Childhood Lead Exposure in Illinois and Leeds

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My Research Interests

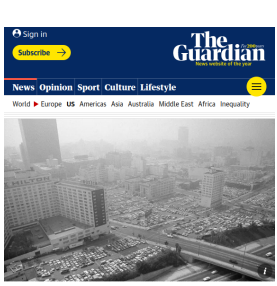
Econometrics

Causal Inference, Spillovers, Measurement Error, Model Selection, Bayesian Inference

Applied Work

Childhood Lead Exposure, Pawn Lending in Mexico City, Colombian Civil conflict

Why did I start thinking about lead?



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Half of US adults were exposed to harmful lead levels as kids, study finds

Researcher calls findings 'infuriating' as team finds significant impact on cognitive development

Associated Press

Tue 8 Mar 2022 00.20 GMT

Over 170 million Americans who were adults in 2015 were exposed to harmful levels of lead as children, a new study estimates.

Researchers used blood-lead level, census and leaded gasoline consumption data to examine how widespread early childhood lead exposure was in the country between 1940 and 2015.

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America's dirty divide

'We're losing IQ points': the lead poisoning crisis unfolding among US children

The US banned lead 30 years ago. So why are thousands of kids being poisoned every year?

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About this content

Erin McCormick *in Rhode Island and* **Eric Lutz**

Wed 8 Dec 2021 10.00 GMT

Nine-year-old Turokk Dow loves spelling, airplanes and basketball. He is learning to read and write in his third grade classroom.

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Our unequal earth

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'It was everywhere': how lead is poisoning America's poorest children

The toxin has endangered hundreds of thousands of kids. But parents in the hardest-hit neighborhoods may never be warned of the threat

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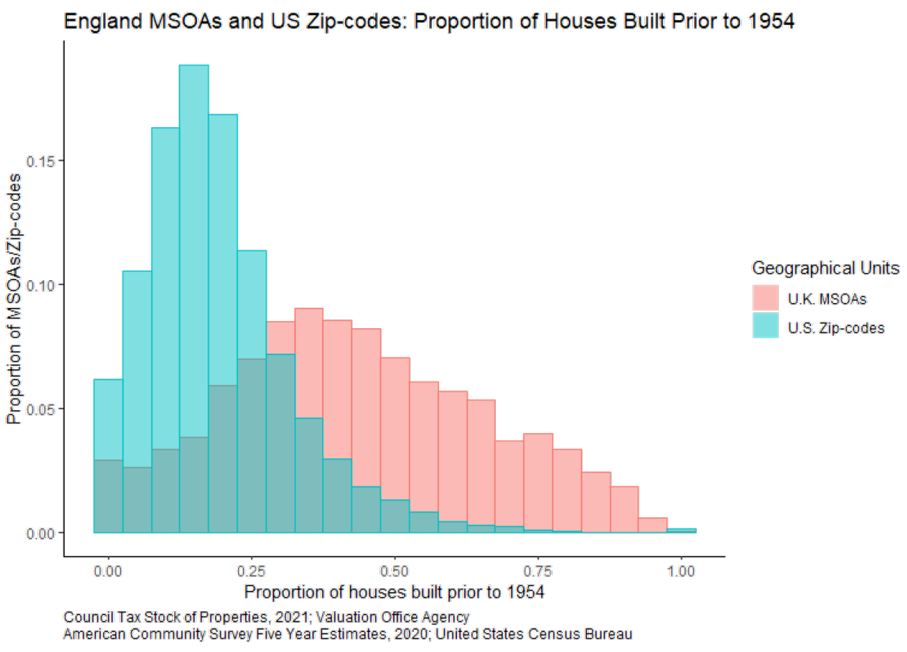
11th Hour Project

About this content

Nina Lakhani *in Philadelphia*

Wed 26 Feb 2020 09.00 GMT

Shanava Ball did everything right during her pregnancy: she https://www.theguardian.com/...


England MSOAs and US Zip-codes: Proportion of Houses Built Prior to 1954
Proportion of MSOAs/Zip-codes
0.15
0.10
0.05
0.00
0.00
0.25
0.50
0.75
1.00
Proportion of houses built prior to 1954
Geographical Units
U.K. MSOAs
U.S. Zip-codes
Council Tax Stock of Properties, 2021; Valuation Office Agency
American Community Survey Five Year Estimates, 2020; United States Census Bureau

There is no screening for lead exposure in the UK.

2018 National Screening Committee Report

The volume, quality, and direction of evidence published since 2012 does not indicate that screening for elevated BLLs should be recommended in the UK. Several uncertainties remain across key criteria including: lack of evidence that elevated BLLs in children is an important health problem in terms of UK prevalence.

2019 Lead Exposure in Children Surveillance System Report

There are no recent comprehensive survey data estimating how many children in England are exposed to lead.

2021 Public Health England (now HSA)

Public health intervention level for lead halved from 10 to 5μg/dl.

This Talk

1. Background on lead exposure.
2. Hidden Hazards and Screening Policy: Predicting Undetected Lead Exposure in Illinois
3. Environmental Lead in the 21st Century
4. ECLIPS: Piloting a Lead Screening Program

1. Background on Lead

What's so bad about lead?

Lead is a potent neurotoxin

- Toxic whether inhaled or ingested: "mimics" calcium, disrupting all biological processes that depend on it.
- Harms reproductive, hematopoietic, endocrine, renal systems.
- Particularly harmful to **central nervous system**: calcium crucial for neurotransmission $\implies$ damage to prefrontal cortex, hippocampus, cerebellum

Lead is most harmful at younger ages

- Permanent damage to developing nervous systems.
- Blood-brain barrier more permeable in young children.
- Digestive systems of children more likely to absorb ingested lead.
- Lead accumulates in bone and *stays there* even after leaving the blood.
- Young children put things in their mouths (paint chips, soil); lead **tastes sweet**.
- E.g. Roman sweetener/preservative *sapa* aka *defrutum*: concentrated grape juice boiled in lead vessels

Didn't we get rid of all the lead?

We largely stopped *adding* lead, but much remains in place.

Leaded gasoline

- Responsible for the overwhelming majority of lead exposure during 20th century
- Phased out for cars between 1973 and 1995 in US; banned in 2000 in the UK
- Still used in fuel for small planes: AVGAS.
- Soil near major roads remains contaminated.

Lead paint

- Ubiquitous in first half of 20th century; US ban for residential use in 1978; (mostly) banned in the UK in 1992
- Likely the main exposure source today, after phaseout of leaded gasoline
- HUD estimate: 20% of US homes with small children still have lead paint
- Ingested, or inhaled in form of dust (EPA requirements for renovations)

Lead pipes: it's complicated

It depends on the water

- **Scale**: plaque on inside of pipes that prevents lead from leaching into water.
- Water hardness (mineral content) tends to increase development of scale.
- Phosphates can be added to artificially create scale: compounds bind to lead.
- U-shaped relationship: water pH and lead solubility
- (pH $6 \uparrow 7$) $\implies$ (water-lead $\downarrow$) 50 to 90%, depending on above.

DC 2002; Flint Michigan 2014

- Changes in water sources/treatment $\implies$ sudden corrosion of protective plaque.
- High levels of lead flush into the water supply (need to test at the tap)

Measuring Lead Exposure

Blood Lead Levels (BLLs)

- BLLs, either venous or capillary (finger prick), proxy for lead exposure.
- Measured in micrograms per decliter (μg/dl)
- Best we can do, but not ideal:
  - Half life of lead in blood ≈ 36 days: "instantaneous" versus cumulative exposure
  - Venous tests are more accurate, but still noisy: measurement error

Screening in the US

- National Health and Nutrition Evaluation Survey (NHANES): venous BLLs, representative cross-section
- Various screening programs run by the states
- Federal guidelines mandate screening of all children on Medicaid at ages 1 and 2.
- Some states have *de jure* universal screening; others have targeted screening

Blood Lead Levels (BLLs): how high is too high?

- 1991-2012 CDC considered BLL ≥ 10 *elevated*; since 2012 BLL ≥ 5
- Essentially arbitrary: 97.5%-tile, most children no longer exposed to lead
- "No safe level of lead" but "the dose makes the poison" and BLLs have declined
- Clear **symptoms** of lead poisoning (anemia) and acute harm: BLL ≥ 40 μg/dl
- Permanent damage at levels too low to observe symptoms, e.g. lower IQ.

Aizer & Currie (2018; AEJ Applied)

Lower BLLs explain 75% of decline in school suspensions from 1994-2015 in RI

Aizer, Currie, Simon & Vivier (2019; ReStat)

Low levels of lead (BLL ≤ 5) have a discernible negative affect on test scores.

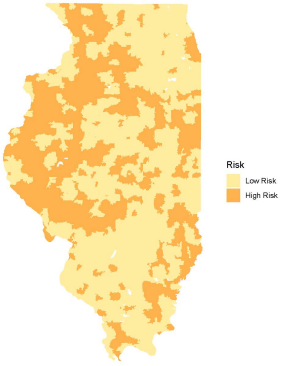
Groenqvist, Nilsson & Robling (2020; JPE)

Long-term effects on human capital and crime from low doses of lead

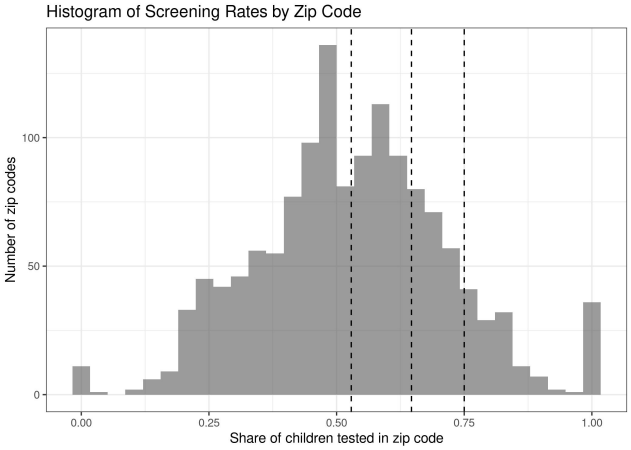
2. Hidden Hazards and Screening Policy: Predicting Undetected Lead Exposure in Illinois

Targeted Screening in Illinois: 2010-2014 Birth Cohorts

High and low-risk zips



Screening compliance in high-risk zips



IL Dept. of Public Health designates zip codes as "high risk" based on housing age and % of children below 200% of poverty line.

How should IL target lead screening?

Build novel dataset

- Link lead tests to geocoded birth records for IL children born from 2010 to 2014
- Merge with spatial characteristics that predict lead exposure: housing age, proximity to major roads, industrial lead emissions, etc.

Impute missing BLLs

- Rich set of individual and spatial controls, including all variables used to target.
- Selection observables (into testing) is plausible here
- Flexible machine learning models, tuned/evaluated with novel policy-relevant loss.

Policy Experiments

- How many children with elevated BLLs are missed by current screening?
- Can we reliably identify children who *shouldn't* be screened?
- Can we improve on the "high risk" zip code designations for IL?
- How best to target screening at the individual level?

If selection-on-observables is outlawed...

- Not completely airtight, but we go much further than existing work
- Policy discussions of targeted vs universal screening often assume BLLs *missing completely at random*, i.e. BLLs of tested and untested are equal on average.

Novel Policy-relevant Loss for Model Tuning/Evaluation

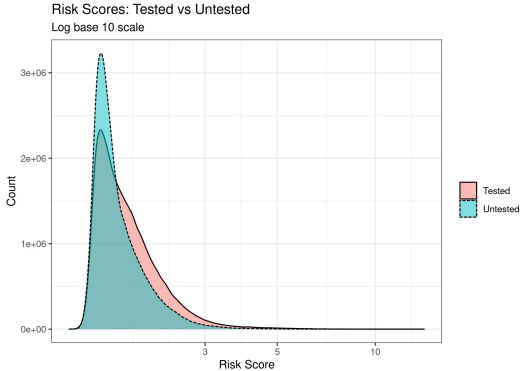
Naive Approach

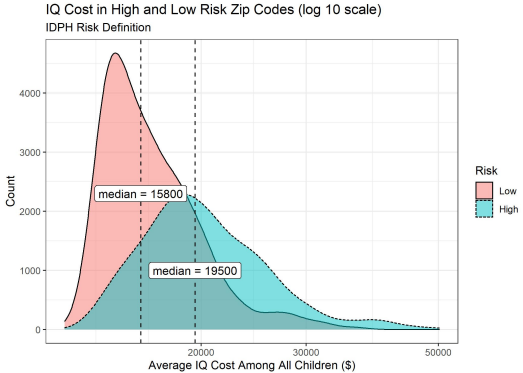
- Classification model to predict *elevated* BLLs: $1(\text{BLL} \geq 5)$ or 10.
- How to weigh false positive against false negatives?
- Is a BLL of 4.5 that you classify as "elevated" really a false positive?
- Much worse to classify a BLL of 20 as "not elevated" than a BLL of 5.5
- Cutoff of 5 or 10 is essentially arbitrary; why not 7?

Our Approach

- Prefer to identify children with higher BLL before those with lower BLLs.
- Score BLLs based on the *harms* they cause in dollars: *averted cost*
- Targeting function $r(X_i)$: ranks children based on observed covariates X_i.
- If you plan to screen n children, choose those with highest $r(X_i)$.
- Evaluate $r(\cdot)$ by comparing its *total* averted cost to infeasible optimum that perfectly ranks children from highest to lowest BLL.
- Develop cost-weighted targeting efficiency (CWTE) for tuning and evaluation.

Some Key Results

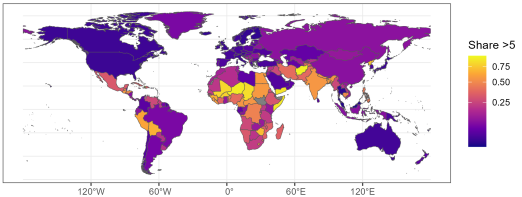


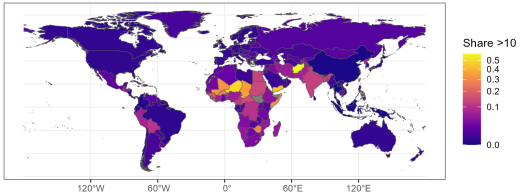


- The untested are, on average, lower risk than the tested: targeting works
- Estimate 6600 missed cases relative to 18,000 detected cases
- Over 80% of missed cases *should have been tested* under status quo: high risk
- Model-based targeted screening superior to status quo and "universal" screening

3. Environmental Lead in the 21st Century

Environmental Lead in the 21st Century





- With Mengli Chen, Ludovica Gazze, Caroline Taylor, Dominik Weiss, et al.
- Review Article: retrospective: 20 years after the phase-out of leaded gasoline
- Remaining global lead exposure; data gaps; back-of-the-envelope economic costs
- Estimated global yearly cost of childhood lead exposure: \$3 trillion (2% of global GDP in 2019)

4. ECLIPS: Piloting a Childhood Lead Screening Program

ECLIPS – Piloting a Childhood Lead Screening Program in Leeds

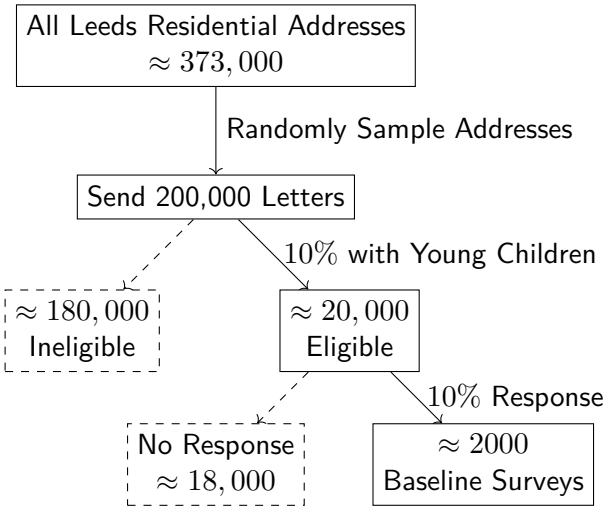
Elevated Childhood Lead Interagency Prevalence Study

- Jane Entwistle, Lindsay Bramwell, *Northumbria*
- Frank DiTraglia, *Oxford*
- Ludovica Gazze, *Warwick*
- Carys Lippiatt, *Leeds Teaching Hospitals*
- Priya Mondal, Ovnair Sepai, *UKHSA*
- Jackie Morton, *Health & Safety Executive*
- Caroline Taylor, *Bristol*

UKRI Cross Research Council Responsive Mode Scheme

- Funded from Jan 2025 – Dec 2027
- Pilot a home test for childhood lead exposure in Leeds
- Finger-prick test using Capitainer (at right)

Phase I: Recruiting / Study Participation Decision



5 GBP gift card for sign-up and baseline survey completion

Phase I: Recruiting / Study Participation Decision

Research Questions

- How do LSOA characteristics predict response rates?
- Randomized Controlled trial: test alternative outreach messages

Personalized Risk Information

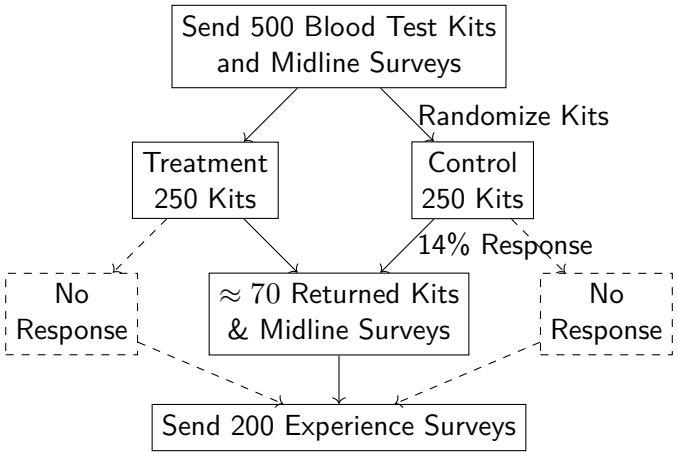
- Merged EPC certificates for Leeds with residential addresses
- Gives us age of 250k properties (out of $\approx$ 373k)
- "Our records indicate that your home was built before XXXX so it might have lead paint or pipes. Taking part can help you learn if these affect your child's health."

Lead Exposure Sources

- "Lead can be found in various products including XXXX. Taking part can help you learn if any of these affect your child."

Phase II: Collecting Blood Samples

Baseline survey & census: choose probs of sending each household a kit (2000 to 500)



35 GBP for returned sample / midline survey; 10 GBP for experience survey

Phase II: Collecting Blood Samples

Research Questions

- Who returns the blood test kits?
- What fraction of returned kits are a usable sample?
- What are the BLLs of the returned kits?
- Randomized controlled trial: vary the contents of the kit
- Survey: barriers to participation, experience with the kit, etc.

Thanks for listening!