50	99
Highly contaminated soil at a ULAB processing site	10000	**40**	4-100	99

Indoor Dust is usually contaminated with lead coming from soil brought to the house from the street. By default in IEUBK the contribution of soil lead to indoor household dust is calculated using conversion factor of 0.7. Which means the concentration of lead in indoor dust is about 70% of the concentration of lead in the soil in the yard. This was calculated based on many field studies.

Another major source of lead in indoor dust is lead based paint used for painting interiors of buildings. Chipped or deteriorating painted surface produces dust that could be inhaled and ingested by children.

Indoor dust could also be contaminated with lead as a result of air pollution, especially in industrial areas.

Drinking Water is rarely a source of exposure to lead, because all lead compounds are not very soluble. The drinking water could still be contaminated with lead if the pipes or its connections and faucets are made with lead-containing materials. Sources of drinking water could also be contaminated with lead in areas with high levels of anthropogenic or naturally occurring lead in soil, sediments and rocks.

There could be **other sources** of lead exposure of people to lead. For example, some toys could be made with materials containing lead or painted with lead-based paint. Children may chew or lick such toys and become exposed to lead.

Appendix E: Budget

GiveWell

		YEAR 1 (7/1/2021 - 6/30/2022)				
		DIRECT COSTS		INDIRECT	TOTAL	%
Country	**Months**	In-country	HQ staff			
Bangladesh	1-18	$351,193	$42,838	$70,926	$464,956	16%
India/Bihar	1-30	$395,320	$42,838	$78,868	$517,026	17%
India/other	1-30	$311,499	$42,838	$63,781	$418,117	14%
Philippines	1-30	$212,533	$42,838	$45,967	$301,337	10%
RMS	1-12	$331,591	$42,838	$67,397	$441,826	15%
Additional 2 countries	7-36		$91,508	$16,471	$107,979	4%
GAHP	1-36	$150,000		$27,000	$177,000	6%
MEL	1-36	$151,650	$121,440	$49,156	$322,246	11%
Comms	1-36	$108,000	$65,464	$31,223	$204,687	7%
TOTAL		**$2,011,786**	**$492,599**	**$450,789**	**$2,955,175**	100%
		68%	17%	15%	100%	

	YEAR 2 (7/1/2022 - 6/30/2023)				
	DIRECT COSTS		INDIRECT	TOTAL	%
Country	In-country	HQ staff			
Bangladesh	$307,255	$26,964	$60,159	$394,379	14%
India/Bihar	$245,318	$53,928	$53,864	$353,110	13%
India/other	$320,806	$53,928	$67,452	$442,185	16%
Philippines	$309,636	$53,928	$65,441	$429,005	15%
RMS					
Additional 2 countries	$426,533	$53,928	$86,483	$566,943	20%
GAHP	$150,000		$27,000	$177,000	6%
MEL	$122,685	$125,083	$44,598	$292,366	10%
Comms	$62,882	$67,428	$23,456	$153,765	5%
TOTAL	**$1,945,115**	**$435,185**	**$428,454**	**$2,808,754**	100%
	69%	15%	15%		

	YEAR 3 (7/1/2023 - 6/30/2024)				
	DIRECT COSTS		INDIRECT	TOTAL	%
Country	In-country	HQ staff			
Bangladesh					
India/Bihar	$313,939	$49,991	$65,507	$429,437	19%
India/other	$347,272	$49,991	$71,507	$468,770	21%
Philippines	$175,505	$49,991	$40,589	$266,086	12%
RMS				$0	0%
Additional 2 countries	$345,459	$99,982	$80,179	$525,620	24%
GAHP	$150,000		$27,000	$177,000	8%
MEL	$83,621	$128,836	$38,242	$250,699	11%
Comms	$30,616	$69,450	$18,012	$118,078	5%
TOTAL	**$1,446,412**	**$448,241**	**$341,037**	**$2,235,690**	100%
	65%	20%	15%		

	TOTAL				
	DIRECT COSTS		INDIRECT	TOTAL	%
Country	In-country	HQ staff			
Bangladesh	$658,449	$69,801	$131,085	$859,335	11%
India/Bihar	$954,577	$146,756	$198,240	$1,299,573	16%
India/other	$979,577	$146,756	$202,740	$1,329,073	17%
Philippines	$697,674	$146,756	$151,997	$996,427	12%
RMS	$331,591	$42,838	$67,397	$441,826	6%
Additional 2 countries	$771,992	$245,417	$183,134	$1,200,543	15%
GAHP	$450,000		$81,000	$531,000	7%
MEL	$357,956	$375,359	$131,997	$865,312	11%
Comms	$201,497	$202,342	$72,691	$476,530	6%
TOTAL	**$5,403,313**	**$1,376,025**	**$1,220,281**	**$7,999,619**	100%
	68%	17%	15%	100%	