Getting Ahead of Lead: Can Predictive Modeling Help Prevent Childhood Lead Exposure?
Children 0 to 6 years with BLL ≥10 mcg/dL in Chicago
1997 - 2015
Percent of Children under 3 with BLL>6 by Community Area in 2014

3.5% of Chicago children under 3 have ELEVATED BLOOD LEAD LEVELS

COMMUNITY AREAS where more young children have elevated blood lead levels:
- Austin
- Garfield Park
- Englewood
- West Garfield Park
- North Lawndale
- North Lawndale
- Pullman
- Chicago Lawn
- Roseland
- South Chicago
Changing Our Model

Reactive

CHILD POISONED

Proactive

IDENTIFY HIGH RISK HOMES

LEAD MITIGATION
<table>
<thead>
<tr>
<th>DATA</th>
<th>YEARS</th>
<th>RECORDS</th>
<th>VARIABLES</th>
<th>OWNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Lead Level</td>
<td>1995 – 2017</td>
<td>2,700,000</td>
<td>First name, last name, date of birth, address, blood lead level, sample type, sample date</td>
<td>CDPH Lead Program</td>
</tr>
<tr>
<td>Home Inspection Records Summary</td>
<td>1989 -2017</td>
<td>66,000</td>
<td>Date of initial inspection, lead based paint hazard (yes/no), location of lead-based paint hazards (interior/exterior/both/), date complied, address</td>
<td>CDPH Lead Program</td>
</tr>
<tr>
<td>Building Permits</td>
<td>2006 - 2017</td>
<td>400,000</td>
<td>Address, issue date, permit type</td>
<td>Chicago Department of Buildings (Chicago Open Data Portal)</td>
</tr>
<tr>
<td>Building Violations</td>
<td>2006 – 2017</td>
<td>1,500,000</td>
<td>Address, violation Date, violation description, violation ordinance, inspection status</td>
<td>Chicago Department of Buildings (Chicago Open Data Portal)</td>
</tr>
<tr>
<td>Building Footprints</td>
<td>2015</td>
<td>800,000</td>
<td>Year of building construction, physical condition, number of units, stories (floors), vacancy status</td>
<td>Chicago Department of Buildings (Chicago Open Data Portal)</td>
</tr>
<tr>
<td>Cook County Assessor</td>
<td>2013</td>
<td>800,000</td>
<td>Address, assessed property values, building classifications, building characteristics, year built</td>
<td>2014 Cook County Assessor</td>
</tr>
<tr>
<td>Chicago Census Boundaries</td>
<td>2010</td>
<td>800</td>
<td>Shape File</td>
<td>Chicago Open Data Portal</td>
</tr>
<tr>
<td>Chicago Ward Boundaries</td>
<td>2015</td>
<td>50</td>
<td>Shape File</td>
<td>Chicago Open Data Portal</td>
</tr>
<tr>
<td>American Community Survey</td>
<td>2005 - 2014</td>
<td>800</td>
<td>Census tract variables including socio-demographics, education, health insurance, home ownership.</td>
<td>US Census Bureau</td>
</tr>
<tr>
<td>Frequently Occurring Surnames</td>
<td>2000</td>
<td>150,000</td>
<td>Census surname ethnicity</td>
<td>US Census Bureau</td>
</tr>
</tbody>
</table>
The Childhood Lead Paint Hazard Data Sharing Across Sectors of Health Project

Support for this project is provided by the Data Across Sectors of Health grant from the Robert Wood Johnson Foundation.
A Predictive Model

Blood Tests → Home Inspection → Census ACS → Building Permit Violations → Assessor → Building Footprints

Spatio-Temporal Features

Spatial Features

Predictive Model

Children & Homes Prioritized Using:
1. WIC Data (Validation)
2. WIC Data (CBO Letter)
3. WIC Data (HUD CHW Study)
4. EHR Data (Lead Safe API)
CBOs & Reminder Letter

Test whether reminder is effective in getting people to schedule an appointment with CBO’s to perform the visual inspection.

1. Explain briefly why they are getting this reminder.
2. First box checked to encourage inertia to completing the task.
3. Make it easy for people to write the appointment time down.
4. Reminder that the goal is safety for family.
5. Provide deadline to schedule appointment within a week, not leave it open-ended.

Letter:

Dear [Name],

The Chicago Department of Public Health is contacting you because we believe your home may have lead paint, putting children in your home at risk for lead poisoning.

The Chicago Department of Public Health wants to keep you and your family safe. This is a reminder to schedule your free lead appointment today.

The free visual lead appointment conducted by trained Imagine Englewood (IE) staff, who are working with the Chicago Department of Public Health.

If lead is found in your home, IE and the Chicago Department of Public Health will work with you to make your home lead-safe.

Make sure your home is safe from lead – for free:

1. [ ] Receive this reminder to schedule a free lead inspection. (If you’ve already made your appointment, ignore this reminder)
2. [ ] Call 773-488-6704 and talk with the friendly Imagine Englewood (IE) staff.
3. [ ] Schedule your free appointment before November 14, 2016.

My appointment is on:
Date: __/__/___ Mon Tues Wed Thur Fri
Time: __:__ AM/PM

4. [ ] Work with Chicago Department of Public Health and Imagine Englewood (IE) to make your home safe.
5. [ ] Enjoy knowing that you have a lead-safe home for your family.

Questions? Contact us at 773-488-6704
Validating the Model

To compare our performance in predicting lead paint poisoning with a baseline, given by random predictions.
Electronic Health Record Clinical Decision Support Tool

- Access the predictive model through an EHR Clinical Decision Support Tool (CDST)

- The CDST can alert providers to the risk of lead exposure based on the patient’s current address

- CDST provides recommendation for visual home inspections and patient education on lead abatement strategies
Operationalizing the Model

Predictive Model

Clinical Data from Electronic Health Record using an API

Risk Score in Electronic Health Record

Referral for visual home inspections and patient education on lead abatement strategies
Submitted to City

- Address / ZIP Code
- Date of Birth
- Expected Due Date
- Gender
- Race
- Ethnicity
- Past visits to doctor’s office
- Past lab results

Returned to Clinic

- Risk Score
- Instructions to doctor
Challenges Encountered

1. CDPH limited resources for interventions

2. Difficult to access datasets to validate model due to antiquated & siloed IT infrastructures and governance
   - Birth certificates (State)
   - Immunization records (State)
   - WIC enrollment (USDA)

3. Establishing partner with healthcare systems to pilot
   
   Privacy, interpreting laws, policies and data sharing barriers prevented initial pilot in healthcare settings

4. Compare performance in predicting poisoning with a baseline, given by random predictions
Challenges Encountered

5. Finding appropriate community partners
6. Abiding by clinical decision support tool design standards
7. Time required for data exchange between model & HER (electronic health records)
8. Developing interoperability standards for data exchanges with other EHRs
9. Healthcare has difficulty justifying technology costs on prevention
Community Health Worker Study

Partnering with a health system’s community health worker (CHW) to assess:

- Feasibility
- Impact
- Cost effectiveness

of using CHWs to conduct proactive visual inspections for lead-based paint hazards at homes on the south and west sides identified as high risk by our model using WIC enrollment.

Funded by US HUD Office of Lead Hazard Control and Healthy Homes Lead Technical Studies Program
Challenges Overcome

Project identified gaps in Antiquated & Siloed IT Infrastructure
  • New mobile Lead Inspector Application
  • Data Warehouse

Project identified policies not addressing new methods and data sharing
  • Amended authority to include data science and other analytic models in ordinance
  • IGA to share data bidirectionally with schools

States agencies can be a rate limiting step
  • Work closely to find solutions to HHLPSS automation

EHR Interoperability
  • Standardize API

Applicability of model is diverse and still discovering potential uses
160 Commissioner - Additional powers and duties.

The Commissioner of Health shall have the following powers and duties:

(a) Public health related powers and duties:

(7) To request, collect, receive, and maintain confidential information, records, and data, including protected health information consistent with 45 C.F.R. § 164.512(b)(1)(i), for the purpose of preventing or controlling disease, injury, or disability. The confidential information, records, and data may support activities including, but not limited to, the reporting of disease, injury, or vital events such as birth or death; the conducting of public health surveillance, public health investigations, and public health interventions; the performance of epidemiological studies; and the application of data science methods or other analytic models that protect and promote public health.
Innovative Agreement
Predictive Modeling for Public Health: Preventing Childhood Lead Poisoning

Eric Potash
University of Chicago
epotash@uchicago.edu
Subhajit Majumdar
University of Minnesota
majumdar1@umn.edu
Eric Rozier
University of Cincinnati
eric.rozier@uc.edu

Joe Brew
University of Florida
joebrew@ufl.edu
Andrew Reece
Harvard University
reece@g.harvard.edu

Emile Jorgensen
Chicago Department of Public Health
Emile.Jorgensen@chicagoph.gov
Rayid Ghani
University of Chicago
rayid@uchicago.edu

Alexander Loewi
Carnegie Mellon University
aloewi@andrew.cmu.edu
Joe Walsh
University of Chicago
jwalsh@uchicago.edu
Raed Mansour
Chicago Department of Public Health
Raed.Mansour@chicagoph.gov

ABSTRACT
Lead poisoning is a major public health problem that affects hundreds of thousands of children in the United States every year. A common approach to identifying lead hazards is to test all children for elevated blood lead levels and then investigate and remediate the homes of children with elevated tests. This can prevent exposure to lead of future residents, but only after a child has been poisoned. This paper describes past work with the Chicago Department of Public Health (CDPH) in which we built a model that predicts the risk of a child to being poisoned so that an intervention can take place before that happens. Using two decades of blood lead level tests, home lead inspections, property value assessments, and census data, our model allows inspectors to prioritize houses on an inscrutable list of potential hazards and identify children who are at the highest risk. This work has been described by CDPH as pioneering in the use of machine learning and predictive analytics in public health and has the potential to have a significant impact on both health and economic outcomes for communities across the US.

Categories and Subject Descriptors
J.3 [Life and Medical Sciences]: Health, K.4.1 [Public Policy Issues]: Human Safety

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.

©2015 ACM ISBN 978-1-4503-3563-7/15/06 $15.00 DOI: http://dx.doi.org/10.1145/2789110.2789115

1. INTRODUCTION
Lead poisoning is a major public health issue, imposing lifelong health and economic costs on hundreds of thousands of children every year in the United States. Although European societies banned lead paint as early as 1900, political forces and vested business interests delayed bans on leaded consumer products in the United States until the late 1970s[29]. Throughout most of the 20th century, cars ran on leaded gas, houses were coated with leaded paint, and industry emitted leaded waste products directly into the environment. Today, lead in paint remains a significant hazard. In Chicago, almost 90% of the housing stock was built before the ban[25]. Exposure to lead has been found to be associated with premature birth and early neurological development issues such as obesity, herniation, atrophy, and white-matter degradation[12,19]. Lead can cause vomiting, convolution, paralysis, and in high concentrations, death[12]. Elevated blood lead levels are associated with lower IQs in children. A retrospective study by Masumoto et al[29] shows that, on average, a 1 μg/dl increase in blood lead level is associated with a decrease of 1 IQ point among six-year-olds and 2 IQ points among 10 year olds.

Because of the permanent damage it can inflict, lead poisoning imposes significant indirect costs on society. Based on its well-documented effects on IQ and contributions to neuropsychologic disorders such as ADHD, lead poisoning has been estimated to significantly lower lifetime earnings for individuals and greatly increase the costs of crime prevention and special education programs for the government. Lead-related child health costs conservatively cost over $38 billion annually [1]. Completely eliminating lead in the United States could indirectly save $200 billion dollars per year [2], ten times more than needed for removal.
Milbank Memorial Fund and AcademyHealth State & Local Innovation Award

Childhood Lead Paint Hazard Data Sharing

Smart Project in Digital Transformation
Lead Safe API
Open Source Code

"Lead Safe" API Documentation

Building and Testing

The documentation is compiled with MkDocs and is required while testing.

Local Testing

Test changes to the documentation by opening a terminal and run

```
mkdocs serve
```

Preventing Childhood Lead Poisoning

Introduction

Lead poisoning is a major public health problem that affects hundreds of thousands of children in the United States every year. A common approach to identifying lead hazards is to test all children for elevated blood lead levels and then investigate and remediate the homes of children with elevated tests. This can prevent exposure to lead of future residents. But only after a child has been irreversibly poisoned. In partnership with the Chicago Department of Public Health (CDPH), we have built a model that predicts the risk of a child being poisoned. Our model's risk scores facilitates an intervention before lead poisoning occurs.
Thank You!