SMEP | Sustainable Manufacturing and Environmental Pollution

Development of Business Models and Policy Interventions to

REDUCE INFORMAL RECYCLING OF LEAD-ACID BATTERIES IN BANGLADESH

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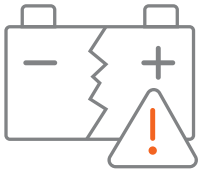
GEORGETOWN UNIVERSITY McDonough School of Business

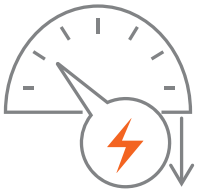
STANFORD GRADUATE SCHOOL OF BUSINESS

The Circular Economy of Lead Acid Batteries in Bangladesh with Formal and Informal Processes

Circular Management Challenges of LABs: Bangladesh has millions of electric three-wheelers (E3Ws) powered by large number of Lead-Acid Batteries (LABs).



Poor quality, short-lived, requiring frequent recycling and replacement



Inefficient in energy usage

Large amount of Lead recycled with high emission

80%

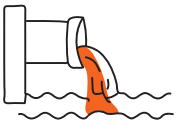
of used lead-acid batteries are recycled in illegal, informal sites.

125kg

of lead is contained in each E3W, which is 15 times that of a car battery.

30kg

of lead is emitted annually per E3W in Greater Dhaka.



10-20%

of lead is released into the environment every time a battery is recycled, causing widespread contamination.[1]

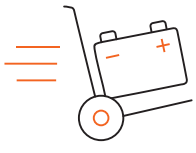
200,000 MT

of lead waste are generated annually through recycling.[1]

Why Informal Recycling Dominates

Lower Operating Cost

as it avoids taxes and regulations



Faster and Cheaper

access to used batteries at the point of collection

Formal Recyclers Face Higher Costs

due to logistics, storage, and compliance requirements

Current Market Structure

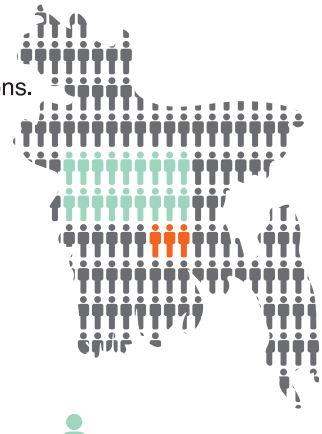
rewards low-cost, high-emission recycling

Health and Economic Impacts of Informal ULAB Recycling

3rd most lead-impacted country globally is Bangladesh, according to global estimations.

20% of the population lives within 5 km of informal smelting sites.

~5 *percentage point* increase in terminated pregnancies



National survey shows ~38% children under 5 years have elevated blood lead levels

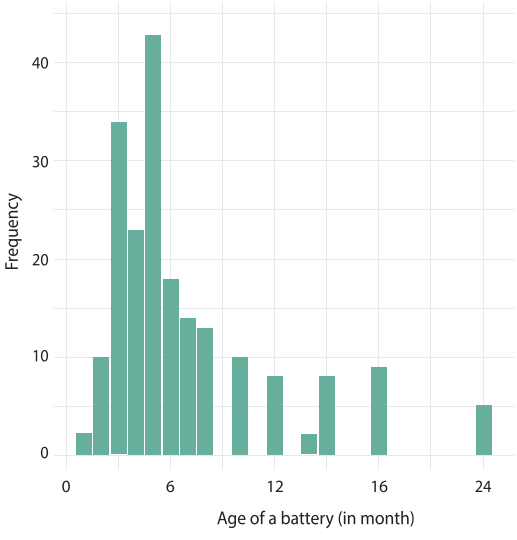
$29 B annually lost due to lead exposure (approximately 8% of GDP).

$91M tax revenue is lost annually by the government due to informal recycling.[2]

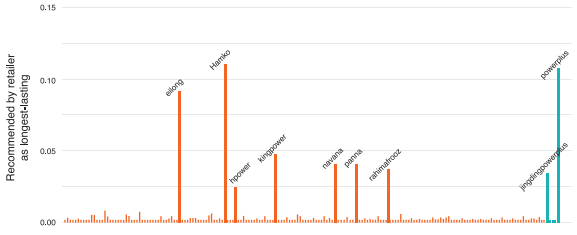
Lead-associated health risks:

IQ loss · *Learning Disability* · *Loss of Income* · *Cardiovascular Diseases* · *Renal Diseases* · *Pregnancy Miscarriages*

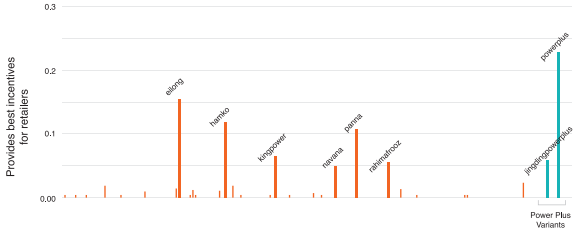
Retailers' Informational Role in an Informal Circular Economy



Most E3W lead-acid batteries have short lifespans, with 11% failing within 6 months and few lasting beyond 18 months. This figure shows the histogram of their ages.



(a) Percentage of visits in which the retailer recommended the brand as longest-lasting.



(b) Percentage of times the brand was listed as providing the best incentive, in the survey of consenting retailers. The above shows that a retailer recommends as longest-lasting a brand that gives them the best incentive.

Market Observations

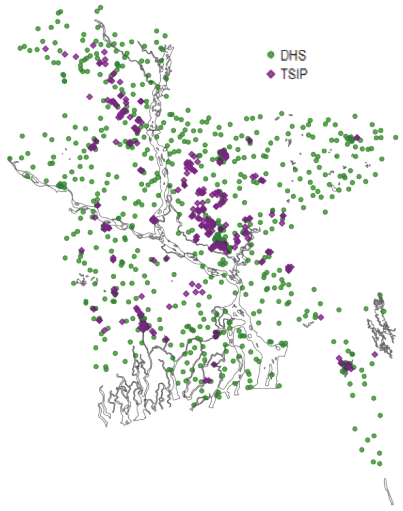
- Only 1 among 261 retailers recommended a lead-free battery (low-quality lithium).
- 190 unique brands are recommended as the longest-lasting battery brands.
- 80% of retailers respond differently to different types of customers.
- Retailers often recommend the brand that provides them the best incentive to poor customers.
- Predicted life differs across retailers and customers for the same brand of battery.
- Retailers exaggerate battery life to poor customers and charge them more.
- Warranty is at most 7 months. Usually 0, 3, or 6 months.

Customers lack reliable information about battery life. Consumer protection and reliable battery performance information can therefore help reduce lead emissions.

Barrier to Import Batteries and Lead Poisoning in Bangladesh

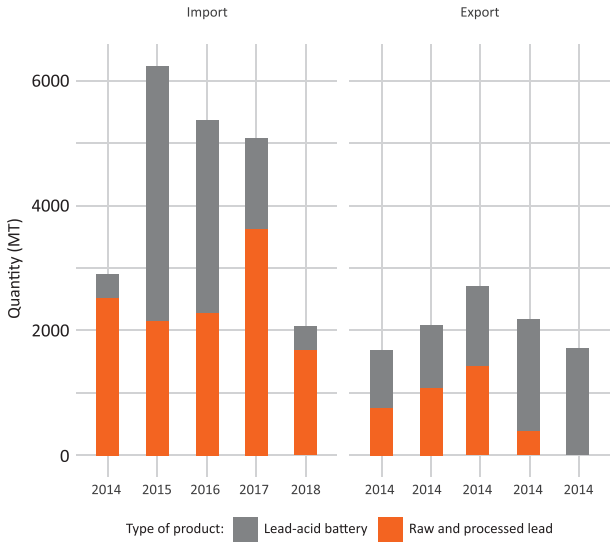
Geolocation of DHS* Clusters

*Demographic and Health Surveys (DHS)



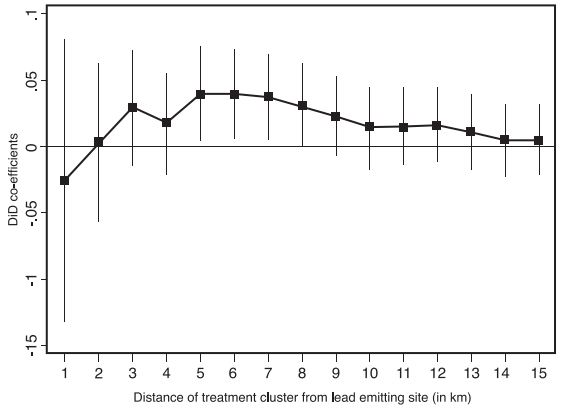
The map shows toxic sites identified through Pure Earth's TSIP program (purple squares) and the geolocation of the household clusters for maternal health data (2014 & 2018 surveys- green circles). After a 2015 LAB tax hike, women near toxic sites had more terminated pregnancies, boosting local battery production and recycling.[3]

Import and Export Quantity of Lead Products In and Out of Bangladesh



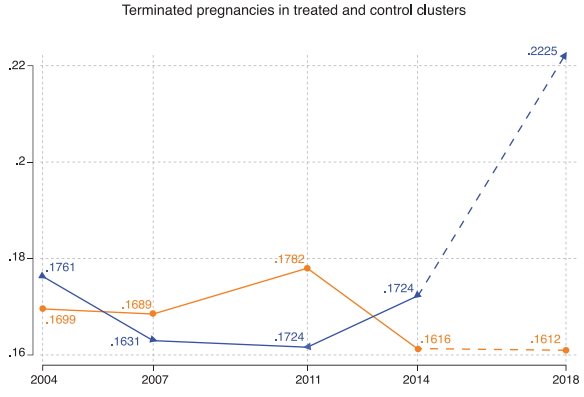
The study finds that Bangladesh's 2015 battery import barrier increased domestic battery manufacturing and recycling, contributing to a 4–5 percentage point rise in terminated pregnancies near lead-processing facilities, highlighting the need for stronger regulation of battery circular supply chains and reduced incentives for polluting domestic recycling.

Impact of the Battery Import Barrier on the Likelihood of Terminated Pregnancy



Impact of the battery import barrier on the likelihood of a terminated pregnancy when varying the treatment group definition. The results illustrate that the increased likelihood of a terminated pregnancy is the highest for pregnant women residing within 5km of a lead-emitting site. Then it starts decreasing as the distance of households from lead-emitting sites increases.

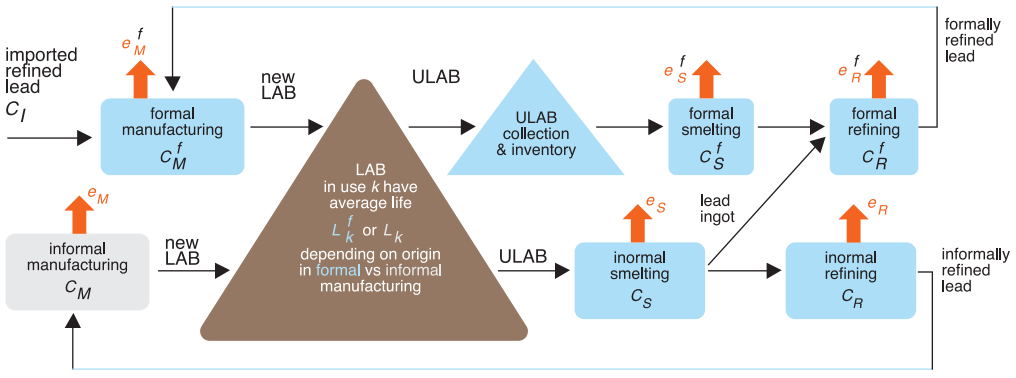
Contemporaneous Spike in Miscarriage (Lead Poisoning Indicator) Near ULAB Recycling Sites



- Mapped 294 toxic sites. There are many more.
- 4-5 percentage point increase in miscarriage under-estimate of effect.
- Most of the population lives within 3 miles of ULAB recycling.

Key Processes and Parameters of a LAB Circular Economy

The partial equilibrium model shows how used lead-acid batteries flow through formal and informal collection, smelting, refining, and manufacturing systems.



In the figure,
c = process cost
e = emission-intensity
e^f = A formal process
e_M, e_s or e_R = Type of process

The equations of the model show: Increment of battery prices = Increment in process costs & lead losses, because each stage higher emissions = More lead input.

Figure: Partial Equilibrium Model for LAB

The model compares the formal sector's three possible lead sources: imports, informal recycling, and formal recycling, to explain how costs, emissions, and battery lifespan shape market outcomes and how policy can redirect the system toward lower-emission formal recycling.

Recommendations

Smelting Fee Scheme

Subsidize qualified formal smelters with low emissions and verified traceability

Manufacturers pay a smelting fee for each new LAB

A balanced smelting fee subsidy design → increases government revenue, giving market advantage to environmentally compliant manufacturers and recyclers

Impact: Raises ULAB market value, phases out informal, high-emission recycling, and shifts demand to formally manufactured LABs

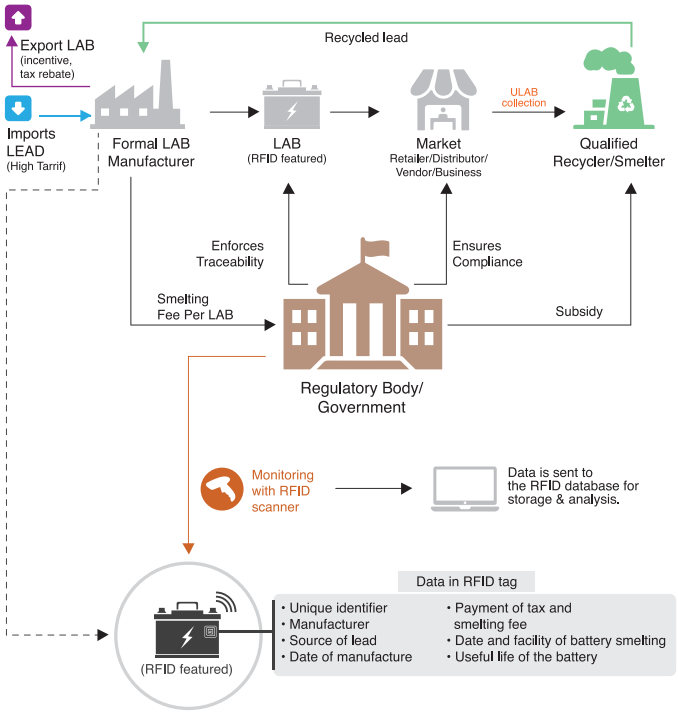
Traceability and Enforcement

Implement RFID tags on all batteries to track the manufacturer and smelter, confirming smelting fee payment

Regular checks by authorities in shops and on streets; fines for unregistered batteries

Monitor & publicise battery lifespan → encourage longer-lasting batteries and reduce informal ULAB recycling

Potential Solution: Proposed Circular Economy Model



Without proper policy intervention, falling demand for LABs can lower ULAB value, encourage dumping, and temporarily worsen emissions.

About SMEP

The “Development of Business Models and Policy Interventions to Reduce Informal ULAB Recycling in Bangladesh” project under the Sustainable Manufacturing and Environmental Pollution (SMEP) programme is led by Pure Earth Bangladesh, who have anchored the policy and stakeholder dialogues, supported by a research team led by Georgetown and Stanford Universities, along with local partners. The program is funded by the UK’s FCDO and implemented with UNCTAD, supporting developing countries in reducing industrial pollution while promoting sustainable production. The lead acid battery sector was prioritized in Bangladesh due to its importance to the country’s transportation, energy storage, and manufacturing systems.

Annex 1: Assumptions for the numbers in the factsheet

1. Conservatively assuming 3 million electric three-wheeler vehicles in Bangladesh today, each with 4 lead-acid batteries with 25kg lead on average and recycled every 1.5 years, the total amount of lead recycled is 200,000 MT, 10-20% of which is lost to the environment, causing tragic lead poisoning.

2. Assuming that only 30% of the ULABs recycling market is formal and pays 15% taxes, a 70% informality level results in tax revenue loss* for the government in the range of =0.7*0.15*871 million = USD 91 million or 915 crores BDT.

3. In this study, 18% of the BDHS clusters (123 out of the 617) are assigned to the treatment group, so in each of our 1000 simulations we randomly assign around 18% of BDHS clusters as treatment.

Disclaimer

This document is an output of research funded by the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme. UK International Development from the UK Government and the United Nations Conference on Trade and Development (UNCTAD) provide financial and technical support for SMEP.

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