Understanding Lead Poisoning in India
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Richard Fuller (Founder and President)
Date: 11th October 2022
Venue: IHC, New Delhi, India
**Pure Earth - Global and India**

Founded: **1999.** HQ In New York City

Active in over 26 Countries

Mission: Reduce children’s exposures to toxic chemicals

Early years: Identification & remediation of toxic hotspots

2006: Established office in India- New Delhi

Collaborative work on lead and mercury – governments, UN agencies, industry, World Bank
The Toxic Truth: Children’s Exposure to Lead Pollution Undermines a Generation of Future Potential
800 million children are lead poisoned globally.

The largest number of lead-poisoned kids are in India

275 million India kids are above 5 ug/dL

Lead poisoning responsible for 230,000 premature deaths in India
BRAIN DAMAGE

IN BABIES.

Exposure prenatal, or in first year of life:

- Permanent damage to frontal cortex
- Permanent IQ loss—3 to 5 points
- Increase in disability, learning disorders
Huge Loss of Intellectual Capital

Lowering intelligence at population-level scale has implications for:

- Entrepreneurship
- Productivity
- Disability costs

India loses $237 billion in GDP per year - 5%

Affects global competitiveness

The poorest are most affected
Other Health Impacts

Lead exposure can also cause

Loss of intelligence
Cardiovascular diseases
Stroke
Kidney diseases

Lead during pregnancy can cause

Miscarriage
Stillbirth
Premature birth & low birth weight
Violence & Security

Lead linked to violent crime.

Crime drops dramatically 18 years after lead levels drop.
After Gasoline Ban, India has gone backwards

Rate of Death from Lead in India vs UK (per 100K, 1990-2017).
(IHME)
Major Sources of Lead Exposure in India

- Substandard Informal Battery Recycling
- Adulterated Spices
- Cookware (Metallic alloys & Glazed Ceramics)
- Local Paint
- Cosmetics (Kumkum)
Case Study: Bihar, India

Prevalence of elevated blood lead levels and risk factors among children living in Patna, Bihar, India 2020

135 kids below 6 years tested & houses surveyed in Patna

87% had BLLs ≥5 µg/dl.

Along with battery recycling, adulterated spices are identified as the major source of high BLL

https://journals.plos.org/globalpublichealth/article?id=10.1371/journal.pgph.0000743
Solvable Problem

Solvable at modest cost as tested solutions exist

Monitoring programs — Test blood in newborns, schoolkids.

Source analysis — Where is the lead.

Interventions related to sources.
Spices Interventions

Rapid market survey & testing

Supply chain tracking

Regulatory and enforcement

Public education

Monitoring — product and people

Examples— Georgia, Bangladesh
Car Battery Recycling Interventions

Standard for Clean Smelters

Economic policy incentives to clean (formal) recyclers

Level the playing field – GST- Correct imbalance to benefit formal sector = significantly reduce informal sector

Regulatory and Enforcement control informal sector

Clean-up legacy sites
Thank You
ASSESSMENT OF LEAD IMPACT ON HUMAN AND INDIA’S RESPONSE
Many countries have struggled to address Lead exposure issues

Most have addressed these source specific prevalence [Lead Acid Batteries, Lead coated pipes, Lead in Fuel etc]

India has been also active in reduction of lead related exposures
  - Phased out Lead in 2000 completely from fuel,
  - Lead smelters have been regulated.
  - Others………..

Though many attempts are ongoing, new and unknown sources have emerged and growing
### India - Sources and Patterns of Lead Exposure

<table>
<thead>
<tr>
<th>Category</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industries</td>
<td>PCBs, batteries, nuclear power plants, antioxidants for oils, antivibration pads for buildings and machinery</td>
</tr>
<tr>
<td>Household Products</td>
<td>facewash, face packs, hair oils, face creams, shampoos, conditioners, body soaps, ayurveda medicines</td>
</tr>
<tr>
<td>Recycling</td>
<td>rag pickers and vendors exposed to Pb due to hazardous waste's non-reactive nature and non-scientific handling methods</td>
</tr>
<tr>
<td>Potteries and others</td>
<td>Utensils and glazed ceramic wares (glazed terra cotta (clay) and traditional ceramic dishes)</td>
</tr>
</tbody>
</table>
Exposures of Lead (Pb)

• Normal element of the earth’s crust, present in soil, plants and water.

• Practically immobile element; (Exceptions process of mining).

• Anthropogenic activities (paint, gasoline, water, batteries, deliberate product (food) contamination etc.)

• Children absorb 4-5 times more Pb than adults (WHO, 2021)

• Pb exposure caused 13.9 million DALYs and 540,000 deaths globally and 4.6 million Pb-attributable DALYs and roughly 165,000 fatalities in India. (IHME, 2017a)
Lead Exposure in India

- 275 million children in India with BLLs more than considered safe (5 µg/dL). *(UNICEF and Pure Earth, 2020)*

- Data sets derived in India from 1970 to 2014 collated to analyse BLL

- 23 states # exceed 5 µg/dL limits and Bihar exceeds 10 µg/dL limits.

<table>
<thead>
<tr>
<th>STATES</th>
<th>BLL (µg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bihar</td>
<td>10.42</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>8.67</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>8.32</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>8.15</td>
</tr>
<tr>
<td>Chhattisgarh</td>
<td>7.46</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>7.14</td>
</tr>
<tr>
<td>Odisha</td>
<td>6.94</td>
</tr>
<tr>
<td>Assam</td>
<td>6.72</td>
</tr>
<tr>
<td>Karnataka</td>
<td>6.62</td>
</tr>
<tr>
<td>Telangana</td>
<td>6.61</td>
</tr>
<tr>
<td>Tripura</td>
<td>6.55</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>6.23</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>6.12</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>5.94</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>5.74</td>
</tr>
</tbody>
</table>

# Data sets and numbers vary over a period and locations/groups
Data pointers through various studies

• Automotive, battery and railway sectors utilized 70% of Pb

• Hindustan Zinc Ltd. (HZL) (65000 MTA Pb production) and India Lead Ltd. (ILL) (28000 MTA Pb production) – major Pb producing industries

• Estimates show that Industrial Pb applications in India surpassed 81000 MT by 2020

• Secondary source of Pb production - scrap dealers, recycling vendors and cottage industries (contribute around 15000 to 20000 MTA Pb production)

• Pb concentration in the blood of the users of the cosmetics was higher (12.9 µg/dL) compared to the non-users of the cosmetics (4.3 µg/dL).

• Discarded electronic goods are a major source of toxic metals in municipal solid waste (MSW) of schools, offices, industries etc.
• **Pb (in lower concentrations) tends to bioaccumulate** in the plants, animals, microbes and other marine species, resulting in chronic health-hazard

• An average concentration of 100 to 100,000 μg/L of Pb has been reported in the marine food chain (Pandey and Madhuri, 2014)

• Research on Pb pollution shows that Pb in the human body is now 500-1,000 times higher than pre-industrial ones.

• Around 85% of Pb is consumed worldwide in the production of Pb-acid batteries, which are also recovered from dead Pb acid batteries.

• **Around 31 per cent of household paints in India had a Pb concentration of more than 10000 ppm, while the BIS limit for Pb paint is 90 ppm. [though its better regulated now]**

• The informal recycling sector, with a lack of knowledge about the toxicity of Pb is mainly responsible for Pb poisoning in many countries.
Exposure of Pb through Environment
Sources and their Linkages to Exposure

- **Industry** → **Lead Toxicity**
- **Batteries** → **Lead Toxicity**
- **Domestic Products** → **Lead Toxicity**
- **Cosmetics** → **Lead Toxicity**

**Lead Accumulation**:
- **Water Bodies (Fishes)**
- **Air**
- **Human Health**
- **Soil (Plants, Fruits)**
Health Impacts

- Higher levels of Pb may be found in the blood of apparently asymptomatic people.

### Symptoms in children
- Delay in development
- Sluggishness and fatigue
- Hearing loss
- Abdominal pain
- Vomiting
- Loss of appetite
- Learning difficulties

### Symptoms in prenatal, or in first year of life
- Permanent IQ loss – 3 to 5 points
- Increase in disability disorder
- Slow growth of the infant
- Reduced birth weight
- Permanent damage to frontal cortex
- Learning difficulties

### Symptoms during Pregnancy
- Miscarriage
- Stillbirth
- Premature birth & low birth weight
- Stillbirth
Health Impacts

- India loses $237 billion in GDP per year, or 5% in economic growth.

<table>
<thead>
<tr>
<th>BLLs (µg/dL)</th>
<th>Effects on children and adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>Decreased IQ level, increased incidence of behavioral problems and reduced attention span; impaired renal function; deficit/hyperactivity disorders; reduced fetal growth; decreased synthesis of aminolaevulinic acid dehydratase (ALAD), anemia etc.</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>Developmental disorders and delayed puberty</td>
</tr>
<tr>
<td>&lt; 20</td>
<td>Reduced vitamin D metabolism; higher level of erythrocyte protoporphyrin; reduced calcium homeostasis</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>Anemia</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>Increased vitamin D metabolism; reduced nerve conduction velocity.</td>
</tr>
</tbody>
</table>

**TOXIC EFFECTS OF LEAD**
- Decreased mental ability & learning difficulties
- Reducetion of IQ by 3-5 points
- High blood pressure
- Digestive problems
- Kidney damage
- Reproductive problems (adults)
- Reduced growth
- Violent behavior
- Brain & nerve damage
### Occupational and Non-occupational sources of Pb Poisoning

<table>
<thead>
<tr>
<th>Occupational</th>
<th>Non-occupational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery work (Rabin, 2008)</td>
<td>Traditional medicines</td>
</tr>
<tr>
<td>Mining</td>
<td>Vehicular exhaust</td>
</tr>
<tr>
<td>Glass manufacturing</td>
<td>Pb contaminated cosmetics and sindoor</td>
</tr>
<tr>
<td>Automobile repair</td>
<td>Household storage batteries</td>
</tr>
<tr>
<td>Ceramic work</td>
<td>Household paints</td>
</tr>
<tr>
<td>Painting</td>
<td>Pb-contaminated spices</td>
</tr>
<tr>
<td>Making pottery</td>
<td>Effluent from Pb-based industries</td>
</tr>
<tr>
<td>Smelting</td>
<td>Pb-contaminated soil, dust, and water</td>
</tr>
<tr>
<td>Printing work</td>
<td>Food grown in Pb-contaminated area</td>
</tr>
<tr>
<td>Plumbing (Iwegbue et al., 2008)</td>
<td>Retained bullets</td>
</tr>
<tr>
<td>Soldering (Clark et al., 2005)</td>
<td>Food stored/cooked in Pb-coated vessels (Kumar and Pastore, 2007)</td>
</tr>
<tr>
<td>Manufacturing Pb pipes and plastic (Dongre et al., 2013)</td>
<td>Painted toys</td>
</tr>
</tbody>
</table>
Methodology-Pb Exposure:
Data from various studies published have been analysed and used for estimation through multiple levels of computing for understanding the scale of lead exposure in India.
Methodology-Pb Exposure

Risk Factor Estimation

**Exposure Data Collection and Collation**
1. Data Sources from literature review
2. Fitting ensemble distribution of the microdata
3. Blood Lead Level based on demographics, age, sex etc.

**Exposure Estimations**
- Spatio-temporal Gaussian process regression
- Estimation of blood lead levels with distribution

**Relative Risks**
- Calculation of cumulative blood lead index (CBLI) based on conversion factors and available distributions
- Estimation of blood lead levels with distribution
- Calculating Shift in IQ levels and Systolic Blood Pressure (SBP)
- Pollution attribution fraction by risk, cause, age, sex etc.

**Final Burden Estimation**
- Deaths, YLLs, YLDs, DALYs attributable to each risk by age, sex, year, geography.

YLL : Years of Life Lost due to premature mortality
YLD : Year of healthy life lost due to disability or ill-health
DALY: Disability-Adjusted Life Year

DALY is a time-based measure that combines years of life lost due to premature mortality (YLLs) and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability (YLDs)
Way Forward

Recommendations and Conclusions

- Disease prevalence and its burden estimation are last pointers
- Identification of sources and their mitigation is key for the future operations
- Exposed population, especially children must be brought under close surveillance through education, clinical examination and rehabilitation.
- Regulatory system alone may not yield results.
- Local level and NGOs/public participation can aid the process
- Industries specific (SSI) needs and technologies use and validation through targeted innovation

Country level primary assessment needed especially in population hubs of potential hotspots and also in supply chain of Lead use, transport, manufacturing and distribution
Dr Rakesh Kumar
OSD, CSIR HQ, New Delhi
Former Director, CSIR NEERI

Acknowledgements:

- Dr. Rajiv Kumar of Niti Ayog and his colleagues
- Dr. Karti Sandilya and his colleagues from Pure Earth
- IHME scientists/researchers
- Reviewers : Dr. B. Sengupta Ex. Member Secretary, CPCB, Dr. Meena Sehgal, TERI, New Delhi, Dr. Rajiv Bhirud, Industries expert and Dr. A. Shariff, Professor & Head, Department of Anatomy Founder Professor In-charge, Clinical Ecotoxicology Facility, AIIMS, New Delhi
- CSIR colleagues [ Dr. S Mande, DG CSIR; Dr. A. Kapley, Dr. S. Kumar, Er A. Gupta and others ]
HEALTH IMPLICATIONS OF LEAD EXPOSURE

A TERI and PURE EARTH SEMINAR

T K Joshi
FFOM (Royal College of Physicians, London)
Fellow Collegium Ramazzini,
Technical Advisor Health, UNOPS, India
Lead – A toxic metal

- Lead is a non essential metal and serves no useful role in the body,
- Lead is a metal and as such it can not be created or destroyed and will outlive the humanity,
- Though lead is an ancient poison, large scale lead exposure was the result of addition of tetra ethyl lead to the gasoline/petrol & aviation fuel as an anti knock agent and its use in paints in 20th century
- Lead acetate was used as an artificial sweetener in Ancient Rome; is still used in some hair dyes and lipsticks today.
- In US candies imported from Latin America have been found to be contaminated with Lead acetate
Historically recorded health implications

- Lead production started at least 5000 years ago,
- Hippocrates (370 BC) diagnosed lead colic in a metal extractor,
- Second century-BC Nicander knew the relationship of constipation, colic, pallor and paralysis to the action of lead on the body.
- Pliny (AD 23–79) knew of lead poisoning; lead workers tied up their faces in loose bags ‘lest they should inhale the pernicious dust’.
- Dioscorides (AD 100) knew that ingestion of lead compounds caused colic, paralysis and delirium and,
- Ramazzini observed that for potters working with lead ‘at first tremors appear in the hands, soon they are paralyzed’.
- Vernatti (1678) probably made the earliest record of lead poisoning among white-lead workers in England.

Lead Exposure in India

• Lead exposure in India is largely an urban phenomenon,

• In remote rural areas Blood Lead Levels (BLL) were in the range of 2-3 µg/dL,

• In urban areas in was not uncommon to find BLL of 40 µg/dL,
Blood Lead Levels in Workers at e-waste Recycling Facility, Delhi

*Source: A Jointly Conducted Study by “Centre for Occupational and Environmental Health and The Energy and Resources Institute, funded by GTZ, Germany” at Seelampur, Mandoli, and Shastri Park areas of Delhi

Ref Std: 20 ug/dL
WHO Position Statements

• Lead is one of 10 chemicals of major public health concern needing action by Member States to protect the health of workers, children and women of reproductive age,

• There is no ‘safe level of exposure’ to lead, even blood lead concentrations as low as 3.5 µg/dL may be associated with decreased intelligence in children, behavioural difficulties and learning problems,

• Nearly 1% GBD is attributable to lead exposure,

• Lead poisoning is a notifiable disease in India but there is no data as to the number of lead affected victims,
Exposure-Impact factors

• The fraction of Pb that is absorbed depends mainly on the physical and chemical form, particularly particle size and the solubility of the specific compound.
• Other important factors are specific to the exposed subject, such as age, sex, nutritional status and, possibly, genetic background,*
• has a mean biological half-life of about 40 days in adult males,
• Half-life in children and in pregnant women was reported to be longer, because of bone remodeling,#

*Ref-[Agency for Toxic Substances and Disease Registry (ATSDR) 1999; National Research Council 1993]

#(Gulson et al. 1996; Manton; J Lab Clin Med 125:703–712.)
Lead Exposure in India

- Toxicity concerns are on account of large scale E-waste recycling in informal sector, and
- Lead Acid Battery recycling once again in informal sector,
- The soil contamination from these activities affects environment and food safety,
Lead Exposure Determination Methods

- Blood Lead measurement still remains the standard method,
- Others that are being looked into:
  - Plasma/serum lead concentration,
  - Saliva lead, Sweat
  - Lead in Hairs,
  - Urinary and fecal lead,
  - Nail Lead,
  - Bone Lead,
  - Lead measurement in tooth
  - Provocation test
• The body stores lead in the **teeth and bones**, where it accumulates over time.

• As we age, our bones demineralize and the internal exposures may increase as a result of larger releases of lead from the bone tissue,

• Lead stored in bone may be **released into the blood during pregnancy**, thus exposing the fetus,
Vulnerability of Children

• Children are especially vulnerable to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage.
• Diets low in iron, calcium, and vitamin C increase the likelihood of lead absorption and resultant lead poisoning.
• Mounting evidence suggests that lead poisoning in childhood produces a long-term problem with learning, intelligence, and earning power.
Target organ may not have highest concentration

• Once lead enters the body, it is distributed to organs causing adverse Effects:
  • neurological,
  • hematological,
  • gastrointestinal,
  • cardiovascular,
  • immune and
  • renal systems
  • Reproductive
Short term exposure

• Abdominal pain
• Constipation,
• Loss of appetite
• Tiredness,
• Headache,
• Irritability,
• Memory loss,
• Pain or tingling in the hands and/or feet
• Weakness
Continued Exposure

• Lead exposure also causes anemia, hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs.

• The **neurological and behavioral effects of lead are believed to be irreversible**.

• Dietary fibre helps promote good peristalsis and decreases the opportunity for lead absorption; thus, at least 15 g of dietary fibre is suggested for children each day,

• **2 syndromes of lead poisoning exist, depending on exposure:**
  • Syndrome I- Acute or subacute high-level lead exposure, and
  • Syndrome II- Chronic low-level lead exposure
Health Implications-Acute/Subacute exposure

- Exposure to high levels of lead, patients develop lethargy, progressing to coma and seizures
- Acute nephropathy manifests with tubular defects, which may include phosphaturia, glucosuria and amino aciduria.
- This combination of tubular defects is referred to a Fanconi’s syndrome.
- Deaths may result from the elevated intracranial pressure (ICP) associated with lead encephalopathy

Ref; Author: Christopher P Holstege, MD; Chief Editor: Tarakad S RamachandranPathophysiology and Etiology of Lead Toxicity. Medscape. https://emedicine.medscape.com/article/2060369-overview#a2
Chronic Exposure

• Men with lead poisoning tend to have a reduction in libido, abnormal spermatogenesis, chromosomal damage and infertility, lower sperm counts and may experience frank impotence;

• Women experience an increase in the incidence of stillbirth, pregnancy induced hypertension, and prematurity, increase in miscarriages and smaller babies

• Lead causes demyelination of the peripheral nervous system and the abnormalities mostly affect the extensor motor nerves and may result in hand and foot drop.

• Gout is associated with chronic lead toxicity,

• One of the most well-characterized symptoms of lead poisoning is porphyria.

• The biochemical signs of lead intoxication related to porphyria are delta-aminolevulinic aciduria, coproporphyrinuria, and accumulation of free and zinc protoporphyrin in erythrocytes.
Conclusion

• The future of our children and their neurological development depends up on how seriously the authorities realize the magnitude of lead toxicity,

• The toxicity of lead and exposure are entirely preventable provided there is a commitment and will,

• A national policy and programme including childhood lead screening and, worker education, good work practices, and capacity building to be able to identify lead toxicity early and chelating those as per standard protocols should offer hope.
LEAD IMPACTS IN DEVELOPING COUNTRIES

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Number 1 environmental poison

- Has greater impact in developing countries
- Main cause is poverty affecting vulnerable groups
- Lack of regulation and non availability diagnostic tools
- Lack of bio-monitoring data for scientific studies
- Mechanism to monitor control and review outcome
WE NEED

• Implementable policies developed by all concerned parties
• Gradual time bound implementation
• Self regulation before any regulator intervenes
• Understand economic implications on a long run at country level
• Mechanism to monitor control and review outcome
## EXCLUSIVE STUDY

**The Week**

### Wooden Toys and Levels of Lead

<table>
<thead>
<tr>
<th>Toy Description</th>
<th>Lead Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooden ball and sliding cat toy</td>
<td>0.21% - 0.26%</td>
</tr>
<tr>
<td>Wooden ball</td>
<td>0.22% - 0.26%</td>
</tr>
<tr>
<td>Farmer the Tank Engine (Pen)</td>
<td>0.16% - 0.16%</td>
</tr>
<tr>
<td>Fascia</td>
<td>0.15% - 0.22%</td>
</tr>
<tr>
<td>Wooden Mickey Mouse car</td>
<td>0.18% - 0.20%</td>
</tr>
</tbody>
</table>

### Plastic Toys

<table>
<thead>
<tr>
<th>Toy Description</th>
<th>Lead Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic car from the Film Cars</td>
<td>0.26% - 0.26%</td>
</tr>
<tr>
<td>Plastic opening top</td>
<td>0.26% - 0.26%</td>
</tr>
<tr>
<td>Disney Princesses Glitter Bag Set</td>
<td>0.26% - 0.26%</td>
</tr>
<tr>
<td>Plastic cups</td>
<td>0.26% - 0.26%</td>
</tr>
<tr>
<td>Plastic bucket (small)</td>
<td>0.26% - 0.26%</td>
</tr>
</tbody>
</table>

### Toxic Substances

Toys can contain several toxic substances, one of which is lead. Lead tastes sweet, so children may develop a liking for it.

**Dr. Veinbahn Doremel, MD, Professor**
Dasara or Navarathri, the Nadahabba of Karnataka is an important occasion for Kannadigas. Dasara is celebrated in a very grand way in the costal Karnataka. Celebrations of this festival are unique.
Where children play are loaded with lead
Challenges and opportunities

One of the challenges is to achieve the global standard for BLL of 2ug/dl. Still need to be taken with all seriousness
Lead free    lead safe

Lead free world is not possible however
Lead safe work place is achievable
Thuppi
“LEAD”
THANK YOU FOR BRINGING US TOGETHER
Lead man of India