CHARITY ENTREPRENEURSHIP

# Lead-acid Battery Recycling Regulation Advocacy

AUTHOR T. JACOBS

REVIEW F. MURÁR, V. COX

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**Ambitious Impact (AIM)** exists to increase the number and quality of effective charities improving human and animal well-being worldwide. We strive to achieve this goal through our rigorous research process and our Incubator Program, which connects talented individuals with high-impact ideas.

Our Charity Entrepreneurship Incubation Program provides potential entrepreneurs with two months of cost-covered, intensive training designed by founders for founders, along with ongoing support. Our researchers identify evidence-based, high-impact interventions and guide founders in finding co-founders to launch and scale these ideas.

**Note to readers:** Our research is designed for AIM decision-makers and Charity Entrepreneurship Incubation Program participants. It aims to identify the best ideas for our programs. Consequently, reports on those not recommended for incubation can often be less polished.

**For questions** about the content of this research, please contact Filip Murár at filip@charityentrepreneurship.com. For questions about the research process, please contact Morgan Fairless at morgan@charityentrepreneurship.com.

# Strengthening regulation of used lead-acid battery recycling / Summary

## Description

Lead-acid batteries are widely used across industries, particularly in the automotive sector. While recycling these batteries is essential because the lead inside them can be recovered and reused, it is also a major source of lead exposure—a significant environmental health hazard. Lead exposure can cause severe cardiovascular and cognitive development issues, among other health problems.

The risk is especially high when used-lead acid batteries (ULABs) are processed at informal sites with inadequate health and environmental protections. At these sites, lead from the batteries is often released into the air, soil, and water, exposing nearby populations through inhalation and ingestion. Though data remain scarce, we estimate that ULAB recycling accounts for 5–30% of total global lead exposure.

This report explores the potential of launching a new charity focused on advocating for stronger ULAB recycling policies in low- and middle-income countries (LMICs). The primary goal of these policies would be to transition the sector from informal, high-pollution recycling to formal, regulated recycling. Policies may also improve environmental and safety standards within the formal sector to further reduce pollution and exposure risks.

## Counterfactual impact

**Cost-effectiveness analysis:** We estimate that this charity could generate about 59 income doublings[1] per $1,000 (USD). However, this model carries significantly more uncertainty than our typical estimates due to limited evidence. Our model assumes that the charity would operate in three countries in parallel, with a 20% chance of success per country. If successful, we estimate that it could reduce

[1] An *income doubling* refers to an increase in a person's lifetime earnings equivalent to twice what they would have earned in a single year without the intervention, based on projected career earnings and adjusted for present value.

blood lead levels by 5% in the target country. See Section 6 for more details or view the model.

**Scale this charity could reach:** We estimate that, if this charity's work is successful, it could generate around 14,000 income doublings per year at scale per country of the size of Thailand.

### Potential for success

**Robustness of evidence:** This intervention does not have a very strong evidence base, as it largely relies on case studies (see Section 3.1). Most evidence comes from high-income countries, though around seven LMICs have also made good progress. The most relevant case is Brazil, where implementing the three policies listed above was associated with a shift away from informal recycling, reducing its share from 45% to 10%. Some of the progress made in these countries has been industry-led (like in Brazil) rather than driven by NGOs, indicating potential industry support and opportunities for collaboration.

Additionally, the experience of existing nonprofits working on lead exposure mitigation suggests strong government interest. However, we anticipate that progress on ULAB recycling will be less tractable than for other lead exposure sources due to the complexity of the lead-acid battery market.

**Theory of change (ToC):** The primary ToC focuses on country-level policy advocacy, supported by local data (quantitative and qualitative) collection on the ULAB-recycling market, along with technical assistance to governments on regulatory and enforcement issues. Initially, we propose exploring three main policies: a tax exemption for ULABs to reduce the price difference between formal and informal recycling; extended producer responsibility (EPR), which requires manufacturers or importers to ensure that ULABs are recycled in the formal sector; and the establishment of a producer responsibility organization (PRO) to oversee enforcement of these policies on behalf of the government. However, other policies may also be promising (see Section 2.3), and solutions will likely require significant country-specific tailoring.

A secondary ToC envisions accelerating global progress on this issue by generating new evidence and advising governments and NGOs on the best practices. Currently, almost no one is filling this role, and experts have emphasized that a team focused specifically on ULAB recycling would be highly valuable (see Section 2).

### Neglectedness

**Neglectedness:** We are confident that there is room for a new organization in this space. While major actors working on lead exposure—such as Pure Earth, UNICEF, and UNEP—are addressing ULABs, their efforts appear to be ad hoc rather than a core focus. However, there is some chance this could change in the short to medium funding from the Lead Exposure Action Fund increases.

**Geographic assessment:** Our analysis prioritizes countries with high lead exposure, a large informal employment sector, a sizeable population, and relatively low fragility and corruption (see Section 5.2 or view the model). Based on these criteria, we identify Indonesia, India, Pakistan, Bangladesh, Mexico, Peru, Thailand, Colombia, Argentina, and Egypt, among others, as promising locations for this intervention. In general, we expect the greatest potential in middle-income countries that already have at least one high-quality formal ULAB recycling facility.

### Other

**Expert views:** We spoke with 13 experts, who we believe represent the majority of those working in this field. Most were enthusiastic about the prospect of a new organization, emphasizing that increasing engagement in this space could generate valuable new insights. The most common concern was that Brazil's approach may not be directly applicable to other countries, as policy solutions would need to be tailored to local contexts (see Section 4).

**Implementation factors:** Our main concerns relate to access to information and execution challenges. There is a significant lack of data in this space, which will likely slow progress. Even basic details—such as the scale of lead poisoning from

ULAB recycling and the locations of recyclers—are not readily available. Combined with the economic interests of the informal ULAB recycling industry, these factors make us believe that failure is more likely than success, with the probability of successfully reducing lead exposure estimated at around 10–25% per country (see Section 7). However, even if the charity does not achieve policy change, it would still generate highly valuable information for other actors in this space.

# **Advocacy for used lead-acid battery recycling regulation** / Crucial considerations

### Can we easily close any of the information gaps for this intervention?

There are significant gaps in our understanding of this intervention, including: (i) the true scale of lead poisoning from informal ULAB recycling, (ii) the number and locations of recyclers, (iii) whether governments will be willing and able to implement the proposed policies, and (iv) the extent to which these policies would reduce lead exposure.

We do not believe these gaps can be resolved through desk research alone. However, it should be possible to address (i) and (ii) within the charity's first year of operation in a target country, while (iii) may become clearer within the first few years. (iv) is likely to remain uncertain for several years. The charity's founders should work to close these knowledge gaps where possible while recognizing that they will need to act under considerable uncertainty.

### Is this idea a good fit for the Charity Entrepreneurship Incubation Program (CEIP)?

We typically recommend CEIP ideas with a stronger evidence base and a clearer ToC. The level of uncertainty in this idea may make it less appealing to potential founders or CEIP's seed funders.

However, we believe these challenges are outweighed by the idea's potential impact. Lead exposure has gained significant attention in recent years, both from past CEIP participants and from seed funders. Additionally, the skills required to lead this charity are not highly specialized. Founders should primarily be motivated to tackle a complex problem, comfortable with uncertainty—both regarding the best courses of action and the charity's impact—and resilient in the face of slow progress.

We also believe now is a great time to launch this charity, given the neglected nature of this approach and the increasingly available funding for lead exposure mitigation.

### How does this idea overlap with the work of existing AIM-incubated charities focused on lead exposure?

The Lead Exposure Elimination Project (LEEP), an AIM-incubated charity founded in 2020, is exploring new sources of lead exposure beyond paint. ULAB recycling is one possibility under consideration. However, we expect LEEP to prioritize sources that can be addressed using a similar approach to lead paint, where it has a strong comparative advantage.

Lead Research for Action (LeRA), incubated by AIM in 2024, plans to conduct market studies to identify consumer products adulterated with lead. Since ULABs are already known to contain lead, they fall outside LeRA's current scope. Given its current strategy, LeRA's work is unlikely to significantly overlap with this charity.

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# 1 Background

**Ambitious Impact (AIM) exists to increase the number and quality of effective charities working to improve human and animal wellbeing**. AIM connects talented individuals with high-impact ideas. We give potential entrepreneurs intensive training and ongoing support to launch ideas to scale. Our research team focuses on finding impactful opportunities.

**As part of our 2024 research agenda, we reviewed interventions aimed at increasing income and economic growth**.[2] In that context, we explored the potential of advocating for stronger regulations on used lead-acid battery (ULAB) recycling. This report provides an overview of our findings.

We have previously researched various lead-related issues and, as a result, have incubated two organizations working to understand and eliminate lead exposure. Lead Exposure Elimination Project (LEEP) operates in more than 20 countries to remove lead from paint, while Lead Research for Action (LeRA) conducts actionable research and recommends targeted solutions to reduce lead exposure in neglected countries (Ladak, 2020; Murár, 2024). Where relevant, we draw on our previous research.

## 1.1 Introduction to the idea and problem

### 1.1.1 The burden of lead poisoning

**Lead (Pb) is a heavy metal that humans have used extensively for thousands of years. It is a very useful element**: it is abundant, malleable, and corrosion-resistant, with compounds that have a range of useful applications, from creating brightly colored pigments to serving as antiknock fuel agents[3] and storing energy in batteries. For its versatility and wide-ranging usefulness, it used to be considered a “gift from the gods” (Reh et al., 2021).

[2] To read more about our approach to selecting intervention ideas for our program, please see Murár (2025)
[3] Antiknock agents are chemical compounds added to fuel to prevent engine knocking (an undesirable sound emitted by engines) and improve fuel efficiency.

**At the same time, it is extremely toxic.** Exposure increases the risk of heart disease, and childhood exposure, in particular, is associated with impaired development and lower IQ levels, among other harms. The World Health Organization states that "there is no level of exposure to lead that is known to be without harmful effect" (World Health Organization, 2024).

**Lead poisoning unfortunately remains widespread**. UNICEF and the nonprofit Pure Earth estimate that one in three children worldwide suffer from lead poisoning, defined as having blood lead levels (BLL) greater than 5 µg/dL (Rees and Fuller, 2021). Nearly all these children live in low- and middle-income countries (LMICs). While these children's BLLs typically aren't high enough to cause signs of acute poisoning, they are sufficient to cause a whole range of developmental and metabolic problems, resulting in disrupted cognitive development and an increased risk of cardiovascular diseases. Lead exposure has many sources, including lead-based paint, adulterated spices, cooking food in lead-contaminated aluminum cookware, the use of ceramics with lead-based glazes, cosmetics using lead-based pigments, and the informal recycling of ULABs.

**The scale of harm is immense.** Recent studies estimate that lead-exposed children may lose, on average, around 6 IQ points (Larsen & Sánchez-Triana, 2023). This loss then results in worse learning outcomes and lower productivity. In their meta-analysis, Crawfurd et al. (2023) estimated that for every 2.7-fold increase in blood lead levels, learning outcomes declined by 0.12 standard deviations (SDs). This means that a child with a BLL of 7 µg/dL is expected to perform 0.24 SDs worse than a child with a BLL of 1 µg/dL.[4] Crawfurd and colleagues estimated that lead exposure alone may account for one-fifth of the gap in learning outcomes between rich and poor countries. Rhys Bernard and Schukraft (2021) estimate that the cognitive deficit caused by lead exposure translates into roughly $300-500 billion in lost productivity per year.[5]

[4] Note that developed countries typically have average BLLs lower than 1 µg/dL (e.g., Egan et al., 2021).
[5] However, there is significant disagreement on the exact figure due to uncertainty about the precise relationship between lead exposure and IQ, as well as between IQ and productivity in LMICs.

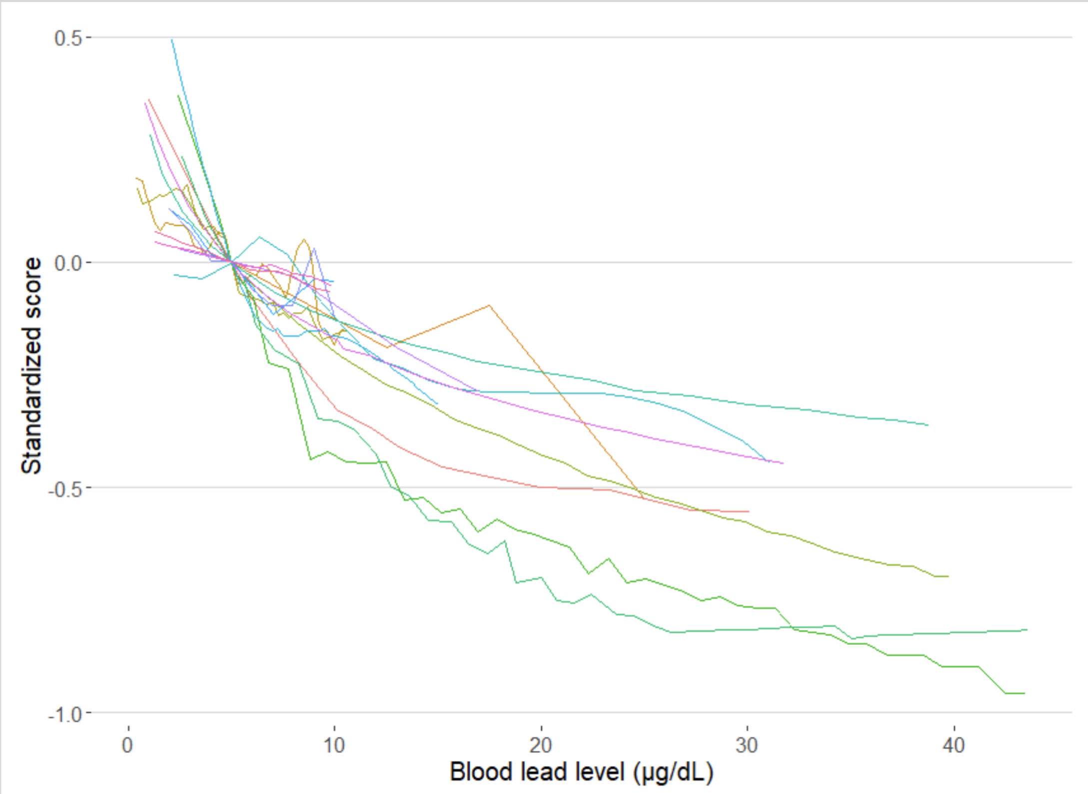


**Figure 1: A dose-response relationship between BLLs and standardized learning outcomes**, from Crawfurd et al. (2023). Each line represents data from one study.

**Lead exposure also has various other adverse effects on human health.** Recent meta-analyses have estimated that between 1.5 and 5.5 million people die each year due to the increased risk of cardiovascular diseases caused by past lead exposure (GBD 2021 Risk Factors Collaborators, 2024; Larsen & Sánchez-Triana, 2023).

**Despite these extensive negative effects, awareness of lead poisoning is very low**, both among the general public and key decision-makers, such as government officials and aid agencies (based on our expert interviews). A key problem is that lead poisoning is nearly invisible: Subclinical levels of exposure (which are most widespread) do not have any easily recognizable signs. The only way to confirm exposure is by testing people's blood for lead. However, this is rarely done in developing countries, partly due to a lack of the necessary equipment and partly due to the lack of awareness that lead exposure could be a problem at all. This has created a cycle of ignorance in the global community whereby the burden of lead exposure has long been underestimated and the sources of exposure poorly understood.

**Progress is starting to be made in reducing the burden of lead exposure.** Varying levels of progress have been seen across the different sources of lead exposure. Leaded petrol has largely been banned worldwide, and significant progress is being made to reduce exposure from lead paint, spices, and cookware. Moreover, Open Philanthropy, USAID, and other philanthropic organizations have recently initiated the Lead Exposure Action Fund (LEAF) to further accelerate progress on averting lead exposure.

**At the same time, progress on lead exposure due to the recycling of ULABs is limited, particularly in LMICs**. In general, there are two approaches that can be taken: preventing the contamination of the environment (or of consumer products) during the ULAB recycling process and cleaning up sites that have already been contaminated (so-called remediation). The latter has been done in many places by the non-profit Pure Earth (e.g., Das, 2023); however, progress on the former has been slow and uncoordinated. This report focuses on what progress can be made on limiting lead exposure by advocating for improved ULAB-recycling policies.

### 1.1.2 Lead-acid batteries (LABs)

**Lead-acid batteries (LABs) make up the largest percentage of global lead consumption**, contributing to 86% of the total global lead consumption (UNEP, 2017). As a result, the LAB industry is a 50-billion-dollar industry (Fortune Business Insights, 2024). The main uses of LABs are the automotive industry,[6] which makes up about 55% of the global market, and stationary purposes (renewable energy storage, backup power supply, telecommunications, etc.), which make up about 40% of the global market (International Lead and Zinc Study Group, 2023).

**LABs for cars contain 9–14 kg of lead on average. They are a relatively cheap type of battery and have been used for a very long time, which is why they are attractive for many applications.**

[6] In some low- and middle-income countries, as many as 40% of the automotive LABs in circulation are used for domestic power storage (Global battery alliance, 2020).

**It is unclear how the market for LABs will evolve over the coming decades, but we think it is likely to continue to grow, especially in LMICs.** This growth is largely driven by the growing demand for motorized vehicles in developing countries (WHO, 2017). The energy transition may be another driver of growth as LABs are widely used for off-grid solar systems in Africa (Kinally interview). Given the solar targets of some countries, this will very likely lead to a substantial increase in LAB usage. As stated by Pure Earth and UNICEF "there are currently no readily available, economical and environmentally sound large-scale alternatives for lead-acid batteries, particularly for vehicles" ((Rees and Fuller, 2021, p.28), so this rising battery demand will be met by LABs unless we can find a viable alternative. Although there is ongoing development of alternative ways to store energy or design batteries, it is unclear whether we will find solutions that will outcompete LABs at some point for some of its many uses. One hope is that the increased adoption of electric vehicles, which only sometimes contain LABs (see e.g. Smith, 2024a), might lower the use of LABs. However, experts expect that any impact on the market would be gradual (International Lead and Zinc Study Group, 2023).

### 1.1.3 Used lead-acid batteries (ULABs)

**Once a LAB loses its capacity and needs to be replaced, it is considered a ULAB.** A LAB's lifespan is usually 2–5 years (Wikipedia, 2024, PowerTechSystems.eu), though this can vary across different contexts and countries. In areas that are humid and warm, the battery lifespan is usually shortened ((Rees and Fuller, 2021)). For example, in Bangladesh, many LABs need to be recycled after 8 to 11 months (SMEP, 2024).[7]

**ULABs are recycled because their lead content is valuable, and the smelting process is relatively simple.** Lead is traded in the global market for ~$2,000 per metric ton (International Lead and Zinc Study Group, 2023). Between 50% to 99.9% of the lead in the batteries can be retrieved from a ULAB, depending on the quality of the recycling process. This recycled lead is mostly used for the manufacturing of new LABs (87%), while the rest is sold in rolled form, alloys, or

[7] This range may be more relevant to our target countries where LAB usage is highest (and where ULAB recycling is more informal), as these tend to be humid and warm.

ammunition (International Lead and Zinc Study Group, 2023). Therefore, ULABs in and of themselves are valuable and are traded for about 30%–60% of the price of pure lead. They make up ~55–65% of the market of refined lead worldwide. The market is especially large in Asia (International Lead and Zinc Study Group, 2023).

### 1.1.4 The harms of ULAB recycling

**During the ULAB recycling process, some fraction of the lead leaches into the environment and can become a source of exposure.** The exact percentage depends on the quality of the recycling process and, to our understanding, ranges from less than 0.1% to over 10%.

**ULAB recycling is likely a major source of lead pollution**. However, it is currently unclear what exact percentage of lead exposure comes from ULAB recycling. Some notable sources describing the scale of the ULAB recycling problem say the following:[8]

- "There is little research on quantitatively assessing the relative importance of exposure pathways [...] Our impression from conversations and the gray literature is that lead paint and unsafe recycling of lead acid batteries are the largest sources of exposure in LMICs." (Rhys Bernard & Schukraft, 2021, p.5)
- "Substandard recycling of lead-acid batteries is a leading contributor to lead poisoning in children." (UNICEF, 2020)
- "A major source of lead exposure in developing countries where regulations are less stringently enforced is [an] unsafe practice in the informal recycling of ULABs" (Asian Development Bank, 2023, p.2)

**Only a handful of authors have tried to quantify this burden**. One estimate comes from Ericson et al. (2016), which estimated that it caused 127,248 to 1,612,476 DALYs in 2013, or 0.6%–7.5% of the total lead exposure burden (Smith, 2024b).[9] This is likely a very conservative estimate as the LAB market has increased significantly since 2013, and experts have suggested that this paper may not

[8] The first two quotes are courtesy of Lead Batteries Notes' substack where more such quotes can be found.
[9] For comparison, lead paint is estimated to possibly be responsible for 2–15% of global exposure, although even that estimate is highly uncertain (Kudymowa et al., 2021)

consider all potential routes to exposure. The experts we spoke to gave estimates in the 10%–30% range. This number also undoubtedly varies from country to country.

**There are multiple ways ULAB recycling can lead to human lead exposure.[10] The main pathway is through its environmental emissions during the smelting process.** This is especially problematic in LMICs, where recycling is often done informally (see Section 1.1.5) in open-air, densely populated urban areas with few (if any) health, safety or environmental controls. This leads to "considerable amounts of lead particles and fumes [being] emitted into the air, deposited onto soil, water bodies and other surfaces" (UNEP,2017.). This emission of lead particles is the major pathway we are looking to eliminate.

**Other pathways of lead exposure from ULAB recycling include:**

- Inadequate use of operational health and safety equipment by recyclers, leading to direct worker exposure and the spread of lead particles via clothing, skin, or hair.
- Lead particles getting into nearby soil and ending up in crops, as was shown to happen in China (Gao et al., 2023).
- Lead dust collected by recyclers being sold to artisanal cookware makers (as an expert we spoke with explained).
- The dumping of lead-containing solid residue material after the recycling process—the so-called slag—into unmanaged locations, from where it can leak into the environment.
- The intentional release of the (relatively low-value) acid from the battery—which can contain some lead—into the environment.

### 1.1.4 Different types of ULAB recycling

ULAB recycling plants look different around the world. **Recyclers exist along a spectrum, from low-quality, low-investment, and high-polluting operations (most common in LMICs) to high-quality, high-investment, and low-polluting facilities (most common in HICs).** This spectrum is illustrated in Table 1.

[10] As well as exposure by non-human beings.

**Table 1: The spectrum of ULAB recycling plants.**

| Description | Information | Upfront investment | Recycling percentage of lead[11] | Pollution | Throughput |
|---|---|---|---|---|---|
| **Informal backyard recyclers** | Low skilled workers in LMICs, often individuals | Very low | 50–90% | Very high | Low |
| **Informal small-scale recyclers** | Medium skilled workers in LMICs | Low to medium | 70–90% | High | Medium |
| **Formal medium-quality recyclers** | Often the formal recyclers in LMICs are of medium quality | High | 85–97% | Medium | High - very high |
| **Formal high-quality recyclers** | Best in class recyclers, mostly in HICs | Very high | 99–99.9% | Very low | High – very high |

**Very often, the businesses of formal and informal recyclers are intertwined.** Informal recyclers can be subcontractors of formal ones. Also, the informal sector is usually not equipped for the necessary refining process before lead can be used in LABs and other products again. Therefore, informal recyclers often sell their products again to formal ones for this refining step. The exception is that in some countries, like Pakistan and Malawi, some of the informal recyclers close the recycling loop themselves by producing low-quality new LABs (based on expert interviews).

One major risk factor of informal recycling is that it requires numerous sites to achieve the same throughput as one large-scale recycler, as each informal site has a relatively low capacity. This means that the informal sector in LMICs has a large geographical spread, greatly increasing the exposure it causes.

[11] These intervals represent our best guess from (grey) literature and expert interviews and explicitly do not represent confidence intervals. The ranges may even be wider. The general idea here is that what's not recycled can become pollution (e.g., via lead dust).

### 1.1.5 The economic incentives of ULAB recycling

Due to their recyclability, ULABs are a universally valuable item and are therefore rarely directly disposed. More commonly, consumers return their ULABs to retailers/garages/workshops, and in some cases receive a levy or discount on a new battery in return. **The crux of the problem is whether the retailer then sells their collected ULABs to the formal or informal recycling sector.**

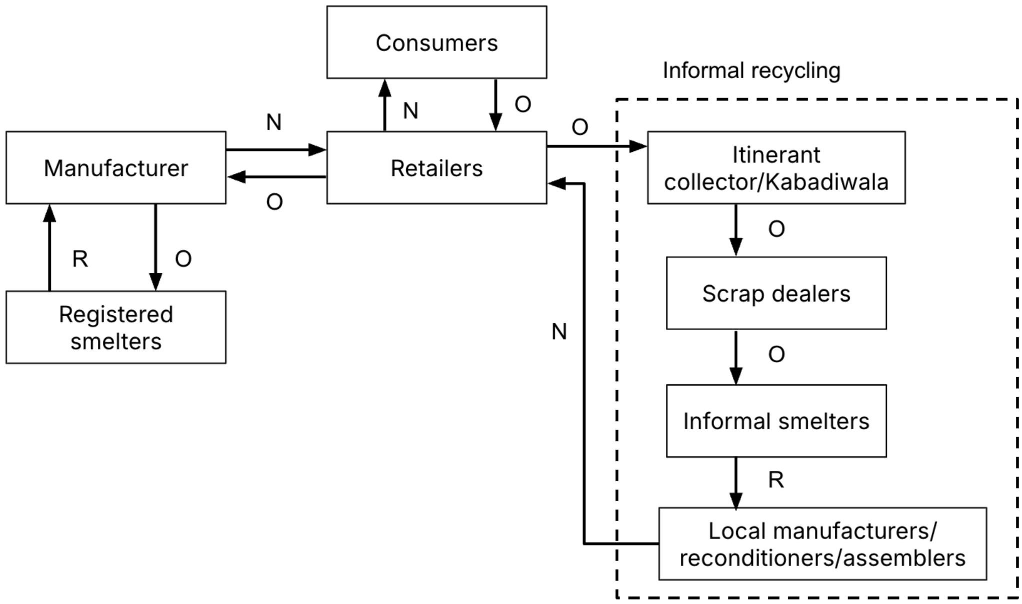


**Figure 2: Simplified supply chain of lead recycling, showcasing the formal vs. the informal industry.**[12] N) New Battery; O) Old Battery; R) Recycled Lead (Adapted from Gupt & Sahay, 2015)

**There are entrenched economic interests that allow informal ULAB recycling to perpetuate itself**. In general, the informal recycling industry can pay a higher price for a ULAB due to its lower costs compared to formal recycling businesses (UNEP, 2022). These lower costs are driven by:

- No need to add value-added tax on the sale of recycled ULABs
- Lower upfront investment costs due to far fewer and much cheaper equipment, especially as informal recycling plants do not typically pay costs associated with environmental protection such as extra baghouses/filters.

[12] Note that the reality might be fuzzier, where informal smelters sell their smelted lead to formal recyclers for further refining it into pure lead or useful alloys.

- No cost for regulatory compliance
- Lower transportation costs as informal recycling is typically more geographically spread (as opposed to formal recycling plants, which are larger and more sparsely located)

**In contrast, the only economic incentive that favors formal recyclers is that they can recycle a higher percentage of the lead in the ULAB**.

**Even where prices paid by formal and informal recyclers are comparable, people may still prefer to sell their ULABs to informal recyclers** due to their greater geographic proximity, more frequent collection schedules, and—in countries like Bangladesh—the ability to pay instantly in cash. For selling to formal recyclers to be attractive, they may need to be able to offer a *higher* price than the informal sector.

**Any formal recycling plant needs a sufficient amount of throughput for it to be a profitable investment and will decrease in profitability if not run at full capacity.** An expert mentioned that, currently, the smallest formal recyclers around the world handle about 2.5 thousand tons of ULAB, which translates to about 250 thousand ULABs per year. Therefore, in small markets, running a formal recycling plant may not be commercially viable and the only domestic option will be informal recycling.

### 1.1.6 Regulatory approaches to addressing the harms of ULAB recycling

**Given the profitable nature of informal ULAB recycling, addressing the harms arising from it requires a fundamentally different approach than for many other sources of lead exposure, such as paint or spices.** In those sources, the added lead has limited economic value[13] and coordinated regulatory action and producer outreach can eliminate lead from these products (Loudon, 2023; Forsyth et al., 2023).

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[13] Lead paint may have slightly more desirable properties than lead-free paint, and spices such as turmeric or paprika can appear more vibrant—and therefore more visually appealing—with the addition of lead compounds. However, these incentives to use lead are relatively weak and can be overcome, particularly when all producers agree to transition away from lead, ensuring no seller has an unfair competitive advantage.

**In the case of ULABs, it is necessary to change the economics in ways that incentivizes formal and/or disincentivizes informal recycling** (Smith, 2024). Advocacy for implementing these changes is the core idea behind the charity explored in this report. The different ways that governments can go about changing these incentives are discussed in Section 2 on theories of change and in the evidence review in Section 3.

We initially became excited about this idea as we were encouraged by the progress made in Brazil to regulate its ULAB recycling market and eliminate most informal recycling practices (see Section 2.2). However, as discussed in Section 2.3, the approach Brazil took may only be applicable to some countries, while other countries may require different tailored solutions.

# 2 Theories of change

## 2.1 Barriers

**We think that there are a few significant barriers that explain the lack of progress on regulating informal recycling in many LMICs.**

**First, governments don't have a limited sense of urgency on the topic.** Lead contamination and the effects of lead exposure can go unnoticed for extended periods of time. Typically, lead exposure tends to only either receive attention as a result of the actions of dedicated researchers or non-profits (LEEP, 2021; Piper, 2023) or when there is a scandal as a result of a intense intoxication (Haefliger et al., 2009; BBC, 2020), after which urgency and attention to the topic is drawn—though this can often be short-lived.

**Second, the size and scope of the problem is often unknown.** Basic information on how bad an informal recycler is, where they are operating, and what market share they have are often unclear.[14] This lack of information causes the lack of urgency described in the previous paragraph, but likely also makes it much harder to act, as it is hard to solve a problem when analysis is non-existent.

**Third, there is a limited sense that progress can be made in the field.** Few countries can be referred to as a best practice to be copied from, especially outside of HICs. Also, the topic and some solutions are somewhat technical or complex. This makes it harder for governments to imagine or discuss what progress could look like.

**Fourth, the problem is complex and technical, and coming up with appropriate strategies to address it requires experience and expertise.** For instance, formal recycling plants vary in some of their technical aspects from country to country (Mark Stevenson interview). Since much of the business happens behind closed doors, this expertise tends to be held by industry experts. However, these are sometimes not fully trusted by the government, due to perceived conflicts of interest (as highlighted e.g. by Carlos Zaim in our conversation).

[14] Note that the availability of information does differ by country. Burkina Faso and Tanzania did an inventory and trade analysis as described in this policy guide by UNEP.

**Fifth, the stakeholders who are benefitting from the status quo recycling are likely to push back against efforts for change.** These include local informal recyclers, for whom informal recycling is directly profitable, as well as, in some cases, large companies in HICs, some of whom have been documented to export ULABs to LMICs where less-well-regulated recycling is cheaper (Gottesfeld & Pokhrel, 2011, reported that "The United States exports a substantial number of used lead batteries to Mexico, South Korea, India, and other countries," p.521).

**Sixth, limited government capacity in some countries is an important barrier to progress**, as highlighted by experts we spoke with (e.g., interviews with Andreas Manhart, Dr. Jenna Forsyth and Prof. Amrita Kundu). Successfully regulating the market requires not only policy changes but also a regulatory capacity, which may be missing in many LMICs.

**Lastly, specific regulatory solutions may at first be unpalatable to policymakers.** For instance, one of the most promising approaches to incentivizing formal recycling may be to implement a tax exemption on ULABs (see Section 2.2). However, some governments may oppose this due to the risk of losing tax revenue[15] or push back against the idea of implementing a tax exemption for polluting products (which formally-recycled ULABs still are)—as was highlighted in our conversation with Andreas Manhart. We are uncertain, however, how big this barrier is and how difficult it would be to overcome with well-argued advocacy efforts.

## 2.2 Potential regulatory solutions to the harms of ULAB recycling

**There is a range of regulatory approaches that countries can take to reduce the lead exposure caused by ULAB recycling.** Some of these approaches have already been implemented in some countries (either HICs or LMICs) whereas others remain as untested ideas, only discussed by experts in this space.

[15] Even though it may actually be the case that, by formalizing the market, the overall tax revenue increases as a result of this exemption – as seems to have been the case in Brazil (Global Battery Alliance, 2019, p. 20).

**We are most enthusiastic about a set of policies implemented in Brazil since 2005, which have resulted in informal recycling rates dropping from 40–45% to around 10%** (Carlos Zaim interview). This is one of the few examples where substantial progress has been made outside of a high-income country. We think that a new organization could learn a lot from this progress in Brazil and try to adapt what has worked in Brazil to a new context. That is, **we think it could be promising for a new organization to implement the "Brazil playbook" in other countries.**

The following policy changes make up the core of the Brazil playbook (The Sustainability Consortium, 2021; Global Battery Alliance, 2020; Hirst et al., 2023, Acosta & Corallo, 2021; Scur et al., 2022; Smith, 2024):

1. Making the manufacturers and importers responsible for the recycling of ULABs, via a so-called **extended producer responsibility (EPR)**. In Brazil, this led to a **reverse logistics system** to be installed, whereby ULABs are transported back up the supply chain and make their way to the formal recyclers. This reverse supply chain applies to all parts of the supply chain: retailers, distributors, transporters, battery manufacturers, and recyclers. New and old batteries are exchanged one-for-one at every stage, and manufacturers are only allowed to recycle ULABs at hiqh-quality formal recycling plants. Non-compliance at any part of the link results in a financial penalty.
2. A **tax exemption for ULABs**. This decreases the cost difference between informal and formal recyclers. Multiple experts we spoke with (e.g., Carlos Zaim and Mark Stevenson) indicated that this may be the most important step to making formal recycling economically feasible. Various sources confirm that, in Brazil, this tax exemption—somewhat counterintuitively—**led to an increase in the overall tax revenue**. This is because it caused more lead to be recycled for a lower cost, which boosted the manufacturing and sales of new LABs, which was able to offset the lost revenue on the ULABs.
3. A **producer responsibility organization (PRO), which implements enforcement on behalf of the government and supports manufacturers and recyclers with their compliance to the new legislation**. In Brazil, this

role is played by Instituto Brasileiro de Energia Reciclável (IBER). As companies across the supply chain share data with IBER, it is well positioned to check their compliance. It then shares non-sensitive compliance data with the public and the government. For the companies, it has been more attractive to interact with a trusted and independent third party than with the government directly. Additionally, IBER has helped companies to comply with the new laws, making it likely the easiest and cheapest way for companies to ensure compliance. The costs of IBER are paid for by its members, the battery manufacturers. This way, the trusted third party is a win-win for both the government and the industry. An independent auditor checks the work of IBER, and might do spot-checks with manufacturers. In our interview, Carlos Zaim—who previously worked for the largest battery manufacturer of the world, Clarios, and was heavily involved in the introduction of legislation in Brazil—highlighted that demanding enforcement of the system was necessary. This was done via warning public servants of audits or via the justice system in case of non-compliance. More details of what IBER does and how it started are explained in this blogpost.

4. ULABs were **exempted from environmental licensing for transport**. Similar to the tax exemption, this improved the relative competitiveness of the formal recycling sector as bureaucracy and costs were reduced. This is especially relevant as formal recycling plants tend to be further from urban centers, whereas informal recycling plants are usually in densely populated urban areas.

**Multiple experts we spoke with have indicated that they would be excited about an organization trying to implement aspects of the Brazil playbook in a new country.**

**However, experts have also cautioned that there are many countries for which this playbook isn't appropriate and where different approaches should be tried.** This includes countries whose regulatory capacity is weak for the successful enforcement of the elements of the playbook; countries whose ULAB markets are too small for domestic recycling to be viable; or countries where formal plants already recycle the majority of ULABs but where the main issue is the low quality of these plants and therefore the pollution caused by them.

**As such, there are other strategies that countries may need to pursue and that this new charity should advocate for.** These include:

- **Setting up systems to facilitate and incentivize exports** of ULABs from countries without local formal recyclers to neighboring countries with formal ULAB-recycling businesses. Exporting ULABs is sometimes made more costly by bureaucratic requirements, or it is outright prohibited due to export restrictions. If these are lifted or eased, export will become more feasible and cheaper and exports will increase. This is an approach that has been followed by Burkina Faso, which exports its ULABs to formal recyclers in Ghana (UNEP, 2022).
- Facilitating the creation of a **global certification system for lead** and encouraging large battery manufacturers to only buy certified lead. This would create a strong disincentive to using the informal sector for recycling. Some of the experts we spoke with saw merit in this idea, though most of them were skeptical and raised valid concerns. Such market-based incentives might bypass the need for country-by-country legislation and could work on a global scale (Hugo Smith interview). However, others have flagged that setting up such a system may be difficult and that past attempts to do so have failed (Mark Stevenson interview). This can be seen as a high-risk, high-reward strategy.
- **Supporting formal recyclers in installing technical upgrades** that would reduce the amount of pollution produced by their plants. These may include, for instance, the installation of quality filters on the fumes produced during the recycling process. Experts have noted that NGOs and regulators need to be careful not to create a cost burden to the recyclers by requiring them to upgrade their plants, as this could again increase their financial disadvantage compared to the informal sector. Financial grants may be necessary to achieve this.
- **Shaping markets toward higher-quality, longer-lasting batteries.** Low-quality LABs may have a shorter life cycle than high-quality ones,

especially in warm, humid climates. This necessitates more frequent recycling, increasing the amount of lead pollution. Policymakers may incentivize the manufacturing of higher-quality LABs—or allow easier import of higher-quality LABs from abroad. This was suggested for the Bangladeshi context where high-quality batteries could be imported from China (Prof. Amrita Kundu interview).

- **Shaping the formal recycling market**. In countries with emerging ULAB markets—especially those in Africa where LABs are used for off-grid solar systems—it could be beneficial to shape the formal recycling market. When new formal recyclers enter the market, it can be beneficial in some cases if the government allows only a limited number of larger recycling plants, rather than multiple smaller ones. This would make regulatory efforts easier and additional environmental investments more affordable (Andreas Manhart interview).
- **Mandating the remediation of contaminated sites.** Policies that foster the remediation of toxic sites, either by the government or by the landowners will decrease lead exposure. For example, Brazil has policies that require the remediation of contaminated informal recycling sites before these are sold (Carlos Zaim interview). We are certain that such remediation causes a decrease in (local) lead exposure. For example, the clean-up of an informal ULAB recycling site in Bangladesh produced a 20% reduction in average BLLs among children in the nearby village when tested four months post remediation and by 42% when tested a year later (Pure Earth, 2019). Rethink Priorities' research made a tentative conclusion that "cleanup of toxic sites in populated areas could be cost-competitive with GiveWell top charities" (Rhys Bernard & Schukraft, 2021, p. 21).

Various other solutions have been proposed by experts in this space. We refer readers to a blog post by Smith (2024) for an extended list.

**Ultimately, to maximize the charity's chances of success and its impact, a tailored approach for every country will be necessary.** This has been highlighted to us by multiple experts we spoke with (including Andreas Manhart, who has worked on ULAB recycling in multiple countries in Africa and Asia).

## 2.3 Other potential charity activities

**Aside from advocacy for the policies listed above, there are several other ways in which a new charity could be highly impactful in this space.**

Firstly, many LMICs do not have a good understanding of their local ULAB markets, as a result of historical neglect of this topic and of many governments' limited capacities. This makes it difficult for them to fully diagnose the problem and design appropriate solutions. **A dedicated charity may be able to support governments in the collection of basic data on the local ULAB recycling market**, such as the extent of the informal recycling sector, locations of formal and informal recycling businesses and the flows of ULAB within and across the country's borders.

**A dedicated charity may also be able to fulfill the role of an expert advisor, providing governments with the locally tailored menus of options and helping them design strategies for implementing proposed solutions.** The experts we spoke with have highlighted that there is currently a major need for actors like this.[16] There are likely no individuals currently working on this topic full-time, from a solutions-oriented global perspective (an impression shared with us by Hugo Smith). Existing advisors include either industry experts—who may not be trusted to have an impartial view[17]—or part-time NGO workers and academics, whose understanding is typically limited to certain geographies. A dedicated team assuming the role of a global impartial advisor could be a major value-add.

## 2.4 Theory of change of this charity

**We think that a new charity should focus on country-by-country advocacy and technical assistance, supported by local data research and data collection**

[16] James Snowden, a grantmaker at Open Philanthropy, said that he expects that "we'll increasingly see requests for assistance from governments, so it would be very helpful to have "best practice" playbooks we could apply to ULAB regulation." To his knowledge, "those don't currently exist" at the moment.
[17] As an example, Carlos Zaim told us that he had provided advice on regulations to representatives of Colombia but struggled to gain their trust, due to his association with a battery manufacturer. He thought that an NGO might be better positioned to credibly advocate for legislative changes.

**where appropriate.** In addition, the charity may be able to maximize its impact by developing expertise on the topic of ULAB regulation and **providing governments and NGOs worldwide with tailored advice on best-practice solutions**.

It is important to highlight that we don't know which of the potential solutions will be most promising (and most feasible) in which countries or how large the effects of each solution may be. Therefore, this charity's exact path to impact is somewhat uncertain at this point, and **the charity directors will need to engage in frequent re-evaluation of potential theories of change (ToC) in order to maximize their impact.** Our belief is that implementing aspects of the Brazil playbook in countries with similar conditions to Brazil may be the most promising path to pursue; however, we could be mistaken in this assessment.

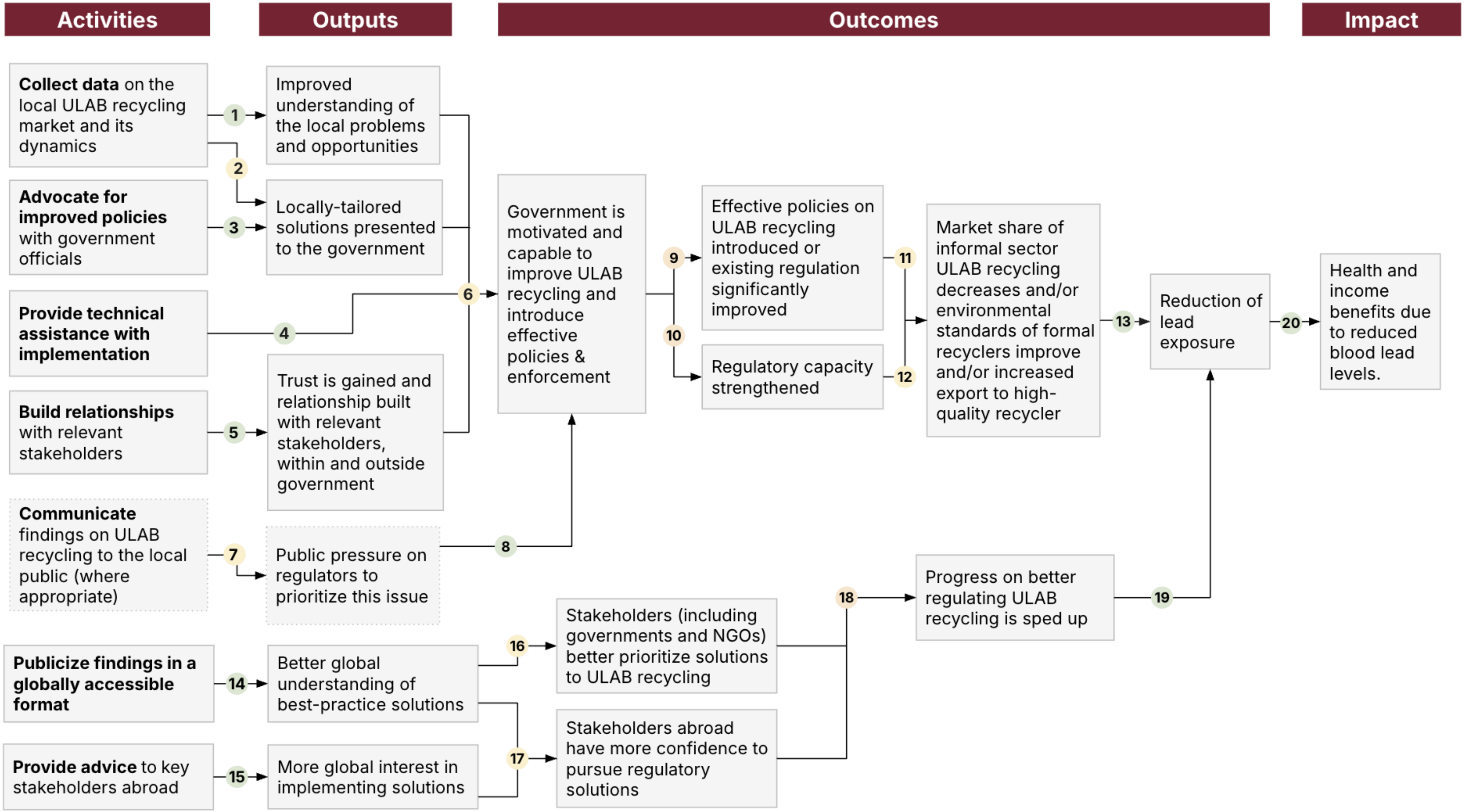


**Figure 3: The theory of change of a new charity working on better ULAB regulation.**

The theory of change makes assumptions, which are covered below in Table 2. Assumptions highlighted in green represent a low risk to the charity, whereas risks in red represent a high risk. Shades of yellow and orange represent intermediate risks.

**Table 2: Assumptions in the theory of change**

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| **1.** | **The charity can collect data to improve the understanding of the target country's problems and intervention opportunities in the local ULAB market**<br>The level of knowledge at the moment is low in many countries. We expect there to be some low-hanging fruit in terms of qualitative and quantitative data collection that the charity should be able to make progress on relatively quickly, e.g., getting some rough numbers on the percentage of recycling that happens in the informal and formal sector, locating where the informal industry operates, or assessing formal recyclers' compliance with best practices. Mapping out the supply chains of the LAB and ULAB markets in specific countries may also be beneficial and tractable. More advanced data on the relative burden from the informal vs. formal sector, effects on BLLs, or isotopic studies are likely too complex for the charity to conduct. We are unsure if this kind of research is necessary for advocacy success (this question is discussed in Section 3.1 of Murár, 2024). The charity directors should assess the need for such research based on the traction of their advocacy efforts in its (likely) absence and then, if needed, collaborate with other organizations in the lead-exposure elimination space to conduct it. |
| **2.** | **The charity can conduct research to get a better understanding of what policies would be effective**<br>This research—made up of mapping out the dynamics of the local ULAB market, investigating stakeholders' support for different solutions, and potentially small-scale pilots—will inform which regulatory solutions are most important to focus on. |
| **3.** | **The charity can advocate the government to implement proposed policy solutions**<br>Based on our conversations with experts and the experiences of existing charities in the lead space, we are confident that, in most countries, the charity will be able to have access to the relevant government stakeholders and discuss its proposed solutions with them. |
| **4.** | **The charity can deliver technical assistance**<br>Given a good understanding of what policies are effective and having relevant relationships, it seems highly likely that the charity will be able to |

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| | deliver technical assistance. Although the topic is somewhat technical, covering economics, health, and potentially some chemistry, we do think a generalist could skill up rather quickly in the field. The charity could hire an expert to support this function (akin to LEEP's early hiring of a paint technologist). |
| 5. | **Relevant relationships can be built**<br>These include relationships with formal recyclers, battery manufacturers, development banks, researchers, local environmental groups, etc. Given the small space of actors interested in ULAB regulation and their general keenness to collaborate, we are confident these relationships can be built. |
| 6. | **Efforts would lead to a motivated and capable government**<br>We think the case for making improvements to ULAB recycling will be attractive to the government, given the large health and economic burden of lead exposure. This is even more so the case when detailed information on the ULAB market—possibly complemented with case studies of affected individuals—is presented and technical assistance is provided. We are, however, somewhat less confident in the charity's ability to increase the government's capability to act in an effective way. It may be the case that some governments will lack sufficient ability to act despite the charity's technical assistance (for instance, due to being under-resourced or due to too much corruption). |
| 7. | **Public communications about the ULAB-recycling problem result in public pressure on the government**<br>In cases where the government is failing to recognize the importance of the problem despite the charity's advocacy efforts, the charity may choose to dedicate energy to public-facing communications, such as news reports about cases of individuals or communities that have been poisoned by lead as a result of informal ULAB recycling. In our interview, Andreas Manhart noted that, in his experience, political action was often only taken after a lead-poisoning scandal had occurred. We are somewhat uncertain about the ability of this charity to create such a media "scandal"—or whether it would have to wait for one to happen organically. Nevertheless, we believe that the charity should consider this approach as a way of gaining traction with its advocacy efforts. |
| 8. | **Public pressure would increase government motivation to act**<br>We are relatively confident that increased public pressure on the government would increase the government's motivation to try to find solutions to the problem. |
| 9. | **The government will successfully pass appropriate and effective** |

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| | **policies regulating the ULAB-recycling market**<br>We think that there are some significant barriers to overcome in introducing this legislation (as outlined in Section 2.1). This may make progress difficult and slow, but we do not think that any barriers are insurmountable, particularly with support from a new charity. |
| **10.** | **The charity can strengthen the country's regulatory capacity**<br>Some countries' regulatory capacity in the ULAB-recycling space may need to be strengthened to achieve success in mitigating lead exposure. This may require either strengthening in-house capabilities or setting up a third-party organization, akin to Brazil's IBER (see Section 2.2). We believe that a charity could plausibly provide technical assistance to make these outcomes more likely, but have a large uncertainty here due to the limited case studies demonstrating past success. |
| **11.** | **Passing effective policies would decrease the market share of informal sector ULAB recycling, improve the environmental standards of formal recyclers, or increase export to high-quality recyclers abroad**<br>We are moderately confident that, if a government implements the main recommended policy changes, this will lead to a change in the ULAB-recycling market (although we don't know how big this change will be). Specifically, we are most confident about the promise of implementing tax exemptions for ULABs, as there is a strong economic-theory argument for it and supportive case-study evidence (see Section 3). We are also confident in the promise of other policies, such as exemptions from environmental licensing for the transport of ULABs, lifting restrictions on the export of ULABs to countries with high-quality formal recyclers, and about mandating the need for the remediation of contaminated sites. We are somewhat less confident about the promise of implementing an EPR (as there seems to be mixed evidence on it as an isolated tool; see Sections 3.1.2 and 3.1.3.) and about raising the standards of formal recycling plants (due to the risk of a negative effect via increased prices). |
| **12.** | **Strengthening of the state's regulatory capacity leads to positive changes in the ULAB-recycling market**<br>We are moderately confident that there are ways in which a strengthened regulatory capacity results in desired changes in the market (less informal recycling, higher-quality formal recycling, or more exports to high-quality recyclers abroad). One promising way of achieving this would be to set up a PRO, as this may help formal recyclers meet environmental and health and safety standards. There are also ways in which this could fail to have an effect: (i) If there wasn't a basic level of trust between the government and industry, (ii) if the system was too inefficient, e.g. due to insufficient |

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| | digitization, or (iii) if corruption made the PRO dysfunctional. Other approaches seem less likely to us to succeed, including improving customs and regulations around import and export (as we worry that informal recyclers may find ways around the improved customs process) and cracking down on informal recyclers (which is a necessary part of better enforcement but unlikely to be effective in isolation, as the informal recyclers may just relocate, potentially worsening population lead exposure). |
| **13.** | **An improved market would lead to a reduction of lead exposure** It seems clear that the informal market creates more pollution per ULAB recycled than the formal market. However, it is not clear by what percentage lead exposure will be reduced as a result of these changes as relevant studies have not been done. |
| **14.** | **Publicizing the findings of the charity's work will improve the global community's understanding of best-practice solutions** The current information environment around best practices to regulate the ULAB market is very poor. Part-time researchers with limited experience have been able to make significant contributions to the space, which makes us confident that a full-time dedicated team would be able to make a significant contribution. |
| **15.** | **Providing advice to stakeholders abroad—including governments and NGOs—would increase the global interest in implementing solutions** While awareness of the harms resulting from ULAB recycling has been relatively high compared to other sources of lead exposure—primarily because it is well known that ULABs contain lead—there seems to be space to drive higher interest in actually implementing solutions. We think that a new dedicated charity could help drive this interest. |
| **16.** | **Better global understanding of best-practice solutions will result in better prioritization of solutions** We speculate that one way this charity could have indirect impact is by helping other actors better prioritize the solutions to ULAB recycling. While we have little evidence to support this, we think this is a likely outcome, given the current information-poor environment and the interest of many actors in finding effective solutions. |
| **17.** | **Increased global interest & understanding of possible solutions will translate into greater confidence to act** Our sense is that, while there has been some interest in the ULAB-recycling problem, many actors have been hesitant to implement solutions, due to uncertainties about the tractability and effectiveness of |

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| | different options. We believe that, by generating new evidence and case studies, this charity could increase other actors' confidence to invest resources into implementing solutions. |
| **18.** | **The charity's communications and expert advice speeds up progress on better regulating the ULAB-recycling market**<br>We speculate that this charity may ultimately be able to encourage actors in other countries to implement solutions faster than they otherwise would have, and that this could generate a significant portion of this charity's impact. However, since this part of the ToC depends on the actions of third parties, we are more uncertain about it than aspects of the ToC that are under more direct control of the charity. Nevertheless, we are encouraged by the collaborative nature and interest of large players in this space—including Pure Earth, UNICEF, and UNEP—so we believe that this path to impact is plausible. This sense was also reinforced by some of our expert conversations (see Appendix 2). |
| **19.** | **An improved market would lead to a reduction of lead exposure**<br>Similar to changes in the charity's target countries, we are confident that better regulating the ULAB-recycling market abroad will result in a reduction of lead exposure. However, we are highly uncertain about the potential magnitude of this effect. |
| **20.** | **Reduction in lead exposure leads to improved health and higher earning potential**<br>We are confident that reduced lead exposure will lead to reduced BLL. We are also highly confident that reduced BLL has health and income benefits. This is discussed further in Section 3.2. |

# 3 Evidence review

## 3.1 Case study analysis—Policy change on ULAB recycling

### 3.1.1 Brazil

Brazil is the most relevant case study and the one that we are hoping that a new charity can replicate in other LMICs.

The policies implemented in Brazil are outlined in Section 2.2. Before the introduction of these policies, 40–45% of the ULABs consumed in Brazil were recycled by the informal sector. Nowadays, it is about 10% and additional efforts are being undertaken to decrease this even further (Carlos Zaim interview).

### 3.1.2 High-income countries

**In many high-income countries, ULABs are mostly recycled in high-quality formal recycling plants** (Global Battery Alliance, 2020). We outline below the policies in place in these countries, which have created this market environment. Note, however, that it was never really the case that these countries had to move from low-quality informal recycling to high-quality formal recycling; the market was always more on the formal end of the spectrum, unlike in many LMICs.

- **The EU has an EPR for ULABs**: "The responsibility for collecting, treating and recycling, as well as public campaigns and their associated costs are with the [battery] producers" and "EU Member States must establish battery collection schemes, managed by producers or third parties, ensuring free returns for non-commercial automotive batteries without requiring new purchases." (European Commission, 2003; European Commission, 2014; Global Battery Alliance, 2020; The Sustainability Consortium, 2021; Malloci, 2004). Some European countries also use a deposit system.
    - ULAB collection rates in Europe are around 97%, and >99,5% in some countries (Seban & Nowak, 2020). Decades ago, these

numbers were much lower (20–60% in 2002), and a recycling rate target of 65% was introduced for 2008 (BBC, 2006).

- **The UK also uses a form of an EPR system on ULABs** where battery manufacturers have a "take-back obligation," requiring them to ensure used batteries are collected and recycled responsibly through certified recyclers. A cooperative scheme pools funds from producers to cover the cost of this recycling responsibility. These costs are in turn paid by consumers, as they are reflected in higher prices for new batteries. Compliance is enforced through the Waste Batteries and Accumulators Regulations (2009)[18] and through reporting requirements,[19] audits, inspections, and the risk of prosecution (Hirst et al., 2023).
- **Regulation in the US is mostly federal, with differences from state to state. Some US states have a deposit scheme for ULABs** where retailers will charge a $5–15 "return incentive payment," which is refunded if a ULAB is brought back to the retailer when purchasing a new LAB. This is a form of an EPR, as it incentivizes consumers to return their ULABs to retailers who are then required to ensure the batteries are formally recycled (New York Department of Environmental Conservation, n.d.; The Sustainability Consortium, 2021; Weinberg et al., n.d.).

### 3.1.3 Low- and middle-income countries

Here we list existing relevant policies in LMICs. This is not a comprehensive list[20] and is largely for illustrative purposes, to show the current state of play and to try and learn what has and hasn't worked in countries outside of Brazil. We also note that this list may over- or underrepresent certain practices or policies, and some sources could be outdated or incorrect. We highlight in green positive case studies where countries have made good progress in formalizing the ULAB recycling market, and highlight in red negative case studies, and in yellow mixed cases.

[18] The Waste Batteries and Accumulators Regulations (2009) mandate approval for battery treatment and recycling, which describes standards for a recycling plant to be allowed to operate.
[19] Battery recyclers must report key data to the Waste Regulation Authority, which assesses the recycling system and its compliance with relevant standards.
[20] This list is largely informed by our expert conversations or from our background reading on the topic.

- Ghana: Ghana has successfully implemented a form of an EPR, which has kept the size of the informal ULAB recycling market small. This EPR imposes a "significant levy on the price of new LABs... [that] can only be reclaimed by licensed, environmentally sound WLAB[21] recyclers. The levy is high enough to provide the licensed recyclers with a financial advantage over the informal sector because the informal sector cannot reclaim the levy." (UNEP, 2022)
- Burkina Faso: The country doesn't have any licensed ULAB recycling plants as the market size isn't sufficient to justify the necessary investments to set these up. However, looking at trade data, it seems that the majority of ULABs are being exported to Ghana for recycling. Ghana has a strong formal ULAB recycling market where informal recycling is claimed to be minimal (UNEP, 2022).
- Tanzania: There are sufficient ULABs generated each year in Tanzania for formal ULAB recycling to be financially viable. As a result, the country has three licensed formal ULAB recycling plants and there is no evidence of informal recycling (UNEP, 2022).
- Philippines: The Philippines has a functioning EPR system in place. Retailers offer discounts to those handing in ULABs when new LABs are purchased. While there is still some informal recycling, the government is addressing this, though the nationwide enforcement agency has a staff of only eight people (Sañez, 2023).
- South Africa: In South Africa, up to 90% of LABs are formally recycled. There is a levy of about $9 on a ULAB, which one can reclaim when returning a ULAB to the retailer. This deposit system originated as far back as 1942, when lead was a valuable product for ammunition in the second world war. There is a reverse logistic system in place as the retained ULABs are collected by distributors when new LABs are distributed. This deposit system is managed by the industry and is a form of EPR. The national waste information system was advanced in 2012 and "required anyone who generates, recycles, recovers, treats, disposes and/or exports hazardous waste to register such an activity in the System and to report on quarterly

[21] WLAB means waste lead-acid battery which is another word for ULABs.

basis, the quantities of hazardous waste managed". The disposal of ULABs in landfills has been prohibited and norms for storage were introduced in 2013. (Westmore, 2020, Department of Environmental Affairs, n.d.)

- Senegal: Following 18 child deaths due to lead poisoning from informal ULAB recycling in the town Thiaroye-sur-Mer, the government contacted the World Health Organization and other organizations to ask for help in formalizing the sector. Pure Earth and the International Lead Association (ILA) provided technical assistance and other support to the government, which enabled it to shut down the informal recycling plants and remediate the land. They also secured investment which allowed for a formal recycling plant to be set up. The government later allowed the import of ULABs to support this formal recycling plant and in turn prohibited the export of ULABs. We note that these efforts seem to be concentrated in Thiaroye-sur-Mer. It is unclear what the state of the industry is in other parts of the country (UNEP, 2022).
- Ethiopia: With the help of the Germany development agency and the Öko-Institut, the Ethiopian Environmental Protection Authority attempted to set up an EPR system that puts the responsibility of ensuring formal recycling on the battery manufacturer (Öko-Institut, n.d.). It is unclear how successful this project has been.
- Vietnam: The informal recycling sector has a large market share in Vietnam. An EPR system was introduced in 2022, which demands a minimal return rate of LABs of 12% in the first three years. This has largely been unsuccessful, as the law isn't accompanied with any financial incentives or penalties to enforce the recycling rate (UNDP, 2021, Huld, 2024; Hirst et al., 2023).
- Bangladesh: The problem of poor ULAB recycling is particularly large in Bangladesh. In 2018, the informal recycling sector held 50% of the market share and, in 2020, there were over 1,100 informal recyclers employing over 100,000 people (SMEP, 2024). Informal recyclers also produce new lower-quality LABs. This problem is exacerbated by the high import tariffs on LABs which diminish competition in the market. Because of this, and as a result of misinformation in the market, batteries tend to have a rather short

lifecycle (8–11 months), which increases the throughput of informal recyclers. Existing capacity at formal recycling plants isn't used optimally, as they aren't able to compete with the informal recycling sector, and because the businesses of formal and informal recyclers are intertwined (SMEP, 2024, UNEP, n.d., UNEP, 2020 and expert interviews). Policies to improve ULAB recycling are fragmented over many different local and national legislatures, and capacity to enforce this legislation is very limited. However, some progress is starting to be made as the UNEP provided technical assistance in 2020 and 2021, which led to the creation of a national strategy on lead elimination from ULAB recycling.

- India: India has a buyback program (introduced in 2001) and an EPR system in place, though the informal recycling sector still takes up about 60–80% of the market. The EPR requires formal recyclers to take back 90% of LABs that they sell, but they often only accomplish much lower percentages. There are many reasons why this EPR has largely been unsuccessful. We expect that the most significant reasons are financial: Higher costs for formal recycling due to the taxes that they have to pay on ULABs combined with low labor costs in India make the informal recycling sector more price-competitive. Additionally, informal scrap collectors lower storing costs for dealers and retailers as they collect ULABs more frequently than the supply chain related to the formal recyclers does. Moreover, the existing capacity of formal recyclers is often not used. In 2015, many formal recyclers operated at 50% of their capacity (Toxics Link, 2019; Prajapati, 2015; Gupt & Sahay, 2015; Gupt, 2015; Varshney et al., 2020; expert interviews).
    - In 2010, the EPR was extended to also apply to dealers, but enforcement of this has also been poor, as it has come with a large administrative burden for the capacity-constrained government (ibid)
    - In summer 2024, India introduced a so-called *Reverse Charge Mechanism*, which tries to tax the informal recyclers by charging the formal sector whenever their products return back into the formal sector. They also introduced a system to incentivize all organizations in the supply chain to report transactions in the supply chain to the

government. It is still too early to know whether these policies are successful or not.

- Indonesia: The informal recycling sector still takes up more than 50% of the market. Progress is difficult given the geographical situation in Indonesia, with its many islands and peninsulas, as this increases the transport costs to formal recycling plants as all formal recycling plants are currently on Java Island. This makes informal recyclers a lot more feasible and convenient. The government tried to crack down on informal recyclers, but this often only led to relocation (UNICEF, 2022, Susilorini, 2023).

## 3.2 Evidence that a charity can effect change in this space

**Of the positive case studies outlined in the section above, a handful of these were at least in part due to the work of charities.** For example:

- Pure Earth and UNEP offered technical assistance to governments in Ghana, Burkina Faso, Tanzania, and Senegal to reduce the size of the informal ULAB recycling sector. Note that the progress in Senegal may be limited to just one region.
- Pure Earth also helped the government of the Philippines put a functioning EPR system in place.

A lot of progress has also been made without the assistance of charities, most relevant of which is in Brazil where the change actually came from someone within the industry—from a battery manufacturer. We speculate that this actually increases the promisingness of charitable efforts: by partnering with battery manufacturers and jointly advocating for changes, the charity may achieve changes faster than if it were lobbying the government alone.

**There are also many examples where non-profit actors have offered assistance but progress has not been made:**

- UNEP has been working in Bangladesh and the problem is still very large there.
- UNICEF, UNEP, Vital Strategies, and Pure Earth are working in Indonesia but informal recycling still remains a large problem there.
- UNEP has been doing workshops on improving the ULAB recycling sector in Africa and Latin America for many years, but progress has still not been made in many countries in these regions.

We are most encouraged by the progress of LEEP in their work eliminating lead paint across many LMICs. Although we expect that progress on ULAB recycling will likely be significantly more difficult, LEEP's experience gives us confidence that an AIM-incubated charity can achieve policy success. We are also encouraged by experts suggesting that governments are keen to make progress on this issue and therefore will be very open to working with a new organization and receiving technical assistance to improve the market.

**Overall, although we expect progress to be difficult, we think that a new charity can make progress in this space.** A new charity will need to understand the barriers to policy change and work to overcome them and will need to build and manage relationships with many stakeholders. However, all of these activities are feasible. We are also confident that having a new organization that is entirely focused on the issue of ULAB recycling will be highly beneficial and will likely be able to make more progress than other charities working on lead exposure, which typically work across many topic areas.

## 3.3 Evidence that the change has the expected health effects

### 3.3.1 Evidence that ULAB recycling causes lead exposure

**Both informal and formal ULAB recycling plants cause lead exposure.** This largely happens through the environmental emissions during the smelting process causing lead particles to leach into the environment, but also via contaminated crops that are grown close to ULAB recycling plants, contaminated clothes of workers, lead dust sold to cookware makers, and likely many other ways (Ericson et al., 2016; Ansari et al., 2020, Rachmat et al., 2020, Kumar et al., 2022, Gao et al., 2023). We discuss these exposure pathways in more depth in Section 1.1.3.

**It is clear that ULAB recycling causes lead exposure, but it is uncertain how big the burden is.** We do not know what percentage of lead exposure can be attributed to ULAB recycling, and this apportionment surely differs from country to country. We expect that in countries with a large informal recycling sector, ULAB recycling will be one of the most significant sources of lead exposure. Expert views suggest that 10-30% of lead exposure could be attributable to ULAB recycling. We think 10-20% is a reasonable estimation.[22]

**It is also unclear what percentage of ULAB recycling is done through the informal sector in many countries.** As detailed in Section 5.2, this should be a large consideration for founders when choosing target countries. Formal ULAB recycling may also cause some lead exposure, and we do not currently understand the size of this problem. However, it is clear that informal recycling is much worse than formal recycling, especially when it is done in densely populated urban areas and without any environmental or health and safety standards.

We should also consider how the proposed interventions reduce lead exposure. **The main proposed policies—a tax exemption on ULAB recycling and an EPR—discourage future informal recycling and shut down existing informal plants, which is expected to avert exposure via further release of lead.** However, lead that has already been released may still cause human exposure. It is unclear how long lead will remain in the environment in the sites of the (in)formal recycling plants, but it is expected to be a long time (Ericson et al., 2016). To remove these sources of exposure, a total cleanup of the sites (remediation) is also necessary. With active remediation efforts, one can reduce this ongoing lead exposure. For example, studies in Bangladesh have shown that remediation can reduce mean BLL by ~28%–35% within 7–14 months (Rahman et al., 2024, Chowdury et al., 2021). Remediation efforts in former informal recycling sites by Pure Earth, also in

[22] For comparison, lead paint is estimated to possibly be responsible for 2–15% of global exposure, although even that estimate is highly uncertain (Kudymowa et al., 2021)

Bangladesh, produced a 42% reduction in average BLLs among children tested in the village (Pure Earth, 2020).

### 3.3.2 Evidence that our proposed policies reduce the rate of informal ULAB recycling

**We can see in our case study analysis in Section 3.1 that our proposed policies decrease the size of the informal ULAB recycling sector.** Most relevant is the policy change in Brazil, which reduced the size of the informal market from 40–45% of the ULABs to about 10%. Most of the other successful case study evidence comes from HICs.

**There is also a limited number of modeling studies evaluating the effectiveness of our proposed policies.** These studies largely align with the economic theory, supporting interventions like tax exemptions, and align with our intuitions and expert views. They also support what we have seen play out in practice in most case studies. We think that this evidence is suggestive but fairly weak.

- **Tax exemption for ULABs:** Taxes are a very well-studied economic topic. We found two academic studies specifically modeling the effects of tax breaks—or subsidies, which basically have the same effect—on ULABs. Joshi et al. (2021) uses a systems dynamics modeling approach showing that reducing tax on formal recyclers, or offering them a subsidy, in India, will have a positive effect on the market, shifting production from informal recyclers to formal ones (though it doesn't investigate the size of the shift). An econometric approach by Tian et al. (2023) in China showcases that subsidies need to be implemented alongside supervision and further enforcement efforts to reduce informal recycling rates in the long term. If implemented well, Tian et al. (2023) find that subsidies and supervision can reduce the number of illegal recycling enterprises and waste lead emissions by 95.6% and 45.9%, respectively, nationwide.
- **Extended producer responsibility**: EPRs are also a well-studied economic topic, although most of the studies focus on applications outside of

(U)LABs, such as tires, general e-waste or plastics. On batteries, Gupt & Sahay (2015) detail the various forms of EPR used across India and how they are ultimately ineffective due to a lack of monitoring and the invested interests of the informal sector. An analysis by the Dutch government found that its EPR for batteries has largely been successful and has been "effective in raising consumer awareness, increasing the collection of batteries, providing uniformity in collection and an increased number of collection points" (Tijm et al., 2021, p.20). Compagnoni et al. (2024) focuses on a certain aspect of this issue, namely showing that EPR can help to increase the export of waste batteries. A report assessing EPR systems for batteries in the UK and Switzerland suggests that is an effective but costly policy (Ahlers et al., 2021). Outside of batteries, much more was found on EPR systems. Most notably, we found a library on EPR practices pointing to many case studies and theoretical models, mostly outside of battery recycling. We also found case studies, such as Park et al. (2018) on waste tires, which state that EPR doesn't always achieve its goals in LMIC settings.
- **Producer Responsibility Organizations (PROs)**: The effects of PROs seem to be much less studied. Bhadra and Mishra (2021) describe the successful implementation of a PRO matching sellers and buyers for many types of waste (including ULABs) in India. Widyarsana and Nurawaliah (2023) conclude that "the involvement of producer responsibility organizations also emerges as a crucial aspect of effective EPR of e-waste [including batteries] implementation in Indonesia" (p.1). This suggests that there could be synergies between EPR and PRO and that these policies may be best implemented together.

### 3.3.3 Evidence that our proposed policies reduce lead exposure

**While we have case study evidence and modelling studies suggesting that our proposed policies can reduce the size of the informal ULAB recycling sector, we do not have any evidence outlining how much these policies can reduce BLL**, which is ultimately the thing we care about.

We rely on the following logic:

1. These policies reduce the size of the informal recycling sector
2. The informal recycling sector causes lead exposure
3. Lead exposure causes higher BLLs
4. Therefore, the policies would lower BLLs.

However, estimating how large this reduction will be is very difficult; see section 6 for our approach to this estimation. The experts we consulted were also unwilling to estimate how much the policy change in Brazil might have reduced BLL.

### 3.3.4 Evidence that lead exposure is harmful

In the interest of space, this evidence is summarized in Appendix 1.

## 3.4 Evidence on externalities and flowthrough effects

**Overall, we expect that this intervention has largely positive externalities.**

**The most significant positive externality is that reducing lead exposure for some people could have a positive effect on others**—e.g., due to decreased crime or due to societal benefits of increased economic productivity (see Appendix 1). However, we are too uncertain about these effects to give them significant weight.

**We expect this intervention to have both positive and negative flowthrough effects.** On the positive side, as there is some evidence that the lead dust from informal recycling plants is used to make cookware, shutting down these plants will mean that cookware makers will not have access to this source of lead. This should reduce the use of lead in cookware—which has been a suspected important source of exposure (Pure Earth, 2024). Moreover, the removal of lead will likely often have the additional benefit of reducing exposure to other hazardous elements, such as arsenic and cadmium, which are lead's common co-contaminants (OK International, n.d.).

On the negative side, this intervention will increase the throughput of formal recyclers, which do still pose some lead exposure concerns (Mandić-Rajčević et al., 2018).[23] Moreover, as formal recycling is generally more expensive, this could push up the cost of LABs which do have important uses, particularly in solar storage in LMICs. On the other hand, this increase in price could encourage the speed-up in research and development of alternatives to LABs, replacing and eventually removing the hazardous product from the market.

We discuss the potential harms of this intervention in Section 7.2.

# 4 Expert views

**As little relevant information is publicly available on the matter, the research process relied relatively heavily on our interviews with various experts.** We spoke with 13 experts. These conversations often had a focus on understanding the field as a whole and discussing various theories of change (ToCs).

The ULAB recycling field has a limited pool of experts, and many of them are highly knowledgeable about only a specific aspect of the topic (e.g., health impacts, environmental costs, only a certain geographical area), rather than at a broader level. The opinions on potential ToCs in particular often represent intuitions by the experts, as few ToCs have been pursued up until now. As the field is relatively small we think that we managed to speak to most of the relevant actors in the space.

**Overall, the majority of experts we spoke with see value in this type of advocacy** though many question the cross-applicability of the Brazil playbook to other countries, and instead suggest a tailored approach to each target country.[24] Experts also emphasized the need for some level of government capacity and enforcement to enable the successful implementation of the Brazil playbook.

[23] Gottesfeld et al. 2017 shows that the levels of lead contamination around formal recycling plants in Africa vary greatly, including sites with high contamination.

[24] When tailoring the approach of a new non-profit, experts pointed to the need for on the ground in-country research to be able to understand the magnitude and character of the problem and which solutions might work. Others pointed to the need to collaborate with the industry, as they are likely necessary for getting a good understanding of what will work, and industry buy-in may also be necessary for a solution to work.

**A quick summary of views is given in Table 3.** The complete summaries of each conversation with individual experts can be found in Appendix 1. We color-code expert views where green denotes experts that support a new organization working in this space, and red denotes experts that think that a new organization will find it difficult to make progress on this issue.

**Table 3: Summary of expert views**

| Expert | Organization / Affiliation | Summary of views on ULAB recycling regulation advocacy |
|---|---|---|
| Jessica Fullerton & Ben Savonen | Research and implementation at Global Development Incubator | Generally in favor of the idea, but do not expect it to be possible to be able to copy Brazil's model to other countries. They see value in the information a new initiative would bring to the field. |
| Anonymous | Grantmaker with a portfolio that includes lead exposure | Generally in favor of the idea and thinks there is room for new organizations in the space. |
| Jenna Forsyth | Researcher, Stanford University | Generally in favor of the idea. She would expect that limited progress could be made in Bangladesh, though a tax exemption might be beneficial there too. She thinks there is room for new organizations in the space, especially if it would be independent and have relevant expertise. |
| Carlos Zaim | Ex-Clarios (battery manufacturer), pushed for regulations in Brazil | Very much in favour of the idea. Carlos thinks that Brazil's playbook could work in many other countries around the world, including low income countries. |
| Hugo Smith | Undergrad student and independent researcher | Generally in favor of the idea. He thinks that the Brazil model would likely not work in low-income countries with limited enforcement capacity and widespread corruption. |
| Mikey Jarrel | UC San Diego, PhD student and independent researcher | Generally in favour of the idea. He thinks that Brazil was special in the sense that the initiative came from the industry itself. Potentially some other conditions would need to be in place for it to work in other countries. |
| Mark Stevenson | Independent consultant for recyclers and government, extensive experience in the industry | Generally in favor of the idea, but would focus on a tailored approach for every country instead of trying to copy the Brazil playbook in other countries. He thinks that there are improvements possible to the Brazil model and would expect a tax exemption for ULABs to be especially effective as a single policy. |
| Chris Kinally | PhD on african | Generally in favor of the idea. He expects the |

| Expert | Organization / Affiliation | Summary of views on ULAB recycling regulation advocacy |
|---|---|---|
| | Solar systems and ULAB recycling, researcher at Pure Earth | need for on the ground research to be able to indicate the size of the problem in a target country. |
| Russel Hirst | Wiser Group, recycling consultancy | Generally in favor of the idea. He emphasized the need for adequate enforcement of new regulations, and potential job loss in the informal sector. |
| Amrita Kundu | Georgetown University, Associate Professor | She doesn't expect this to work in Bangladesh, but thinks that it might be effective in other countries that have better regulatory capacity and stricter accounting and taxation laws. |
| Bret Ericson | Unicef, Ex-Pure Earth, World bank, Researcher | Generally in favor of the idea. Though he expects that a small NGO will only be able to make limited progress. He expects a route via international organizations (e.g. UNEP, development banks) is more likely to make progress. |
| Andreas Manhart | Öko-Institut. Environmentalist | Generally doesn't expect this to work in low-income countries, and highlights the challenge of limited enforcement capacity and the (politically) illogical nature of providing tax exemptions to a polluting industry. He stresses the need for a tailored approach based on a proper local understanding of the situation. |

# 5 Geographic assessment

## 5.1 What existing organizations do

**We spent comparatively less time on this stakeholder mapping than we have in other reports.** This is because we got the impression, by talking to experts, that very few organizations, if any, in the NGO space have a full-time focus on ULAB recycling specifically. Those who do focus on them tend to generate policy papers and provide assistance to governments on an ad hoc basis. As a result, we do not expect crowdedness to be a limiting factor for this work.

Our stakeholder mapping largely relies on the mapping we did in Murár (2024) and relevant updates from our expert interviews. A review of major international actors is presented in Table 4 below. Note that small, local NGOs are not included. There are also a number of industry consultancies that work in this space that are also not included.[25]

**Table 4: What existing organizations do and where they operate**

| Organization | What they do | Countries |
|---|---|---|
| Pure Earth | Pure Earth is the largest actor in the lead space. They have a multi-faceted approach, consisting of (i) health surveillance using BLL studies, (ii) source analyses[26], (iii) designing source-specific interventions, (iv) disseminating findings and recommendations to governments[27] and funders, and (v) investing in institutional strengthening to enhance the capabilities of local actors. They collaborate with other NGOs and academics to conduct research and put it into action.<br><br>In the period 2020-2023, they implemented projects in 31 countries, conducted 79 awareness-raising events, administered almost 12,000 BLL tests, and assessed over 5,800 product samples.<br><br>**Pure Earth has been involved in ULAB regulation projects in several countries**, including Ghana, Bangladesh, India. Their new | Countries of focus:<br>• Bangladesh<br>• India<br>• Georgia<br>• Kyrgyzstan<br>• Indonesia<br>• The Philippines<br>• Mexico<br>• Colombia<br>• Peru<br>• Ghana<br><br>They also list the following as their priority "watch list" to expand to if additional resources are secured:<br>• Zambia<br>• Zimbabwe<br>• Egypt<br>• Pakistan<br>• Nigeria |

[25] These consultancies include Wiser Group and Mark Stevenson, with whom we spoke. We did not do a comprehensive mapping of these consultancies as we deemed it out of scope. We expect there to be many more organizations and individuals that offer consultancy services to the industry.
[26] Via the Rapid Market Screening project, they worked in a total of 25 LMICs to analyze lead contamination in thousands of consumer products and food samples in markets (though, to our understanding, they do not have continued presence in all of these).
[27] They also provide technical assistance to governments to help them implement their recommendations on an ad hoc basis.

| | | |
|---|---|---|
| | lead-exposure mitigation project, which includes a focus on ULAB recycling and is scheduled to run between 2024 and 2027, targets Colombia, Egypt, Ghana, India (Bihar, Uttar Pradesh, Jharkhand), Indonesia, Peru, and The Philippines.<br><br>**They also run the** Toxic Sites Identification Program **where they identify and clean up sites polluted by ULAB recycling across 50 countries** and they also helped found the Global Alliance on Health and Pollution. | |
| Vital Strategies | Vital Strategies is a large global NGO helping governments to strengthen their public health systems. They operate in 40 countries and work on a range of public health issues, including childhood lead poisoning.<br><br>They have supported governments in Peru and Bihar, India, in setting up BLL surveillance and are working to achieve this in several other locations. **They also emphasize public awareness and better regulation of adulterated consumer products, including ULABs.** | Countries of focus:<br>• Peru<br>• Colombia<br>• India<br>• Indonesia<br>• Kyrgyzstan<br>• The Philippines |
| UNICEF | UNICEF has been focusing on the harm to children's development from lead exposure for some years. In 2020, UNICEF and Pure Earth co-published the influential Toxic Truth report.<br><br>UNICEF seems like a key player when it comes to working with governments on introducing national-level BLL surveillance (see their work in Georgia) and creating and disseminating research and policy briefs on reducing lead exposure. **This does not include a specific focus on ULABs, though their work in Indonesia may be particularly relevant here.** | *We could not find up-to-date information. We are at least aware of their policy brief in Indonesia.* |
| International Pollutants | IPEN is a global coalition working on reducing the risks to people and the | IPEN is a global coalition of more |

| | | |
|---|---|---|
| Elimination Network (IPEN) | environment caused by the production, use, and disposal of toxic chemicals.<br><br>They have also been advocating for the listing of lead chromate—a key lead compound found in many paints and adulterated spices—under the Rotterdam Convention, which would limit its importation. IPEN members have also engaged in awareness-raising campaigns and conversations with policymakers in a number of countries.<br><br>**Since 2009, they have been working on the elimination of lead in paint. We are not aware of any work on ULAB recycling.** | than 600 NGOs in over 120 countries |
| Lead Exposure Elimination Project (LEEP) | LEEP is an AIM-incubated organization that undertakes studies on lead content in paint on the market and subsequently works with policymakers and paint producers on bans (and their enforcement) and on paint reformulation. They engage in a few research activities outside of paint, including into cosmetics & spices and into measurement methods.<br><br>**They are currently exploring which other interventions to expand to and ULAB recycling is one of the options that they are considering.** | Currently operating in 20 countries and planning to expand to 10 new countries per year. |
| Lead Research for Action (LeRA) | LeRA is an AIM-incubated organization producing actionable research and recommending appropriate solutions to reduce lead exposure in neglected countries based on this research.<br><br>Their near term plans are to conduct lead content studies on consumer products in LMICs to identify the main drivers of lead exposure in each country. **This work is focused on figuring out which items contain lead, which does not include ULABs (as we already know that they contain lead).** | Two of: Kenya, Malawi, and Tanzania (still narrowing down) |

| | | |
|---|---|---|
| Occupational Knowledge International (OK International) | OK International is a nonprofit organization based in the US that seeks to reduce exposure to industrial pollutants in developing countries. They work by partnering with local organizations in LMICs, providing technical assistance, training, and certification programs, with the aim of developing local capacity to identify, monitor, and mitigate the harm of lead (among other pollutants).<br><br>**They run programs dedicated to lead paint, lead-acid batteries, hazardous cookware, and mining.** | OK International does not have local offices or staff based in LMICs. Instead, they operate in cooperation with local organizations including NGOs, academic institutions and government partners. |
| Global Alliance on Health and Pollution | An Alliance of various stakeholders, including the World Bank, UNEP, UNDP, UNIDO, Asian Development Bank, the European Commission, and Ministries of Environment and Health of many (LMICs), was set up by Pure Earth in 2012.<br><br>**It works on prioritizing addressing pollution (including from ULABs) through action plans, solutions planning, and resource mobilisation.** | Global |
| Center for Global Development (CGD) | The CGD is a "think- and do-tank for global development." It promotes the issue of lead exposure with governments and intergovernmental organizations, trying to draw interest and funding. They focus on bringing actors together, such as via the CGD Working Group on Lead Poisoning. They also produce various resources to support the movement, such as a report on tools for measuring lead exposure or a meta-analysis of the impact of lead on educational outcomes.<br><br>**They do not seem to do any specific research work or any direct work on ULAB recycling.** | Global |
| U.S. Agency for International | USAID has recently been expanding its focus on global lead exposure. They have committed $4 million toward | Countries of focus:<br>• South Africa<br>• India |

| | | |
|---|---|---|
| Development (USAID) | mitigation efforts, with hopes that this will grow in the future.<br><br>**We expect that this work will include funding interventions to improve ULAB recycling.** | • Bangladesh<br>• Nigeria<br><br>... though this list may expand |
| United Nations Environment Program (UNEP) | **The UNEP works on addressing pollution (including from ULABs) through action plans, policy guides and briefs, workshops, and solutions planning with some ad hoc technical assistance available to governments to implement these solutions.** | Global |
| Global Alliance to Eliminate Lead Paint (aka the Lead Paint Alliance) | The Lead Paint Alliance is a partnership between the United Nations Environment Program (UNEP) and the WHO, which is working on the global phase-out of paints containing lead. UNEP staff have previously been involved in lead exposure studies, but we are not aware of any systematic research programs led by them.<br><br>**They are focused on lead paint. We are not aware of any work on ULAB recycling.** | Global |
| Öko-institut | The Öko-Institut is a German applied research institute with a focus on various environmental topics. **Among the many topics that they cover, they have done some project work on ULAB recycling. These projects on ULAB recycling often focused on improving the quality of formal recycling plants, capacity building with enforcement agencies (EPAs), and technical assistance with legislators.** | Mostly Africa:<br>• Tanzania<br>• Ethiopia<br>• Ghana<br>• Uganda<br>• Nigeria |

## 5.2 Geographic prioritization

**The lack of information on ULAB recycling makes the geographical assessment for this charity idea less robust than many other ideas we have researched.** The most prominent gap in the information landscape is that there is no database on how large the informal recycling sector is per country. Moreover, for many countries, no estimates or figures could be found at all via desk research, even on an individual country basis. Similarly, there is no information on the DALY burden of ULAB recycling; i.e., we do not have an apportionment estimate of the contribution of ULAB recycling to the total lead exposure burden per country.

Our weighted factor model **is based on several input variables, many of which are proxies.** Some variables are *z*-transformed[28] and all are given a weighting[29] before being included in the overall country score. These variables include:

- Proxies for the scale of the problem by country
  - **Total DALY burden due to lead exposure** (weight = 40%): We want to target countries where the burden of lead exposure is large. However, we note that this is an imperfect proxy for the burden due to ULAB recycling as the apportioned burden between different sources of lead exposure is unclear. Therefore, it could be the case that we are prioritizing countries where the overall lead burden is high, but much of the burden is made up from sources other than ULAB recycling. Note that this total burden is a function of the country's population and burden per capita.
  - **Percentage of the whole economy that is informal** (weight = 15%): This is a proxy for the existence and extent to which ULAB recycling is done by the informal sector. We expect that a higher percentage of the economy being in the informal sector correlates with a higher percentage of ULAB recycling that is done by informal recyclers. Although this might sound logical, there is no evidence to back up this contention.
- Proxies for tractability by country
  - **The country's income level** (weight = 20%): We assigned score -1 to low-income countries (LICs); 0 to lower-middle-income countries (LMCs), and +1 to upper-middle-income and high-income countries (UMCs and HICs). This is because we expect this work to be most

[28] A *z*-transformation subtracts the mean of a variable from each value and divides it by the variable's standard deviation. This ensures that all variables are standardized.
[29] These weightings are highly subjective.

tractable in countries with a high state state capacity and capacity to enforce regulations, which will typically be UMCs and HICs. We expect lower tractability in LMCs and even lower in LICs.
    - This indicator was inverted such that if the country is a low income country then it will be given a lower score. This is a proxy for expected enforcement ability where, in general, we expect low income countries to be more capacity constrained and therefore less able to effectively enforce legislation.
    - **Corruption Perceptions Index** (weight = 5%): An index developed by Transparency International, capturing the perceived level of corruption in countries worldwide.
    - **Rule of Law Index** (weight = 5%): An index developed by the World Justice Project intended to capture how countries adhere to the rule of law in practice.
    - **Freedom in the World Index** (weight = 5%): An index developed by Freedom House that measures the degree of civil liberties and political rights.
    - **Elite consultation score** (weight = 10%): An index that estimates the extent to which policymakers consult topic experts. Based on a survey of experts.
- Proxies for neglectedness by country
    - We have not included any proxies for neglectedness. Based on our stakeholder mapping in Section 5.1, we have the impression that no organizations are working solely on improving ULAB recycling in LMICs. However, prospective charity founders should do follow-up research on their prioritized countries to make sure that there is space for a new actor there, without a duplication of efforts.

**A summary of the results from our model is shown in Table 5.** We have excluded high-income countries, as we expect that they are unlikely to face any substantial informal ULAB recycling issues, countries where we had information from experts or desk research that the informal recycling sector is small or practically non-existent, and countries that are unstable or hard to make progress in.

**Table 5: Geographic prioritization (summary of top 10 countries).**

| Rank | Country | Total DALY burden due to Lead exposure | Percentage of economy in the informal sector | Income category | Elite consultation score |
|---|---|---|---|---|---|
| 1 | **Indonesia** | 1,466,358 | 81% | UMC | 3.67 |
| 2 | **India*** | 8,168,864 | 89% | LMC | 2.70 |
| 3 | **Mexico** | 393,634 | 56% | UMC | 2.02 |
| 4 | **Pakistan** | 1,047,056 | 84% | LMC | 2.34 |
| 5 | **Vietnam** | 379,334 | 68% | LMC | 3.27 |
| 6 | **Bangladesh** | 927,511 | 82% | LMC | 1.62 |
| 7 | **Argentina** | 78,594 | 50% | UMC | 2.80 |
| 8 | **Malaysia** | 84,076 | 50% | UMC | 2.87 |
| 9 | **Colombia** | 102,365 | 56% | UMC | 2.43 |
| 10 | **Peru** | 55,943 | 72% | UMC | 2.44 |

∗Note that India is over-rated in our model by being considered as a whole. In reality, work would very likely have to take place at the state level.

**Note that this exercise was done using limited information and in a limited span of time. The results should therefore only be viewed as preliminary. I**nterested users are encouraged to alter or expand our model. Further research on country selection could include improving the proxies that try to capture the actual factor of interest (the size and burden of the informal ULAB recycling industry), and talking to experts with local experience or knowledge about the details of the situation on the ground (e.g. the appetite of the industry and government for improvements). We also suggest using the Global Lead Forum's country profiles website to better understand each country's situation.

**We think that it is very important that the co-founders of this new organization do country scoping visits to get a qualitative sense of each country's situation.** An important component of this will be understanding the scope of existing organizations work in each country, as our stakeholder mapping in Section 5.1 was fairly simplistic. When doing this scoping work, co-founders should be looking for the following (ideal) conditions:

- **There is a small number of large-scale formal lead-acid battery manufacturer(s) in the country.** We expect it will be easier to impose an effective EPR on a small number of local manufacturers compared to a situation with a large number of importers.
- **There should be at least one high-quality formal battery recycler** in the country for the ULABs to be sent to.
- **There should be enough yearly throughput of ULABs to be recycled** for the battery manufacturers and recyclers to be able to operate profitably.
- **Qualitative indicators of the government's regulatory capacity**, such as based on expert reports or past experiences from related sectors.

Additionally, the following factors may also be beneficial, though we are less confident about their necessity:

- **Functioning regulations on imports**, to be able to impose EPR on the importers.
- **The use of electronic invoice systems**, to effectively share data for the producer responsibility organization (PRO) to monitor compliance easily and effectively.
- **Buy-in from the industry**. For example, the initiative for some of the regulatory improvements initiated in Brazil came from Clarios and were thought out by the recycling industry (e.g. the creation of IBER).
- **Limited local lead mining**. Countries that don't produce "primary lead" via mining (such as Brazil) have a greater reliance on recycled, "secondary" lead.

**Given the limited number of existing case studies and success stories, it may be preferable to prioritize tractability over scale in initial country selection**, so that the charity can learn and iterate its approach before moving on to operate in other countries.

# 6 Cost-effectiveness analysis

We built a simple cost-effectiveness model for this charity idea. **Our headline estimate is that this charity could achieve cost-effectiveness of $17/consumption doubling**[30] or (equivalently) $42/DALY. This beats our bar of $100–$150/DALY.

However, **we note that this model is much more uncertain than that for a typical charity idea we investigate** due to the modelling choices made and since many inputs had to be guessed due to the lack of evidence.

In the following two sections, we describe how we approached modeling the costs and effects in our model. Section 6.3 then lists all the ways in which this model could be over- or under-estimating the potential cost-effectiveness of this charity.

## 6.1 Costs

**The costs in our model comprise two categories:** (i) standard fixed costs for co-founder salaries and other typical overheads (office, travel, etc.) of $130,000 in the first two years and $280,000 from year 3 onwards; (ii) additional policy-advocacy costs of $50,000 plus five times the local median salary per target country. We estimate that the charity may be able to operate in three countries in parallel.

**We did not model any other variable costs.** While the charity may have other additional expenses—for instance, on initial research, to understand the problem or potential solutions better—it is unclear whether these will be necessary and how costly they would be, so we did not include them.

**Altogether, we model the total annual cost of this charity to be $645,490.**

[30] Where one "consumption doubling" means one year of one person's doubled consumption and where we use the conversion of 1 DALY = 2.5 consumption doublings, based on our current moral weights (see here for more detail).

## 6.2 Effects

**We modeled the effect of the intervention in two steps**: First, we estimated the effect of the intervention on lead exposure levels. Then, we modeled the effect this reduction in exposure would have on health and economic outcomes. The second step is itself broken down into two steps: modeling the impact on health outcomes, such as cardiovascular morbidity and mortality (Section 6.2.2), and the impact on people's incomes, via the cognitive effects of lead exposure (Section 6.2.3)

### 6.2.1 Effect of the intervention on lead exposure levels

**We estimate that the percentage of lead exposure attributable to (formal and informal) ULAB recycling is around 19.5%.** This is a very uncertain figure, based on a combination of a few best-guess inputs:

- The percentage of global lead exposure that is due to direct exposure to lead particles released by ULAB recycling; based on a combination of expert interviews and our own BOTEC, we estimate this to be 15%.
- Two additional indirect paths to exposure: Via lead from ULABs making its way into artisinal cookware and via the contamination of crops grown near ULAB recycling sites. We estimate that these two together are responsible for an additional 4.5% of global exposure.

**Next, we modeled the effects of Brazil's implementation of a set of policies on lead exposure levels there.** We estimate that exposure from ULABs reduced by 62%, based on the fact that the informal sector decreased from ~45% to ~10% and by estimating that, initially, around 80% of the ULAB-related exposure was due to informal recycling.

**Lastly, we apply a set of discounts for how this effect would differ in another country.** To be conservative, we model that policies applied in the new target country would be somewhat less effective than in Brazil, would be somewhat more weakly enforced, and that contaminated-site remediation may not take place.

Together, these adjustments reduce our effect size by 69%, giving us an estimate that exposure resulting from ULABs would reduce by 19%.

**By multiplying the 19.5% and the 19% figures, we get an estimated reduction in total lead exposure of 3.8%.** We believe that this is a reasonable—and possibly conservative—estimate.

### 6.2.2 Health impacts

**To estimate the health impacts of the intervention, we used the data from the Global Burden of Disease study (GBD) on the burden of lead exposure**. Note that GBD only considers three types of harm caused by lead: an increased risk of cardiovascular disease, kidney disease, and idiopathic developmental intellectual disability.[31] We only used the former two in this part of the model, to avoid a double-counting of the cognitive effects of lead exposure, as we modeled those separately (see Section 6.2.3).[32]

**We took the estimate for Thailand in 2021[33] from the GBD portal—131,213 DALYs—and applied a discount for the percentage of the health burden that is addressable in the short term.** Our reasoning is that, if a source of lead exposure is removed at some point in time, the historical exposure will continue to cause an increased risk of morbidity and mortality. For instance, if an adult is exposed to lead for the first 50 years of their life (after which the source of exposure is removed), they may still develop cardiovascular disease caused by lead exposure at age 60. We are highly uncertain about the percentage of this kind of "locked-in" health burden, but we estimate it to be around 50% in the short term, dropping to 0% within 20 years.

Note that, for simplicity of modeling, we didn't include this drop in the discount in our model, which likely makes us underestimate the total health effect.

[31] I.e., a clinically diagnosable, significant level of cognitive disability.
[32] The burden we arrive at in that section is significantly higher than the burden modeled by GBD. This is because GBD only models the direct health disability associated with severe intellectual disability and not the (much more prevalent) subclinical neurotoxic effects of lead exposure and its impact on learning and employment outcomes.
[33] GBD suggests only a small time trend in this figure, so we didn't extrapolate it into the future.

**Overall, we model that this charity could avert 2,300 DALYs due to cardiovascular and kidney disease per year per target country** (if its advocacy work is successful in that country).

### 6.2.3 Economic impacts

**The economic part of the model is based on two steps: first, estimating the effect of lead exposure on IQ; then, modelling the effect of IQ on productivity and earnings.** In this part of the model, we follow the approach used by Murár (2024), who modeled the cost-effectiveness of conducting research on lead exposure. We refer the readers to Section 6.2 of that report for details.

There are only three differences between that model and this new model:

- **We assume that the charity would operate in Thailand** where current average BLLs are estimated at 5.1 µg/dL (instead of West Africa where we had estimated 7.2 µg/dL).
- **We estimate that our proposed policy changes would lead to a reduction of 3.8% in the overall BLL**, as described in Section 6.2.1. The CEA in Murár (2024) assumed a 12.5% reduction, but that seemed too optimistic in this case.
- **We assumed a stronger relationship between BLL and IQ.** Murár (2024) followed GiveWell (2021) in assuming that a 1 µg/dL decrease in BLLs would cause a 0.15-point increase in IQ. However, we think that this is an overly conservative figure, as the existing literature suggests that this relationship is 0.5 IQ points per 1 µg/dL at baseline BLLs below 10 µg/dL. We apply a validity 25% discount on this figure, to arrive at a value of 0.38 IQ points per 1 µg/dL.

**Our model suggests that this charity could generate a present value of 3,263 DALY equivalents per year in each target country.**

Note that this implies that these economic effects are 59% of the total benefit in our model – significantly less than on other organizations' models, such as that by LEEP (2024), who estimate that over 80% of their impact is due to the economic effects of reduced lead exposure. While we are not fully sure what is causing this difference, we suspect that a part of this is an update in the GBD model from 2019 to 2021, whereby the more recent model attributes around a 50% greater health burden to lead exposure.

## 6.3 Modeling considerations

**Various assumptions affect the final CEA result.** Some of these may be incorrect and bias our results upward or downward. In this section, we list these factors and highlight the direction in which they may be affecting the result.

**Reasons why this charity idea may be *more* cost-effective than we modeled:**

- **Unmodeled types of harm:** We only modeled the effect of lead exposure on cardiovascular disease, kidney disease, and IQ. However, as briefly reviewed in Appendix 1, lead likely has multiple other negative effects on the body.
- **Growth of the health effect over time:** As mentioned in Section 6.2.2, we believe that the health impact will grow over time; however, we haven't included this consideration in our model.
- **Additional cohorts that gain cognitive benefits:** Our model assumes that only future cohorts of children (i.e., those born after the intervention) will benefit from the averted neurotoxic effects of lead. However, to our understanding, the toxic developmental effect of lead on the brain happens over time during the first several years of life, not just before or at birth. As such, several additional cohorts of children are likely to partly benefit from this intervention. However, we have not included this consideration in our model.
- **Indirect path to impact:** As visualized in our ToC in Section 2.4, this charity may generate impact by speeding up progress on ULAB recycling in its non-target countries and sharing information and best practices with other actors. This potential impact isn't included in our model.
- **Value of information** (e.g. for funders): Related to the previous point, by generating insights and evidence, this charity is likely to benefit actors—such as governments and funders—and help them make better

decisions. For instance, if it turns out that making progress on ULAB recycling in LMICs is particularly intractable, it may direct funding to other, more tractable problems (thereby creating counterfactual impact even in the absence of progress on ULABs specifically).

**The following considerations could move the cost-effectiveness in either direction:**

- **The burden of lead exposure:** We relied on GBD's 2021 model for input on the total health burden attributable to lead exposure. However, as a result of poor primary data on lead exposure and a relatively poor understanding of the size of its health effects, this GBD figure has very low accuracy. The estimate's 95% confidence intervals are greater than the mean – implying that the total burden, in Thailand, may be several times less or more than twice as much as GBD's point estimate. This uncertainty can be seen in the evolution of these estimates: The GBD 2019 model provides 44,779 DALYs as the annual health burden in Thailand but the 2021 model says 126,477 DALYs – a figure three times greater.
- **The relationship between IQ and income:** We assumed that productivity (and also people's wages) increases by 0.67% per each extra IQ point. This value is based on GiveWell's (2019) review of studies done in LMICs in the past. However, this relationship may change: On the one hand, it may grow stronger as countries develop – for comparison, the historical figure in HICs is a ~2.0% increase in wages per IQ point. On the other hand, it may become weaker, e.g. if developments in AI weaken the returns to human intelligence.
- **Choice of target country:** We modeled policy changes in Thailand, as this is an average-sized country from the top 20 countries in our geographic assessment. A different choice of country will alter our result.
- **Number of countries the charity can work in in parallel**: We assumed that the charity would be able to work in three countries of the size of Thailand in parallel. In reality, this may turn out to be either overly optimistic or pessimistic.

- **Number of staff needed:** We assumed that a charity operating in three countries would need its small team of central staff plus five staff members per country. However, this is a very uncertain guess.
- **Chance of success:** We assumed a 20% chance of success per targeted country. We think this is reasonable as some experts say that change is possible in this space, and LEEP has shown that a policy approach for working on lead contamination can be successful. However, progress may turn out to be easier or harder to make in this space than we expect.
- **Number of years until impact**: We assumed that the charity—if successful in its first target country—would first generate benefits (in terms of reduced lead exposure) in its third year of operation. In reality, progress on policy change and implementation may take longer to achieve. Or it could take less time, as we have seen in LEEP's case.
- **Time discount rates:** As in our other models, we used a basic time discount rate of 4.0% for costs and income benefits and 1.4% for health benefits. However, these choices are somewhat subjective and debatable. In addition, for simplicity of modeling, we used a single discount rate of 3.2% for benefits, calculated as a weighted average of the 4.0 and 1.4 figures. If we instead modeled health and income benefits separately with their respective discount rates, we would have gotten a somewhat different result.
- **Assumptions about counterfactuals**: We assumed a 4% per year probability that this kind of work would happen anyway as a result of the work of other actors (e.g., other NGOs, governments, international multi-lateral organizations, etc.). However, we are very uncertain about the appropriate values.
- **Projected growth of the ULAB market**: We assumed that the ULAB recycling market will grow by 3% per year over the next ten years, after which it will stabilize.[34] We believe that this number is reasonably conservative. While historic growth rates and most forecasts predict (much) higher growth rates, especially in Africa and Asia, we are unsure how long these will last and err on the conservative side here. However, investments in battery R&D or other market trends could reduce this future growth.

[34] We also assumed that the burden of lead exposure will grow in proportion with the size of this market. In reality, the relationship may be more complex.

# 7 Implementation

## 7.1 What does working on this idea look like?

**At its core, this idea combines policy advocacy with technical assistance to governments.** Founders and core staff will primarily focus on networking with key stakeholders and decision-makers, explaining the technical aspects of proposed solutions, and lobbying for their implementation.

We expect that the key stakeholders will include:

- Government bodies, such as environmental protection agencies and ministries of finance
- Political leaders, including policymakers, legislators, ministers, and both opposition and government officials.
- Industry players from battery manufacturers to recyclers
- Researchers and research bodies
- Advocacy organizations. NGOs, international bodies, and subject-matter experts

As noted in Section 2.4, we expect the organization to also need to engage in additional functions, such as:

- **Collecting data on the local ULAB recycling industry**: This is expected to be a major focus in the charity's first year, providing a foundation for its local strategy and advocacy approach. Gathering local expertise may also improve access to key stakeholders.
- **Communicating findings to the public:** If policymakers don't show enough interest in the topic, the charity may need to invest in building broader public support for its cause, such as by collaborating with local journalists to report on the harm caused by poorly regulated ULAB recycling.
- **Publicizing the charity's findings internationally:** Given the growing interest in ULAB recycling regulations, the charity should allocate resources to making its findings accessible to international audiences, facilitating collaborations and knowledge-sharing across countries.

**Charity staff may need to engage in a broad range of activities,** However, we aren't confident that all these activities will be necessary in every target country or implemented simultaneously. Specific approaches may need to be highly locally tailored. Therefore, we believe charity founders will need to frequently revise their strategy to maximize their chances of success and pace of progress.

**We note that progress may initially be slow.** Due to the initial lack of data, unclear strategies, and the need to build a trusted stakeholder network, founders should not be discouraged if significant impact is not seen in the first one or two years.

## 7.2 Key factors

This section summarizes our concerns (or lack thereof) about different aspects of a new charity putting this idea into practice.

**Table 6: Implementation concerns**

| Factor | How concerning is this? |
|---|---|
| Talent | Moderate concern |
| Access to information | Moderate-high concern |
| Access to relevant stakeholders | Moderate concern |
| Feedback loops[35] | Moderate concern |
| Funding | Low concern |
| Neglectedness | Low concern |
| Execution difficulty/Tractability | Moderate-high concern |
| Complexity of scaling | Moderate concern |
| Risk of harm | Low concern |

[35] By *feedback loops*, we refer to the nonprofit's ability to gather data on the intervention's impact, analyze it effectively, and use that information to refine its approach over time.

## Talent

**We have moderate concerns about AIM's ability to find the right talent to start this charity.** While no highly specialist skills or knowledge are required, founders will need to be exceptionally comfortable with the uncertainties of this work, including advocating for policies that may ultimately have limited impact. This contrasts from the typical profiles of past CEIP participants, who have generally been more uncertainty-averse.

Table 7 summarizes our best judgment about different founder requirements.

**Table 7: Founder requirements and nice to haves**

| Must have | Preferable | Preferable, all else equal |
|---|---|---|
| • Comfort with high levels of uncertainty about the best course of action and about the charity's impact<br>• Comfort with frequent strategic re-evaluations based on new findings generated by the charity's work | • Keen interest in understanding the technicalities of ULAB recycling and the LAB market<br>• Experience in lobbying | • Previous experience that would help give the org some credibility, e.g. previous work at a large well-known GHD international organization or EPA.<br>• Some interest in conducting research and some basic research skills.<br>• Strong stakeholder management. |

## Access

### Information

**Access to information is a major concern for a new charity.** The lack of data in this space will likely slow progress. Even basic details—such as the scale of lead poisoning from informal ULAB recycling and the number and locations of informal recyclers—are not readily available. This could make decision-making, particularly around country selection, more challenging.

### Relevant stakeholders

Success will depend on the charity's ability to access and build relationships with stakeholders and decision-makers.

**We do not expect access to be particularly difficult in general**. In fact, many experts mentioned that governments are keen to receive technical assistance on this issue. However, there will be many relationships to manage at any one time across a wide variety of stakeholders (multiple government departments and bodies, industry players, NGOs), which may be difficult.

**Our main concern is access to industry, as vested interests and economic incentives may favor maintaining the status quo.** However, we expect the industry to generally be on board, as a shift to formal recycling would benefit the large industry players.

A new charity may also need to navigate its relationship with the industry carefully, as the impact on industry affiliation on policy success remains uncertain. Maintaining an independent role may be important for ensuring the charity is seen as a credible provider of technical assistance. Carlos Zaim, former president of Clarios South America (Clarios is the largest battery manufacturer in the world), managed relationships with many stakeholders in the Brazilian government and played a key role in advancing legislation and improvements related to ULAB recycling in Brazil. While this industry involvement appeared to support policy success in Brazil, it may have hindered trust-building with the Colombian government, potentially raising concerns about biased advice (see Carlos Zaim interview).

## Feedback loops

**Monitoring progress for this intervention will likely focus on two indicators:**

1. Changes in the ULAB recycling market, namely the number of ULABs recycled at formal recyclers (the throughput of informal recyclers) and the number of informal recycling plants that are shut down;

2. Changes in BLLs in the population post-reform, though these will be most relevant in areas where remediation projects have taken place.

**Since this idea focuses on policy advocacy, evaluating its direct contribution to policy change is particularly challenging.** It is nearly impossible to model the counterfactual with high confidence—i.e., to determine what would have happened without the charity's efforts. Founders and funders working in policy advocacy should be comfortable with this uncertainty.

**Policy change can take a long time.** In Brazil, it took over a decade for all the relevant policies to be introduced and implemented. However, with the Brazil playbook as a reference, this process could now take much less time (e.g. 1–3 years).

## Funding

**We think it is unlikely that funding will be a barrier to success for this idea.**

### Funding from funders in the AIM network

Lead exposure in LMICs has been an area of focus for multiple funders in the AIM network, including Open Philanthropy, Founders Pledge, and EA Funds. Schmidt Futures has also made donations in this space.

The most relevant consideration here is that Open Philanthropy and partners have launched the Lead Exposure Action Fund (LEAF), which already has a committed $104 million in funding to allocate between now and the end of 2027. The launch of this fund is estimated to have at least doubled the total philanthropic spending toward lead exposure reduction in LMICs.

### Broader funding sources

Other funders in this space include:

- USAID has committed $4 million to lead elimination projects (and is now part of LEAF) and has given funding to LEEP

- Schmidt Futures has also given funding to LEEP
- Global Environment Facility (GEF): According to a Rethink Priorities report, the GEF has committed $2–3 million per year to lead exposure advocacy (Rhys Bernard & Schukraft, 2021). It previously made grants to IPEN and Pure Earth.
- Clarios Foundation: Clarios is a major manufacturer of lead-acid batteries. Their foundation works on projects related to children's health and environmental sustainability (Rhys Bernard & Schukraft, 2021).
- The Swedish International Development Agency (Sida): Sida is one of the largest donors of IPEN (GiveWell, 2021a).
- Oak Foundation

Prof. Amrita Kundu also told us that multiple development agencies have previously commissioned studies on the topic of ULABs, including the SMEP Programme, the Asian Development Bank, the World Bank, and UNEP.

### Neglectedness

As outlined in Section 5.1, very few organizations, if anyone, in the NGO space have a full-time focus on ULAB recycling specifically. Therefore, **we think that there is ample space for a new organization working on this topic.** This was a view shared by many of the experts that we spoke with.

We are somewhat concerned that this may not be the case for long, as the launch of LEAF has generated interest among many organizations in expanding their portfolios. This is not a ruling-out factor for a new organization, but it is worth keeping in mind when considering the counterfactual impact of this organization.

### Tractability

**Tractability is another major concern for a new charity.** Overall, we believe that the policy is more likely to fail to be introduced than to be successfully introduced. As discussed in Section 2.1, a new charity and the government will need to overcome multiple barriers to introduce these policies. However, there are a handful of case studies demonstrating successful policy change in this space (see Section 3.1). Recent progress in Brazil is particularly encouraging.

Effective policy enforcement is also crucial. Limited government capacity and the risk of corruption pose challenges, but appropriate country selection can likely mitigate these risks.

## Complexity of scaling

**We are moderately concerned about how quickly and easily this charity will be able to scale.** On the one hand, given the nature of this intervention, successful advocacy in a country may result in a nationwide impact, thus quickly achieving a high scale. On the other hand, international scaling may be somewhat complicated. Unlike banning lead paint—where a standardized approach can be applied across many countries—ULAB recycling is likely to require significantly more country-specific tailoring, which may slow international expansion. However, we do expect there to be considerable opportunities for learning and for applying lessons from one country to a new geography, so we expect that the pace of international growth will speed up over time.

## Risk of harm

**We see the risk of harm as low.** We can think of two risks of harm:

1. **The negative impact on the livelihoods of those working in the informal recycling sector.** While new jobs would be created in the formal sector, those are unlikely to be done by the same individuals, so some individuals will be made worse off. The number of workers involved in the informal sector is substantial. For example, in 2020 about 100,000 workers were employed in the informal ULAB recycling sector in Bangladesh (Pure Earth, 2022). Whilst the ULAB market in Bangladesh is very likely above average in size, one would expect there to be thousands of people working in this industry across our other priority countries. We take this risk of harm seriously; however, we are confident that it will be greatly outweighed by

the health and economic benefits to those no longer exposed to lead (which may include the workers themselves and their families[36]).

2. **There is some risk that informal recyclers will relocate instead of shutting down completely.** If this happens, then these recyclers will contaminate a new site, spreading the problem instead of solving it. Whilst we think that this is unlikely overall, it is worth keeping in mind and watching out for.

## 7.3 Remaining uncertainties

**Our remaining uncertainties include:**

i) What percentage of the lead burden comes from informal ULAB recycling?
ii) By how much will the proposed policies reduce lead exposure?
iii) How should we balance the scale of the problem with tractability when selecting target countries?
iv) Will other organizations begin to work more on ULAB recycling given the influx of money earmarked for lead elimination from LEAF?
v) How will the LAB market evolve in the coming decades?
vi) How costly is soil remediation? Will governments be willing to engage in it?

# 8 Conclusion

The recycling of ULABs is likely one of the largest sources of lead exposure. Early evidence suggests that regulatory approaches could be an effective way to reduce this risk. While significant uncertainties remain about the best course of action, and progress in this area may be more challenging than for other sources of lead exposure, we see potential for impact. We would be eager to support the launch of a dedicated charity focused on addressing this problem.

[36] The individual-level economic harm of lead exposure is typically delayed (as a result of children's disrupted intellectual development and of workers' potential later-life disabilities). This makes it simultaneously possible for informal-ULAB-recycling workers (and their families) to suffer short-term economic harms *and* long-term economic benefits from this intervention.

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# Appendix 1: Evidence that lead exposure is harmful

The following is copied directly from Murár (2024). We haven't updated this section for the following reasons: This research was finished recently (~half a year ago), there is already a consensus of the harm that lead exposure causes, and we do not think that further exploration of this evidence is crucial to the consideration of founding a new charity in this space.

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There is strong consensus from a large body of literature that lead is toxic to humans. No safe level of lead has been found; the current consensus is that the ideal BLL is 0 (Grandjean, 2010). Lead appears to be a substance foreign to the human body, which disrupts various cellular processes by competing with calcium and interfering with the function of calcium-based enzymes (as well as other biological mechanisms; see Bressler & Goldstein, 1991 and Szymański, 2014).

Firstly, and most importantly, lead is a strong developmental neurotoxicant (Caito & Aschner, 2017). Exposure to lead in all ages causes damage to the nervous system; however, prenatal and early childhood exposure are especially hazardous. This is partly because their nervous system is rapidly developing at those ages, and this process is particularly sensitive to being disrupted (Grandjean & Landrigan, 2014) and partly due to children absorbing 4-5 times more lead than adults from the same ingested amount (WHO, 2023).

Childhood exposure causes lasting cognitive and behavioral changes. Most notably, it is associated with reduced IQ. Larsen and Sánchez-Triana (2023) estimate the average loss in lead-exposed populations in LMICs to be 6 points, or 0.40 standard deviations. Interestingly, the loss of IQ seems to be the steepest at the lowest levels of exposure (Lanphear et al., 2005). However, due to measurement difficulties and methodological limitations, this point has been fiercely debated in the literature (see, e.g., Wilson & Wilson, 2019 or Landingham et al., 2020). We assume a linear relationship for simplicity.

Other studied neurological effects include an increase in the risk of depression, panic attacks, interpersonal conflict, and violence (Bouchard et al., 2009; Nevin, 2007; Stretesky & Lynch, 2001). The effect on crime—the so-called lead-crime hypothesis—has been particularly actively discussed in the literature. Some authors have attributed the majority of the observed decrease in crime in the United States to the banning of leaded petrol (Reyes, 2007). More recent studies have put the attributable fraction much lower, at between 7 and 28% of the decrease in homicides (Higney et al., 2022; Talayero et al., 2023). Nevertheless, even these figures may be highly significant due to the large burden of homicide and the cost crime imposes on society.

Aside from its neurotoxicity, lead exposure increases the risk of heart disease. A study from the USA, using the large-scale NHANES dataset, estimates that an increase in BLL from 1.0 µg/dL to 6.7 µg/dL is associated with significant increases in mortality, including all-cause mortality (hazard ratio of 1.37, 95% confidence interval [1.17–1.60]), cardiovascular disease mortality (HR = 1.70, 95% CI = [1.30–2.22]), and ischaemic heart disease mortality (HR = 2.08, 95% CI = [1.52–2.85]; Lanphear et al., 2018). The authors estimate that lead is responsible for 412,000 deaths per year in the USA alone. The exact burden is, however, very uncertain due to difficulties stemming from the effects taking years or decades to show, symptoms and causes of death being non-specific, and data being sparse. Recent meta-analyses have estimated the number of attributable deaths at 1.5 and 5.5 million per year—a nearly fourfold difference (GBD 2021 Risk Factors Collaborators, 2024; Larsen & Sánchez-Triana, 2023).

Lastly, prenatal lead exposure appears to be a risk factor for miscarriage, stillbirth, premature birth, and low birth weight (Amadi et al., 2017; Xie et al., 2013).

Overall, there is a consensus that lead exposure is harmful to humans on multiple levels. While there is currently disagreement about the exact attributable burden, with studies often producing estimates that vary severalfold, there is agreement that the burden is large, and even the lower-end estimates are highly concerning.

# Appendix 2: Expert interview summaries

This appendix contains summaries of the conversations held with experts on the matter.

## A2.1 Jessica Fullerton & Ben Savonen, Global Development Incubator

**Profile**: Ben Savonen and Jessica Fullerton both work for the Global Development Incubator (GDI), which researches and incubates international development initiatives. For the last year and a half, Ben and Jessica have been researching the lead space, mapping out the current landscape and identifying and prioritizing potential opportunities. This research process started with a particular focus on ULAB recycling. Their views do not necessarily represent GDI's official stance on this topic, which continues to evolve.

**Main takeaways:** Ben and Jessica consider the space to be very neglected, and given that ULAB recycling is a large and multifaceted problem, there is room for multiple organizations. Currently, there are relatively few experts working on this issue. Due to the large burden, many organizations have looked into the topic as a potential field for improvement. However, due to the lack of information, seemingly (and potentially actually) poor tractability, and the rather technical nature of the topic, only very few have actually started to work on it. **GDI is considering investing in a solution in this space but hadn't committed to any particular approach at the time of our conversation.**

Ben and Jessica point out that there is a clear need for additional information, to better understand the problem and know which solutions to scale. In that sense, **an organization working on research to get information out would be valuable in and of itself.** Although much is unknown, the burden of lead exposure due to ULAB recycling is clearly substantial enough to warrant work in this space.

The lead-acid battery market is complex, and addressing the associated lead exposure will require a range of solutions (as opposed to a single replicable "playbook"). **While Ben and Jessica agreed that the Brazil case study is encouraging, they were unsure whether it could be replicated elsewhere**. They pointed out that other countries like China and the US have tried different paths and have also seen success.

**They consider a country-by-country approach worth pursuing but emphasize that a tailored approach to a country would be needed.** The change that happened in Brazil seemed to have been possible due to a specific set of conditions, including an appetite of many government and private-sector stakeholders to cooperate. Ben and Jessica wouldn't advise focusing on a specific subset of what is implemented in Brazil, e.g., only the tax cut, as they think there is value in how the various measures work together.

**Above all, an organization that would try out a specific approach to see if it could work would be useful in and of itself.**

### A2.2 Anonymous grantmaker

**Profile**: This interviewee is a grantmaker whose portfolio includes the reduction of lead exposure in LMICs.

**Main takeaways**: The expert thought that **ULAB recycling might be a substantial source of lead exposure** and highlighted the lack of information on key aspects of the problem. To their knowledge, few actors are currently working on the topic, leaving room for new organizations. Compared to some other sources of lead, though, progress seems much harder to make, so the lack of existing efforts may be indicative of low tractability.

The expert suggested putting the most weight on two theories of change: First, **an organization doing advocacy work that tries to copy, improve, and push for regulatory solutions**, e.g. inspired by the changes implemented in Brazil. Part of this work could be to lobby within higher-level bodies, such as relevant UN agencies or the World Bank, to put ULABs on the agenda and integrate the topic into existing workstreams (such as on the circular economy). Second, an organization that would **lay more foundational work in this field, to enable progress later on**. This could, for example, be an organization that does practical on-site research on key questions around ULAB recycling.

As there are so many open questions concerning ULABs and lead exposure, it is unclear whether it's better to focus on achieving immediate impact vs improving the information landscape, to allow more effective progress later on.

### A2.3 Jenna Forsyth, Stanford University & GCD

**Profile:** Jenna Forsyth is a research scientist at the School of Medicine, Stanford University. She is a leading academic working on lead exposure and apportionment studies in several LMICs. She also collaborates with local partners on implementing regulatory action to mitigate lead exposure

**Main takeaways:** Jenna is convinced that **lead exposure attributable to ULAB recycling is varying a lot from place to place, and she would estimate it to account for 5-30% in many LMICs**. Due to recent studies, she thinks that lead pollution due to ULAB recycling can travel further than she previously thought, e.g., 5 km instead of 500 m. In her opinion, understanding of how far the lead from ULAB recycling sites travels is one of the most urgent knowledge gaps in this space.

**In general, Jenna was in favor of an organization working on ULAB regulations, to for example change incentives in favor of formal recyclers.** As far as Jenna was aware, few organizations are working on this issue, leaving room for a new one. The reason for this might be because timelines for making progress are relatively long.

**In Bangladesh, where Jenna has the most experience, she expects changes in taxes on ULAB scrap and/or imports could be useful.** However, due to connections between politics and the battery recycling/manufacturing industry, the other parts of the Brazil model might not work there. A new organization could collaborate with local researchers to get a picture of the situation. In general, she also sees value in doing capacity building to strengthen governments' enforcement capabilities, or an organization that would focus on getting rid of lead exposure via the uptake of lead-free batteries in the market.

**Jenna expressed the need for an independent body that is knowledgeable and has technical expertise in the field.** Currently, expertise on the matter is sparse, and representatives from the industry or various battery associations might be influenced by or perceived through the lens of their incentives.

## A2.4 Carlos Zaim, Ex-Clarios

**Profile:** Carlos Ziam is former president of Clarios South America. Clarios is the largest battery manufacturer around the world. As part of his role, he managed relationships with the government and was one of the driving forces and minds behind the legislation and improvements seen in Brazil concerning ULAB recycling.

**Main takeaways:** Carlos explained that **an essential part of the type of solution in Brazil**, as is explained in more detail in a blogpost he reviewed, **is that it is working with the market forces**. There were a few essential elements in this solution:

- For the formal sector to be able to compete with the informal sector, the specific tax on ULAB scrap was fully cut. Carlos considers this the most important improvement.
- With the same argument, any bureaucratic hassle was minimized for the transport of ULABs in the country.
- The Brazilian government sets buyback targets and imposes these on both manufacturers and importers, obliging them to bring back a certain percentage of the amount of batteries that they sell. This is a form of extended producer responsibility (EPR).
- Given that the government has limited capacity for enforcement and collecting the right information, they established another independent NGO

that does this task. This producer responsibility organization (PRO) is called IBER in Brazil and is subsidized by the manufacturers. It has the task to collect information and pass this on to the government, and to help recyclers to be compliant to the regulations. An independent auditor then checks the work of IBER and might do spot-checks with manufacturers. As Brazil has an extensive e-invoice system, IBER can now also cross-compare battery handling data from various layers in the supply chain.

**Carlos explained that the system works well, and that IBER has the necessary power to correctly fulfill its task**. Manufacturers and importers can be held accountable by government officials, due to a licensing system. Although this could—at least in theory—be somewhat prone to corruption, another route would be to use the justice system and pursue legal action against organizations that do not abide by the law. Carlos explained that both routes have been necessary and are used to make sure that manufacturers and importers are compliant.

**The system has been good for both the formal sector and the government.** The formal sector and battery manufacturers have an increase in the market size of recycling and helped them reduce their impact on lead exposure, this has clearly offset the increased costs of supporting IBER, which was funded by the battery manufacturers. The government initially saw a reduction of tax revenue due to the tax cut on ULAB batteries. But, at the same time, the legislation moved some of the informal new LAB production market to the formal market. This led to an increase in tax revenues from this substream specifically. Overall, Carlos estimated the government had a substantial increase in total tax collected because of the legislation.

Carlos pushed for such regulation, using his experience from the market whilst working together with the Brazilian government. These efforts were sparked by a policy window over ten years ago when regulations around hazardous waste were being drafted for Brazil. It was a long process to get all of this in place (~10 years), but he reckons now with the policies in place in Brazil it would be much faster to implement this in other countries.

**The results of the system are positive, as it has dramatically decreased the share of the informal recyclers, from 40–45% to ~10%.** A key aspect of the regulations aimed at reducing lead contamination is the requirement to clean contaminated plots before they are sold or transferred to a new user. This way, the costs of professional cleaning are incurred on the plot owner. This has proven effective for cleaning up plots that were contaminated due to informal recyclers.

**In general, Carlos was very optimistic about this being able to work in other countries as well.** He doesn't see any immediate reason why it couldn't work in countries like Nigeria, Thailand, Chile and India.

Carlos explained that the following could prove useful to hold in the target country for the model to be effective: in addition to having an informal market that is causing the problem, it is helpful if the country has a battery manufacturer, a high-quality recycler, and has an interest in health improvements. Although the burden from exposure is large, they have a delay, which could make it more suitable for countries who do not struggle for their immediate needs.

Carlos briefly explained his views on a global certification system, in which he shared his concern that it would be challenging to make countries follow the same regulation. Similarly, there are so many car and battery manufacturers and they are unlikely to be willing to comply.

### A2.5 Hugo Smith, Student and independent researcher

**Profile:** Hugo is a 4th year undergrad student at the University of Chicago studying Economics and East Asian History. He is the main author of a substack on ULAB recycling and spent a year of part-time research into finding scalable solutions to this problem. As part of that research, he spent two weeks in Nigeria to understand ULAB recycling better. Over the course of the research process, we have spoken with Hugo twice.

**Main takeaways:** Hugo explained that the issue is very neglected. To substantiate this, he hasn't come across anyone who works on reducing the harms from ULAB recycling full-time. This contrasts with the large burden associated with lead contamination, and a possible 10-20% attribution to ULAB recycling in LMICs.

Overall, he expects the market to continue to grow, mainly due to the increase of automotive and stationary power for the energy transition. ULAB seems not to be used by Tesla and BYD, who hold a large market share of EV sales. Also, at least in theory, there might be some new battery technique that would phase out ULABs and therefore the associated lead problem with it.

Hugo has done in-depth research into the policy change that improved ULAB recycling in Brazil, which he has written about as well. He could imagine that focusing exclusively on removing taxes on scrap ULABs would have an effect on itself but is unsure about how large that effect would be. He states that for the EPR to be successful, there should be some form of enforcement. In Brazil, the IBER organization has been helpful with this. **He thinks that it is very worthwhile to pursue advocacy in other countries, based on the lessons learned in Brazil.**

In his view, this model with advocacy on a country-by-country basis may not be viable for many low- and lower-middle-income countries with particularly weak enforcement mechanisms or widespread corruption. **Therefore, another potential route for solving this issue would be via a global *certified lead* trademark. He is equally excited about this idea as the country-by-country regulation advocacy.** The advantage of the certification system is that it uses market forces rather than regulations by governments, which means that effects could eventually reach those countries where governments aren't well placed to make improvements on ULAB recycling. He has discussed this idea with various stakeholders, both environmental experts, US policy makers and someone with relations to the industry, all of whom have responded with moderate to positive perspectives. From his knowledge, it makes sense from the perspective of many players, though he also acknowledges that there will likely be implementation challenges.

Many other ideas that could lead to improvement in the field have been discussed. Ranging from additional research to increased media attention and from stronger enforcement of the informal sector to doing consultancy recycling-plant by recycling-plant. For example, Hugo and others have tried to see if using satellite imagery or lead-air testers would help to locate informal recyclers more quickly, to make enforcement on the informal recycling much cheaper. This has proven difficult and seems to be a dead end. **Overall, no other ideas have been found that were as large scale and promising as the ones discussed above, though many routes to improvements are possible as the field is generally underdeveloped.**

### A2.6 Mikey Jarrel, PhD student and independent researcher

**Profile:** Mikey is an Economics PhD student at UC San Diego, studying development economics. He has worked on ULAB recycling partially as part of his PhD, but also substantially researched this topic not part of any formal duties by interest. He has recently visited Nigeria to understand the field of ULAB recycling there better.

**Main takeaways:** The field is still very underdeveloped and researched. By intuition, the biggest problem is the many small backyard recyclers. A partial solution would be to get these out of the populated areas.

Mikey visited Nigeria to understand the ULAB recycling situation there. Somewhat recently, large-scale recycling (either formal or informal) had increased and taken a large market share from small-scale/backyard/informal recycling. It is somewhat unclear why this change—a potentially massive change for the better—happened. Stories about extra enforcement alone don't seem to be very likely the sole driver. In Nigeria, he saw backyard recyclers that directly competed with large-scale recyclers, and that they decide—based on the daily price of lead on the LME market—whether to sell their scrape to the large-scale recyclers or recycle themselves.

**He thought that advocacy work on ULAB recycling—copying useful policies from e.g. Brazil—can be an effective and reasonable approach to this issue.** He stated the target country should have battery manufacturers themselves, as it would be much harder to enforce many importers. He also noted that Brazil was special in the sense that the initiative for the policy change came from the manufacturers themselves (Clarios). Likely, the battery manufacturers saw informal recycling as a competitor, potentially due to their own recycling practices.

In many places where the problem exists, implementing policies similar to those in Brazil seem difficult or impossible, e.g., due to not having battery manufacturers in the country. Mikey thought that one route to circumvent this is by **introducing a certification scheme on lead and convince large buyers of lead to only buy certified lead.** One would need to have many international importers of lead on board, for this to move the needle. One way to do this is by getting this in the state legislation. Some relevant US policymakers have shown interest in the idea, though the idea is still very much in the initial phase. There are also many implementation challenges to this idea.

Mikey thought that using media attention could be a piece of the puzzle. In Bangladesh, a media story and a research paper (by Jenna Forsyth, Stanford) ignited governmental action on the spice front. However, Mikey deemed it unlikely for this to be the main route to impact. **For ULABs, the solution is not as easy and clear as for spices, so progress might be slower and less responsive to media attention.**

### A2.7 Mark Stevenson, Independent lead consultant

**Profile:** Mark Stevenson is an independent consultant in the lead recycling industry, and started his career 45 years ago in a recycling plant himself. He has extensive experience with advising governments (e.g. national environmental protection agencies), NGOs, and the industry. He has a background in metallurgy[37] and is the chair of the Asian Battery and International Secondary Lead Conferences.

**Main takeaways:** Mark highlighted that the sector is vast and expanding, occurring globally and primarily driven by financial interests. **In many countries, especially LMICs, the formal and informal sectors are intertwined and sometimes work together.** Both informal recyclers and formal recyclers do the initial smelting, after which informal recyclers sell their smelted lead to formal recyclers to do the necessary refining. The refining can produce either pure lead or lead alloys, which are then sold to battery manufacturers to be used for the production of new LABs.

Mark said that legacy is the reason for the fact that lead is still in paint in many countries. For ULAB recycling this is clearly different, as the lead itself is the core material of the product.

**Mark explained that there is no uniform/standard recycling plant, and there are variations in recycling practices around the world.** Methodologies vary from place to place, including the use of different types of furnaces, baghouses to capture fumes, battery breaking practices, etc. But they all produce a lead product fit to be returned into the battery market.

Mark considers the changes that happened around ULAB recycling in Brazil an improvement and thinks that this may likely have lowered lead exposure due to informal ULAB recycling but needs to see some firm data. **He thought it is a good idea to learn from best practices and try to implement them in countries but noted that the Brazilian model must be proven to be considered as a "best practice."** He believes that in India, if the 19% VAT for recycled lead from the formal sector could be cut to zero, the informal sector could be decreased by as much as 50%. Finally, he encouraged collaboration with the industry, as they have

[37] "Metallurgy is a domain of materials science and engineering that studies the physical and chemical behavior of metallic elements, their inter-metallic compounds, and their mixtures, which are known as alloys." (Wikipedia)

a willingness to improve their practices and lower the environmental burden themselves.

Overall, Mark was also in favor of the idea of a **lead certification system** for the industry. This idea has been discussed for many years now, and there have been previous attempts to get this off the ground. These attempts have failed for the following reasons: the potential certifier tried to make a profit out of the certification system, and they did not cooperate with the industry to gain an understanding of the economic, marketing, and technical dynamics of the metal industry. In addition, the fact that formal and informal recyclers have intertwined business raises challenges. Overall, Mark encouraged an ongoing conversation on this topic with all players in the industry.

Some further relevant technicalities were discussed, which give a better understanding of the field:

- An average smelter consumes 30 to 40 thousand tons of ULAB. A smelter will conduct both the smelting and refining of the lead. The smallest formal smelters around the world handle about 2.5 thousand tons of ULAB.
- The furnace fume from the smelting operations consists of about 65% lead which is returned back to the furnace. It is collected in baghouses and other filtering devices and is a valuable product to the smelter.
- Mark states that the recycling rate of lead in informal recycling is very high, around ~97%+.
- In some countries there is substantial import and export of ULABs, again driven by economic reasons.
- Battery prices are often stated as a percentage of the LME Lead trading price, and a ULAB is worth about 32% of LME lead price in many countries, but it does vary. In some countries, such as Africa and the Indian sub-continent, scrap collectors expect some substantial fraction (~25%) of the collected batteries to be functioning after minor repair or recharging, and therefore sometimes bid up to 60% of the LME lead price. This practice is often referred to as rejuvenation.

It is relatively easy to smelt lead compounds, compared to other metals. This is the main reason why “backyard smelting” is possible.

### A2.8 Chris Kinally, PhD and Pure Earth

**Profile**: Dr. Chris Kinally has recently finished his PhD on the environmental impacts of solar systems in Africa, and the pollution due to ULABs used for this. For his PhD, he has done on the ground work in Malawi and seen how ULAB recycling is done there. He is currently a freelance researcher with Pure Earth.

**Main Takeaways:** Chris stated that there are many knowledge gaps in the field of lead exposure due to ULAB recycling. In contrast to, for example, lead exposure due to spices or paint, it is even less clear what the main routes are for the ingestion of lead pollution released from ULAB recycling. Many quantitative questions remain, such as what fraction of ULABs are informally recycled and how big the associated health burden is from ULABs. In general, Chris was in favor of an organization that would work on resolving such information gaps and thinks that this could lead to action within governments.

**Chris thought there is also benefit in an organization that would work on ULAB recycling advocacy, trying to improve regulations. He would expect there to be a need for an improved information landscape to motivate the substantial private investment required to develop safe ULAB recycling infrastructure and to encourage governments to take action.** This type of research might include local and on-the-ground testing of soil, food crop, water, dust and blood lead levels and isotope studies for attribution. He advised pursuing regional solutions and prioritizing investment into safe ULAB recycling plants **in more developed economies, which may have a more favorable economic landscape for private investment, more government capacity** for enforcing pollution regulation, and **can collect ULABs from surrounding countries** which may have a lower capacity for developing domestic solutions.

Generally, **Chris thought we are likely underestimating the global health burden of ULAB recycling**, i.e., that in many places it could be higher than the 10% that is sometimes stated. Reasons for this include that studies so far have some limitations, and for example do not include contamination via food that was grown close to ULAB recycling plants. Meanwhile, with the lack of research, it is still unclear how many ULABs are informally recycled, how much lead pollution is released, how many people are exposed to lead pollution from ULABs, how lead pollution from ULABs is ingested, and how big the associated health burden is. **This also means that we should currently be hesitant to draw any conclusions on how the size of the health burden of the informal and the formal recycling relate in a given region.**

During Chris' visits to Malawi, he saw some very basic forms of recycling, e.g., only using an empty bean can and a charcoal stove. People do not use PPE as this might signal health effects to neighbors. Some recyclers weren't able to reach high enough temperatures and only recycled about half of the lead of the ULAB due to this. In Malawi, there is also a practice of producing new improvised batteries from old ones, rather than selling the smelted lead back into a more formal or consolidated supply chain.

LABs are used for solar energy storage for either individuals or on the community level, as an off-the-grid power storage solution. LABs are used as they are the most price-competitive. **Given the current solar targets of some of the countries in Africa, one could imagine that this might at some point be a bigger source for the use of LABs than the automotive industry**.

### A2.9 Russel Hirst, Environmental consultant at Wiser Group

**Profile:** Russell Hirst has over 30 years of experience in environmental and waste matters at Wiser Group. He has extensive experience as a consultant for ULAB recyclers in both Vietnam, UK and other countries. He is the co-author of a publication on 'How to Stop Automotive Battery Recycling from Poisoning our Children' by the Asian Development Bank.

**Main takeaways:** Russell highlighted the interconnectedness of formal and informal sectors, noting that the informal sector can act as a subcontractor to the formal sector. **He didn't expect the market forces to solve the problem in and of themselves and was therefore generally supportive of regulations that would try to improve the situation.** He did note that **adequate enforcement of this is necessary**, just as it is in high-income countries. Russell also explicitly pointed to the **jobs of the people who are currently working in informal recycling.** These people would lose their income if recycling were to move to the formal market, although this would depend on where formalized recycling was located in relation to existing concentration of recyclers.

Russell pointed towards a somewhat concentrated market at the very end of the supply chain, particularly car manufacturers. Although they operate within their system and maximize profits, there might be a potentially useful lever there to improve the market. It would be good if more money flowed into the lower parts of the supply chain, to be able to afford upgrades to in turn improve environmental measures at recyclers of all scales.

Russell mentioned that various institutions, such as development banks, are also interested in and working on ULAB recycling. Although they might not be as quick, agile, and entrepreneurial as an NGO can be, they might be valuable partners.

### A2.10 Amrita Kundu, Georgetown University

**Profile:** Amrita Kundu is an assistant professor of operations and analytics at the McDonough School of Business at Georgetown University. As part of her research, she has engaged extensively with ULAB recycling in Bangladesh, mostly from an economic and business perspective.

**Main takeaways:** Amrita said that **price is the biggest differentiator for a ULAB getting into the formal or informal recycling sector. Payment delays (cash/instant payment vs. later payment) and collection frequency are also key**

**drivers**. Bangladesh has various initiatives at the moment which focus on ULAB recycling, including by Pure Earth, a local hospital research center, and a coalition of researchers like herself—as well as studies being commissioned by different development agencies (including the SMEP Programme, Asian Development Bank, World Bank, UNEP among others).

An improvement in the LAB market that is relevant to Bangladesh (but might apply to other developing countries as well) would be **to improve the average lifespan of LABs, as this would in turn decrease the amount of ULAB that needs recycling**. The average lifespan of a LAB in Bangladesh is ~1 years, whereas they could in theory last ~2 or 3 years. Misinformation on the market and fewer competition from high-quality Chinese batteries, due to import taxes on batteries, among other reasons has led to this quality drop in the Bangladesh market. Among the ideas to solve this are labelling high-quality batteries or organizing 1- to 2-year loans to LAB buyers that could function as quality stamps.

**In Bangladesh, given the weak regulatory capacity, and the political economy, Amrita didn't expect that a ULAB recycling system similar to that of Brazil would be effective.** At the moment, formal battery manufacturers do not pay their full VAT duties, as administration and enforcement levels are low. With additional regulation and tighter administration like in Brazil, this de facto tax avoidance might become less prevalent, which would lead to higher costs in the formal recycling sector, favoring informal recycling. Critically, in addition to this, the regulatory capacity is very limited in Bangladesh, and likely would be susceptible to corruption.

**Amrita thought that ULAB regulation advocacy, inspired by the success of Brazil, might be effective in other countries that have better regulatory capacity and stricter accounting and taxation laws.** She also didn't have much faith in a certification system that requires regulatory oversight. Technological solutions to track the amount of formal lead recycling can be beneficial if the formal sector were to receive some financial incentives based on the quantity of lead recycled, but implementing such a technology might be challenging.

### A2.11 Bret Ericson, UNICEF

**Profile:** Bret Ericson is a consultant and researcher and has extensive experience with lead pollution and ULAB recycling at organizations like Pure Earth, UNEP and UNICEF. He was involved in relevant research on the topic like the attribution lead exposure to ULAB recycling and a systematic review of BLLs in LMICs.

**Main takeaways: In general, the estimates of IHME of the GBD of lead exposure are reasonably correct, and the best we have**. In many cases, there is no countrywide lead exposure test, so value for many countries are extrapolations. This can sometimes lead to substantial changes in estimates when studies are conducted, e.g. the work and studies of UNICEF has been helpful in identifying the high BLLs in Georgia. Additionally, the unknown and variable location, type, and scale of ULAB recycling plants across countries result in a lack of covariates with predictive value for lead contamination due to ULAB.

Bret considers the changes that happened around ULAB recycling in Brazil an improvement and thought that this has likely lowered lead exposure due to ULAB recycling. **In that sense, it would generally be good if similar progress could be made in other countries. Bret thought that this is something that should come from international organizations like the UN and the World Bank, and thought that a small, new NGO wouldn't be able to make meaningful change.** He thought that an NGO could help catalyze change, but it would be limited in what it could do on ULABs at the country level.

Bret said that his papers on the topic have spurred and improved the conversations on ULAB recycling. He believes more research on the topic would be beneficial and encourages such efforts.

Bret explained that sites that are contaminated with lead do not attenuate at any reasonable time scale. Cleaning the plot requires taking deliberate cleaning measures; otherwise, lead exposure will last. This has policy implications for addressing informal ULAB recycling, as strict enforcement to halt such activities may lead to increased relocation, ultimately resulting in a greater number of contaminated sites.

### A2.12 Andreas Manhart, Öko-Institut

**Profile:** Andreas Manhart is a senior researcher at the Öko Institut in Germany, an institute on applied ecology. Andreas has expertise in waste management, extended producer responsibility, and battery recycling. He worked on ULAB recycling for the first time 10 years ago and has experience in working on ULAB recycling in various countries in Africa (including Nigeria, Tanzania, Ghana, Uganda, and Ethiopia) and Myanmar. His perspective has been mostly environmental (e.g., how to improve recycling standards and technical assistance to enforcers), with more political work following from that as well.

**Main takeaways:** Andreas agreed that ULAB recycling is not dealt with appropriately in many countries, that this should be much higher on the political agenda, and that there is room for more organization to work on. As new funding (Open Philanthropy, LEAF) for the lead field has arisen, he has seen various new initiatives interested in the ULAB field. Most of them are US-based organizations with very limited experiences in the field.

There are some capable local groups, often 5–10 person staff organizations, which are part of the International Pollution Elimination Network (IPEN)—but they often do not fit in the global funding landscape.

Andreas explained that little thorough and on-the-ground investigation is being carried out on this topic. He argues that the typical image of the informal recycler as is often mentioned in reports—namely the individual backyard recycler, with low investment equipment by a low skilled worker—only holds a small or even negligible share of the market. Most of the market share is taken by mid- or large-scale recyclers. For these plants, substantial investments are made, albeit often not implemented and operated with proper environmental standards. This is mostly due to economic reasons: individual backyard recyclers are often able to only recycle 50% of the valuable lead, while with a mid- or large-scale operation, the recycling rate of lead is more often about 90%.[38] Often, these recycling plants are registered with the government, and can be considered formal, albeit the quality standards vary from country to country.

**At least in the context of low-income countries, Andreas was not convinced of the idea to try to copy the policies from Brazil into other countries.** We touched upon various points in the conversation:

- He thought that this approach would have limited results, as both ministries and enforcement/EPA agencies are **understaffed and have limited capacity** for all tasks at hand. New regulations in and of themselves (e.g., extended producer responsibility, EPR) need adequate enforcement for it to be effective. Even if an EPR is adopted, there need to be high-quality recyclers to which the ULABs can be brought to.
- Additionally, one of the main drivers of the change in Brazil were the tax cuts on buying scrap/used LABs. **Andreas questioned the rationale for such tax cuts since, from a broader political point of view, a high-risk, polluting industry should not be given tax cuts.** He agreed that a relative benefit should be given to the better-performing recyclers and argued that this could be achieved via regulation of the poorer quality recyclers, e.g., by fining or shutting these down.
- In the case of doing advocacy work, a tailored approach for every country is needed. Andreas would focus on improving the environmental standards of the formal recyclers. This should be an integral part of the strategy, as the effect of other policies would likely be dependent on the quality of formal recycling.

In the conversation, we briefly touched upon the idea of creating a certification system, after which one would need to convince the lead consumers to only buy this certified lead. Andreas said that, as battery manufacturers are the biggest

[38] One way to think about this economically is that with some initial investment, the recycling rates go up and the investment is profitable. To then go from this mid-level plant to a high-quality plant that recycles 99% and is environmentally friendly requires considerable investment that doesn't make sense purely based on private economic returns. Additional regulation is therefore required.

buyers of this used lead, they would need to be on board with this, which seems unlikely and hard to reach. It would be hard to convince the biggest association of the lead market, the International Lead Association (ILA), which controls half of the market, to take affirmative action, as they are tied by the interest of the diverse industry stakeholders that they represent. Vested interest might be against this, as manufacturers are often also recyclers themselves. Along these lines, Öko-Institut did start publishing a positive listing of good recyclers in Nigeria, which might give these recyclers a competitive advantage.

Andreas wasn't convinced of a solution that would incentivize large-scale transport from ULABs form LMICs to HICs. Such a scheme had been tried in 2014, but it was not politically viable and clearly not economically reasonable. Also, as ULAB recycling is a profitable business, countries typically want to do the recycling domestically.

During the conversation, **Andreas brought up the idea of targeted awareness raising**. Often, political action was only taken after a lead poisoning scandal had occurred. In many places, at this moment, these scandals are occurring and forgoing unnoticed. **With some basic knowledge, these scandals can be reported and relevant bodies, such as companies or (local) governments, can be made aware and potentially also be challenged legally**. Andreas thought that more political pressure from the side of citizens is needed. He sees this route as a gap in the field.

In Andreas's experience, the quality of the enforcement of laws by regulators is poor. Regulators often lack the technical expertise, capacity, and urgency needed to address this issue at the necessary scale. The work of the Öko-Institut was often due to an earlier scandal, after which political pressure created interest in the matter.

Andreas mentioned that a level playing field for recyclers is important, as otherwise the recycling plants with high quality/high investment would be outcompeted by those not taking care of their environmental impact. Therefore, enforcement on the lower quality recycling plants is necessary.