Translating Housing Data into Health Data

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Acknowledgments

University of Missouri-Kansas City –
Steve Simon PhD, Ricardo Moniz, Daniel Nicot, Brianna Velazquez

Children's Mercy Kansas City –
Natalie Kane PhD, Rohan Akhouri MD, Ryan Allenbrand, MS

Kansas City, Missouri Dept. of Public Health, Lead Poison Prevention and Healthy Homes Program –
Amy Roberts, RN BSN

Inspiration Emeritus - Kevin Kennedy

US Department of Housing and Urban Development, which funded much of our research through Lead and Healthy Homes Technical Studies Grants (MOLTS0019-20 and MOHHU0083-24)

"The work that provided the basis for this publication was supported by funding under an award with the U.S. Department of Housing and Urban Development. The substance and findings of the work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statements and interpretations contained in this publication. Such interpretations do not necessarily reflect the views of the Government."

The goal of our work is to prevent children from getting sick in the first place!

- Our work strives to identify housing-based lead risks before these children come to our attention due to high blood lead levels or other lead related problems.
- Differentiate at the address level the lead risk posed by a home to its youngest occupants.
- Use publicly available information to **economize on the use of resources**. (cheap, fast, and unintrusive)
- Identify and Estimate **unrecognized benefits** from existing programs

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Two Translations of Housing Data into Health Data.

Investigation of Secondary Effects of Lead-Safe Housing Interventions:

Capitalize on our institutional partnerships and research experience to design an investigation into the effect of housing-based lead interventions on severe asthma.

External Housing Based Lead Risk Index:

Using public information to identify differences in lead risk at the parcel level. Generally, this means quantifying house-by-house variation in lead risk.

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Making the Case for Housing Level Analysis

Example community-based risk factor data sets include:

- Demographic data
- Community data
- Air pollution data
- Point sources
- Traffic density
- Rail traffic
- Poverty
- Crime
- Neighborhood conditions
- Code violations

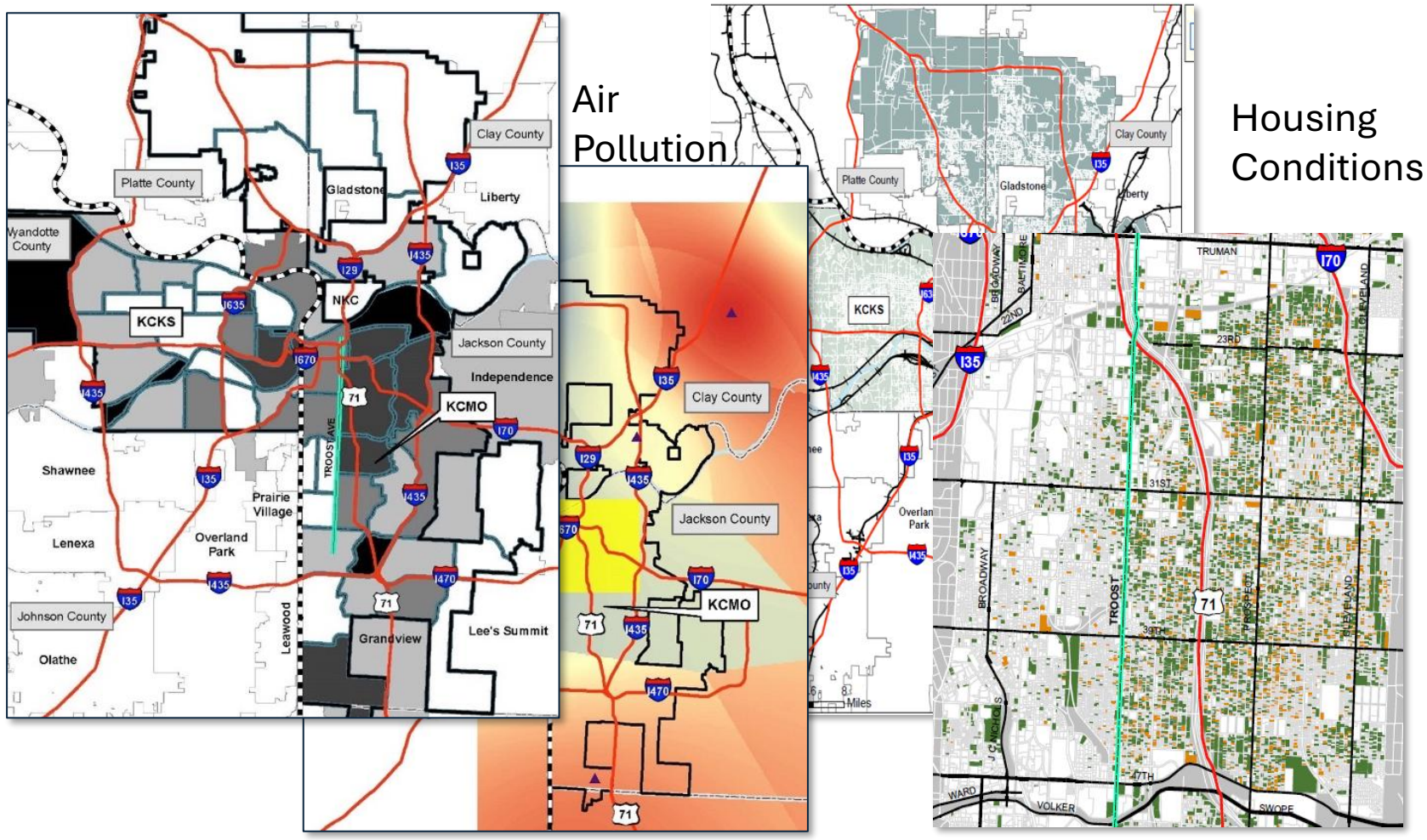
- **Housing Conditions**

Poverty

Traffic Density

Air Pollution

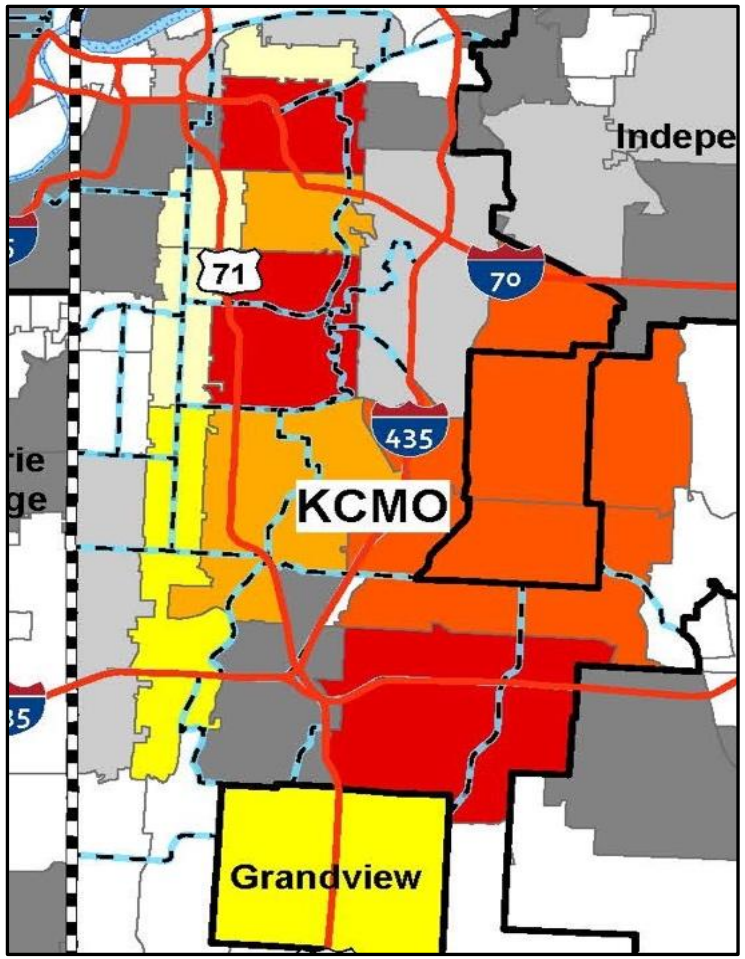
Housing Conditions



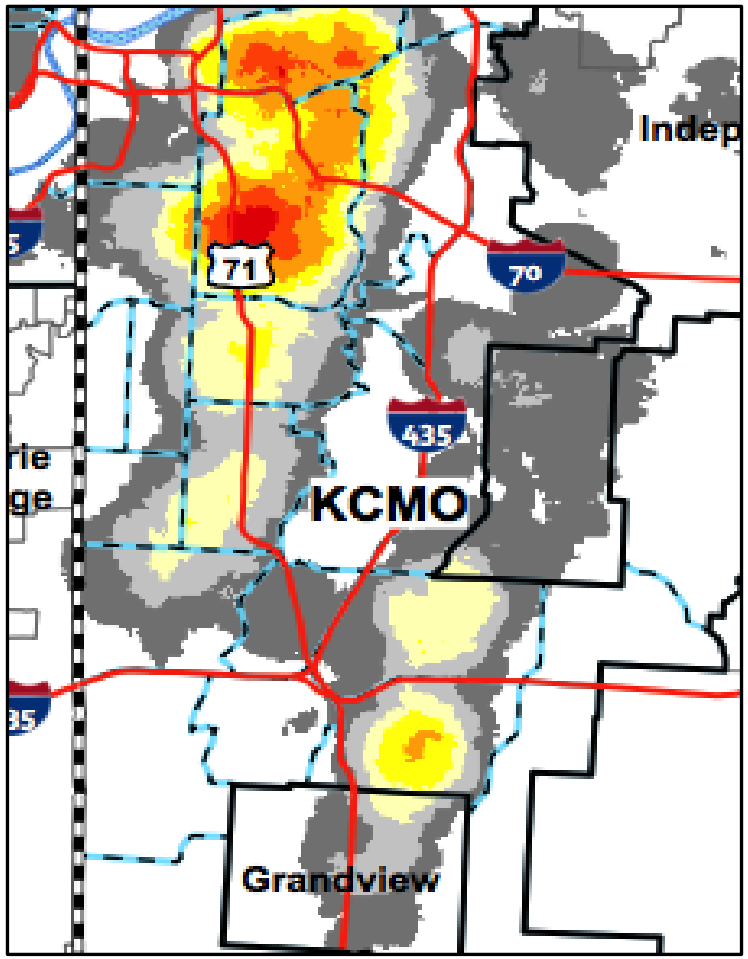
Maps from CEI archive

GIS is a powerful tool but there are Issues to Keep in Mind (I)

Asthma Acute Care Visits



Zip Code



Street Address

Modifiable Areal Unit Problem

Changing the geography of analysis can change the findings

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GIS is a powerful tool but there are Issues to Keep in Mind (II)

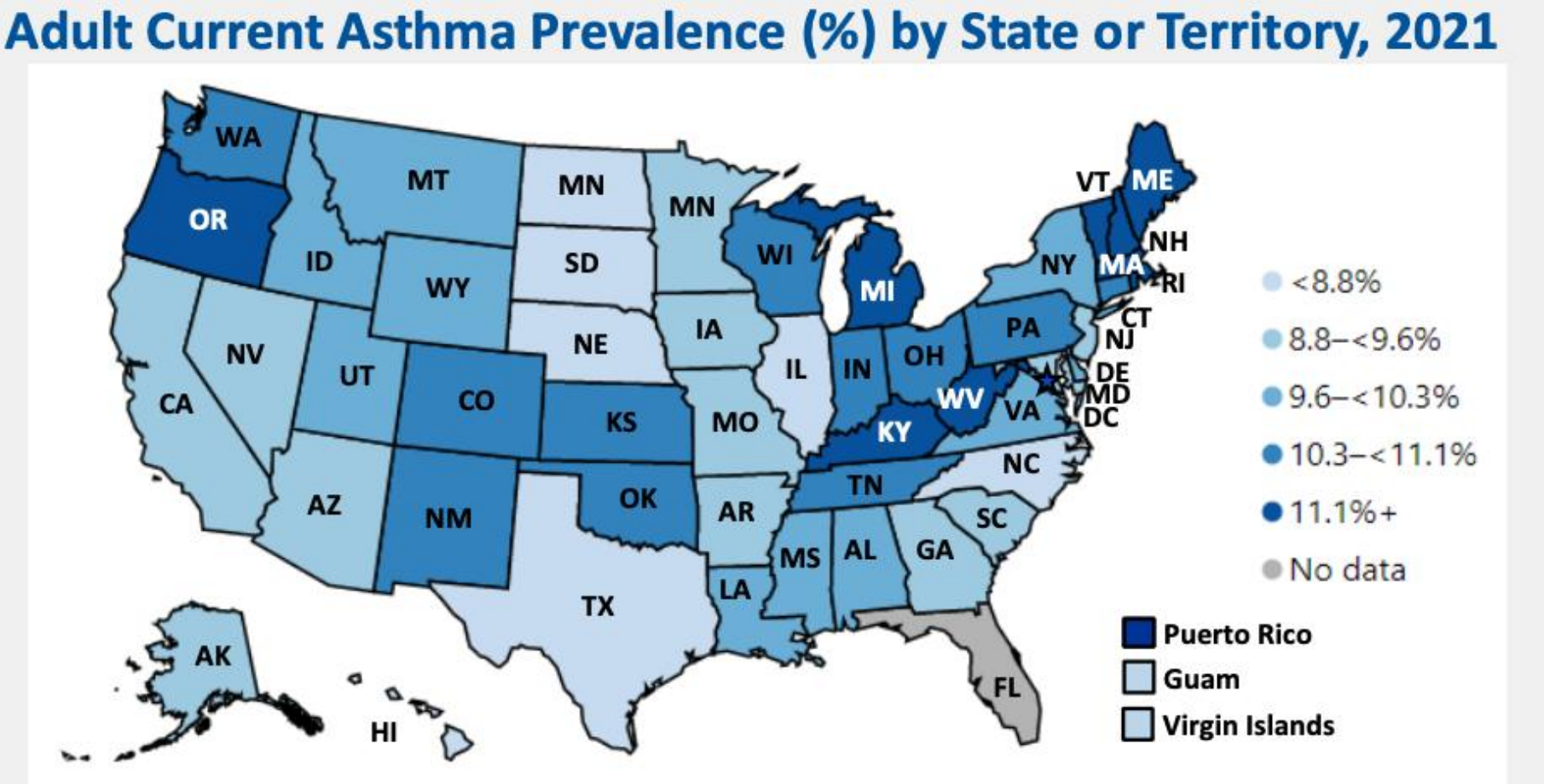

Image Source: Asthma Surveillance in the United States, CDC

The Ecological Fallacy

What is descriptively true about a geography may ***or may not*** be true for an individual within the population.

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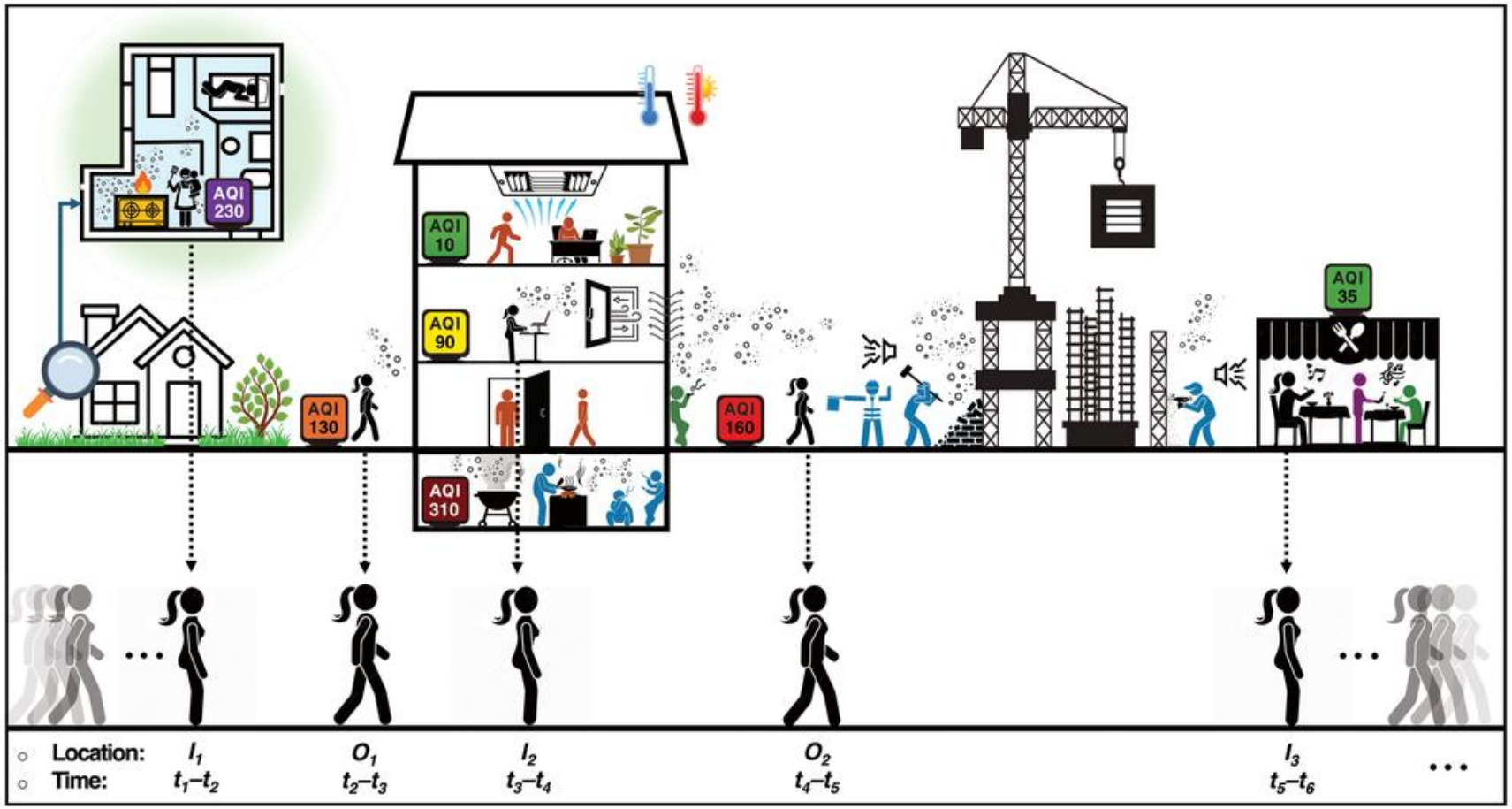
GIS is a powerful tool but there are Issues to Keep in Mind (III)



Uncertain Geographic Context Problem

It is nearly impossible to track individuals as they move within and between geographic units.

Image source: Yoo Min Park & Mei-Po Kwan "Revisiting the Uncertain Geographic Context Problem" *Annals of the American Association of Geographers* (2025) 115, 5

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Housing Level Analysis of Children Addresses these Problems

And yet most public health analyses is not done at the household level

The Housing level analysis addresses the first two issues

Looking at the pediatric population addresses the third issue.

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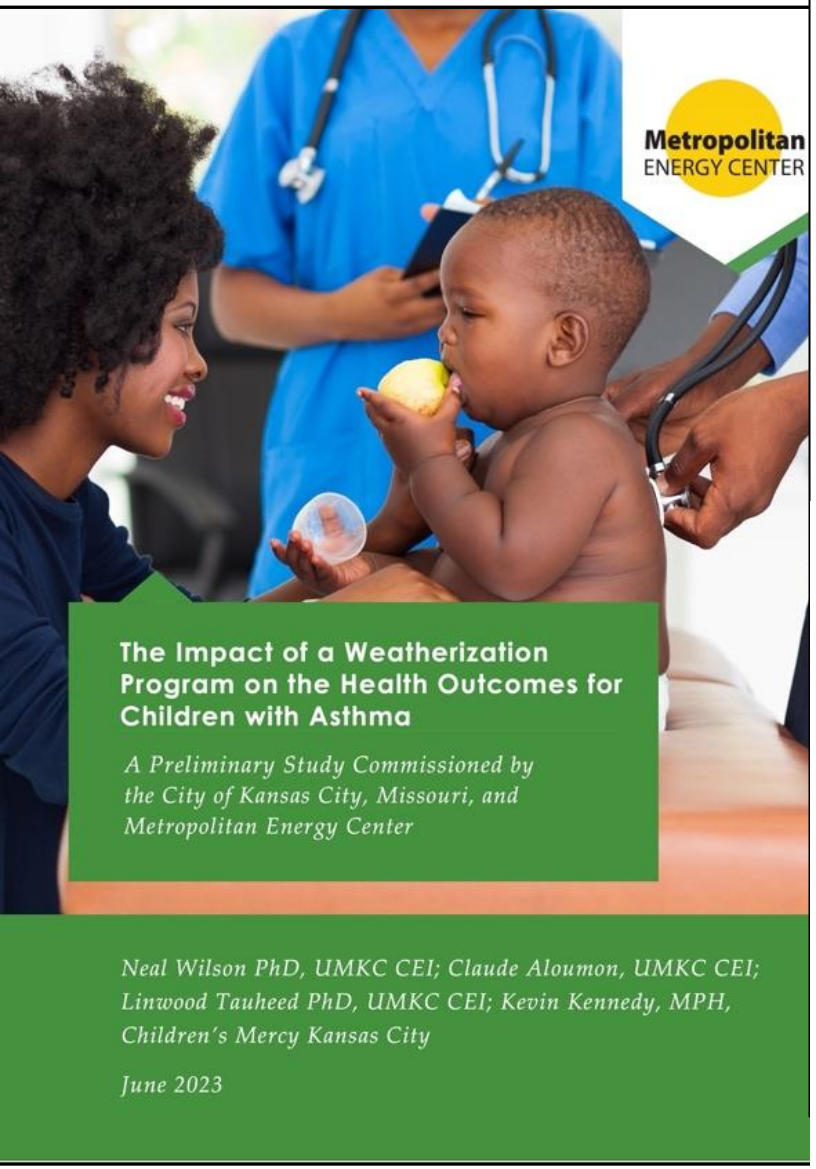
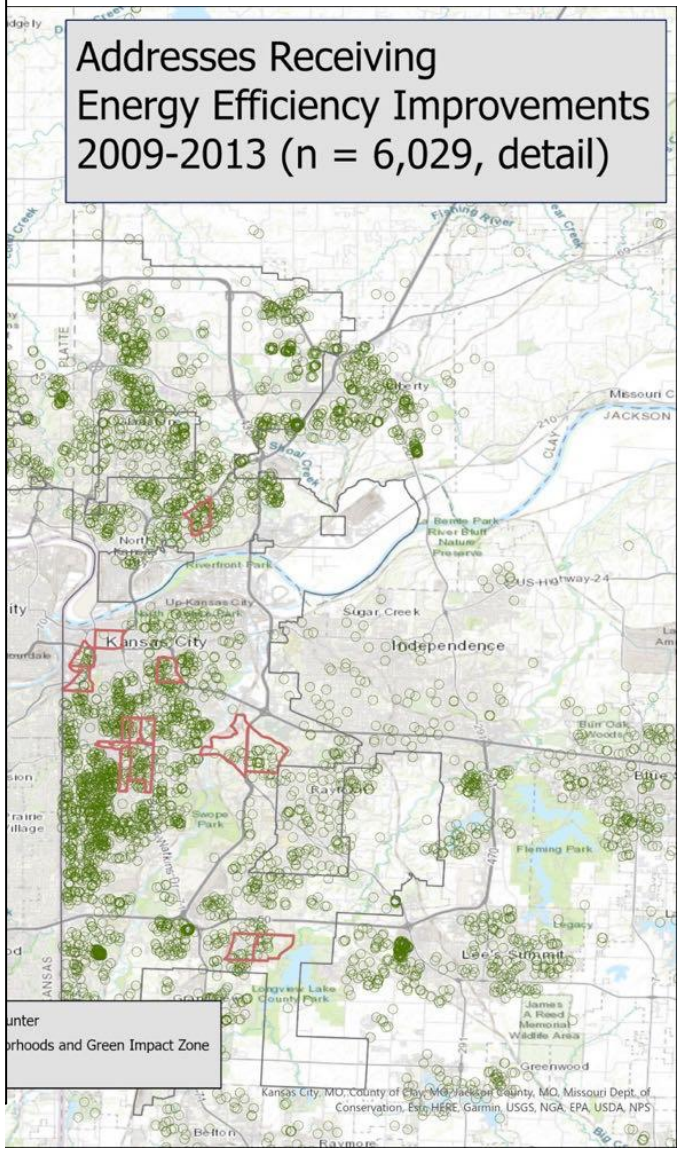
Health Impact of Housing Interventions: Severe Asthma Encounters



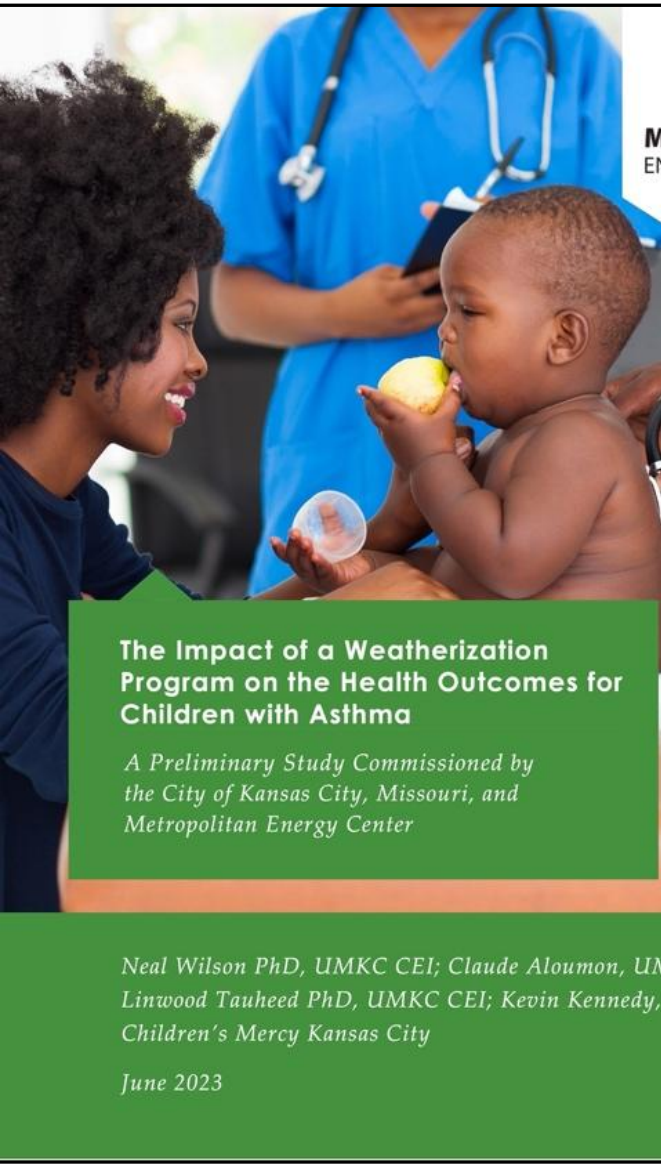
Impact of Energy Efficiency Improvements on the Frequency of Acute Asthma Exacerbation: A Quasi-Experimental Investigation

Neal J. Wilson, Ph.D. (njw2b7@umsystem.edu) – Associate Director, University of Missouri-Kansas City – Center for Economic Information
Kevin Kennedy, MPH, CIEC – Healthy Indoors Training and Consulting, LLC

40% reduction in Acute Asthma Exacerbation after Energy Efficiency Improvements, aka Weatherization



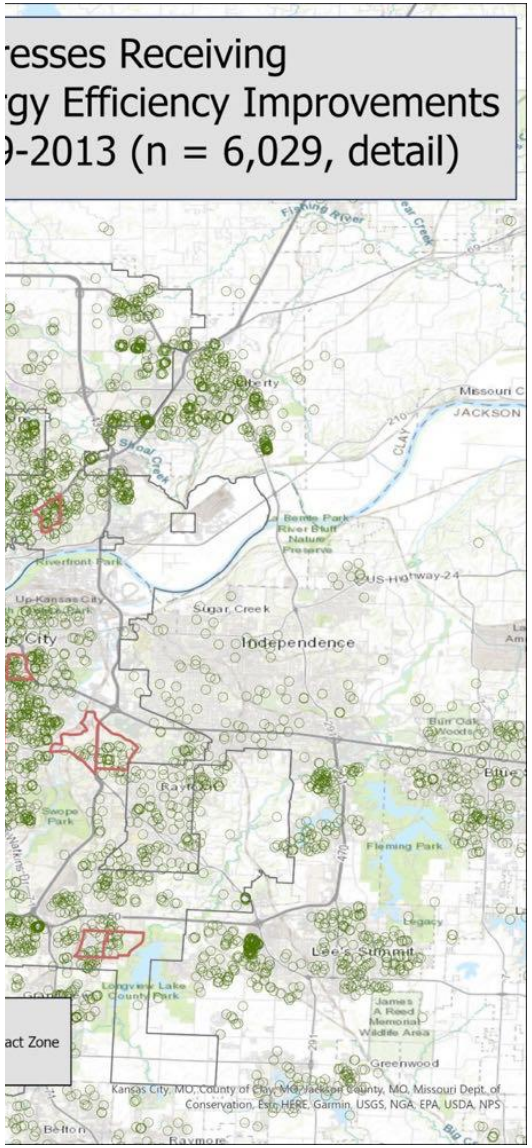
Health Impact of Housing Interventions: Severe Asthma Encounters



Weatherization Activity Includes: Insulation, Window Replacement, Door Replacement, Weather Stripping, etc

Lead-Safe Housing Activity Includes: Window Replacement, Door Replacement, Weather Stripping, etc.

Healthy Homes Supplement Includes: Insulation



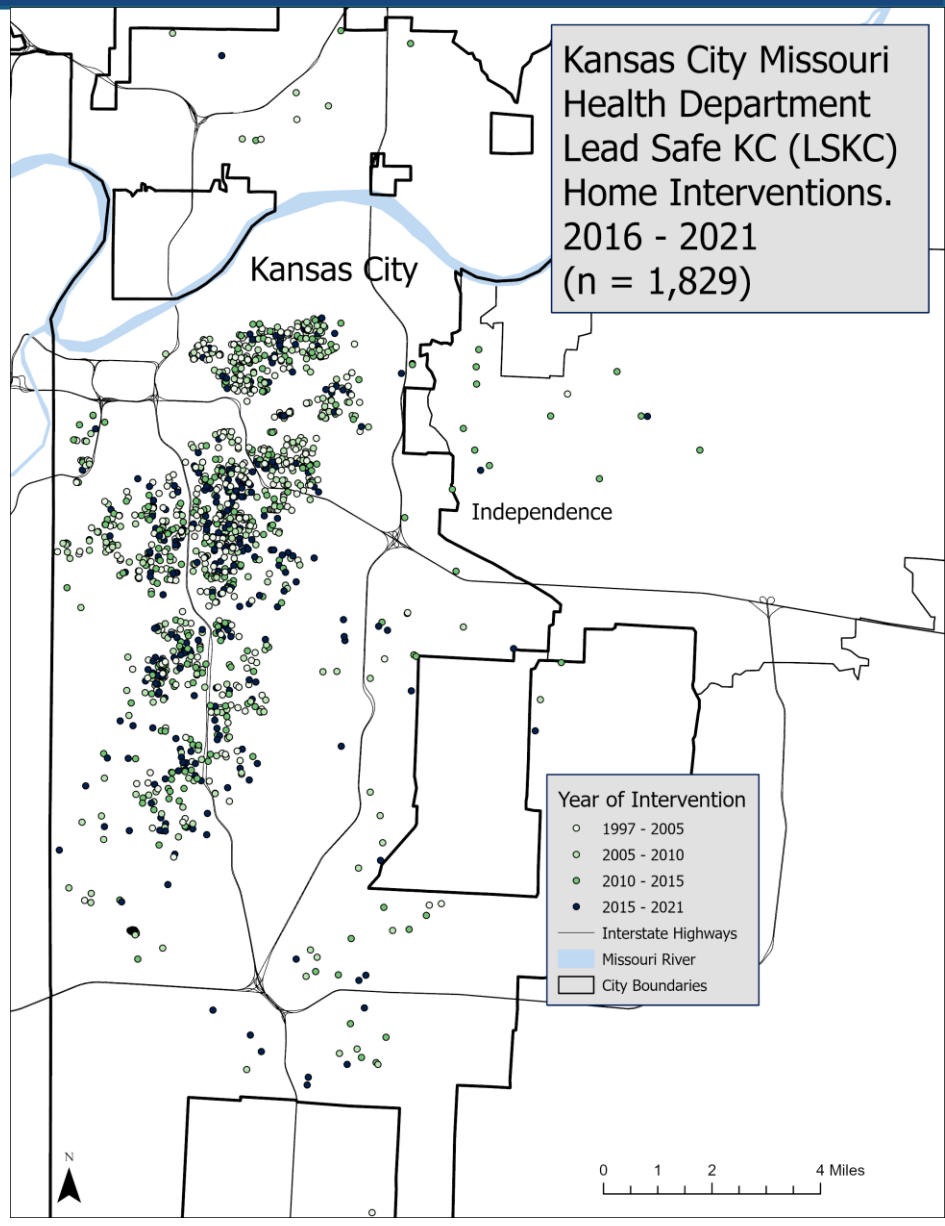
Estimating Secondary Effects of Lead Safe Housing Interventions

Pediatric Health and the Built Environment (PHBE)

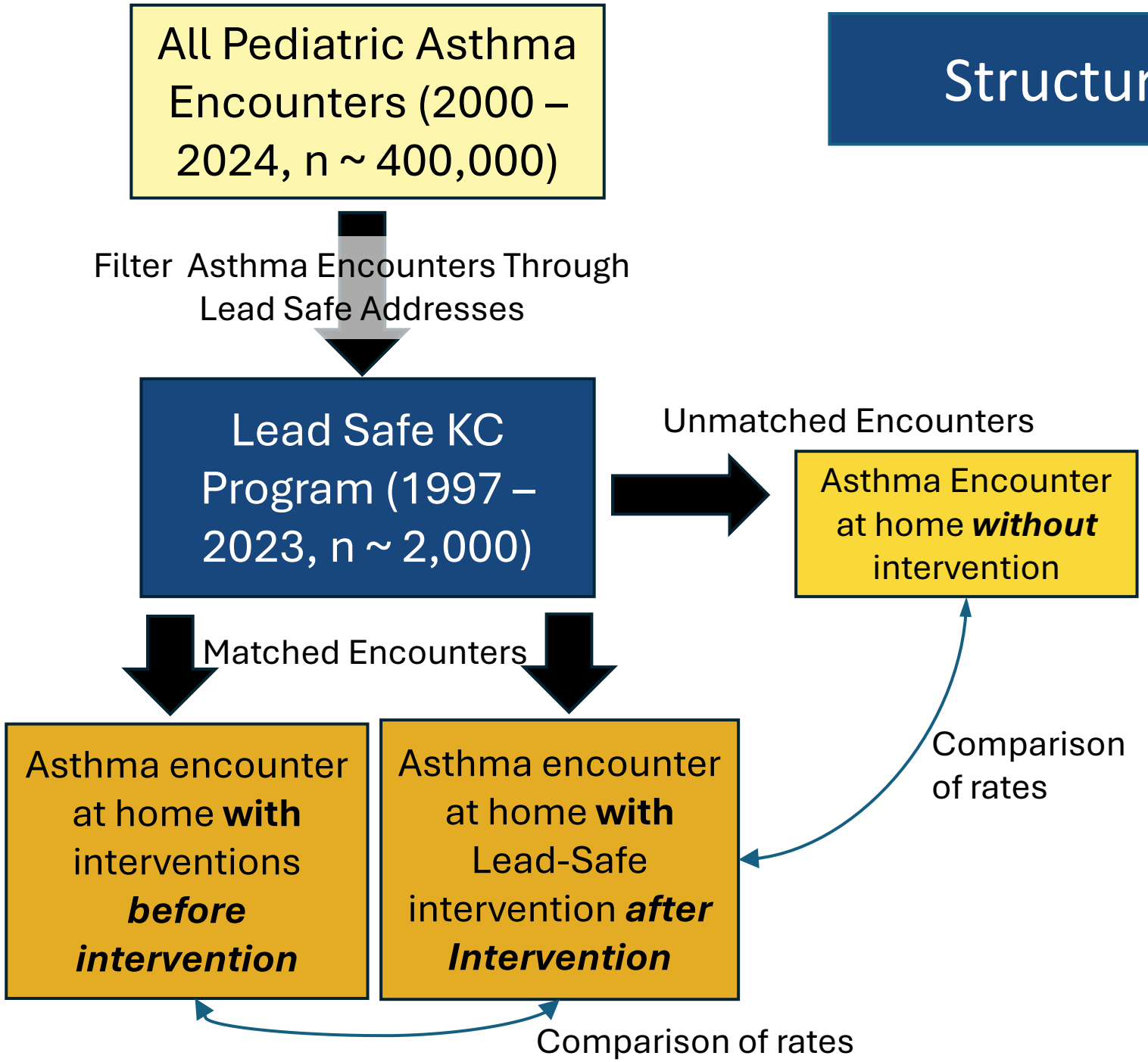
One aim of the Initiative: Quantify Secondary Benefits from Lead Safe Housing Interventions in Terms of Fewer Acute Asthma Encounters

Capitalizing on our Research Network

- KCMO Health Department: 27 years of Lead Safe Interventions
- Children's Mercy KC: 25 Years of Asthma Observations
    - And Billing Records!
- CEI research Experience: Research Environment and Experience with address-level analysis



Structure of this Natural Experiment



After Estimating Changes in Rates of Severe Asthma We will be able to Estimate Savings in Terms of

- Trips to the ER (and other types of health encounter)
- Parental/Guardian Time
- $ Cost to hospital
- $ Cost to the family

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Estimating Lead Risk from Housing Conditions

Image Source: Google Street View

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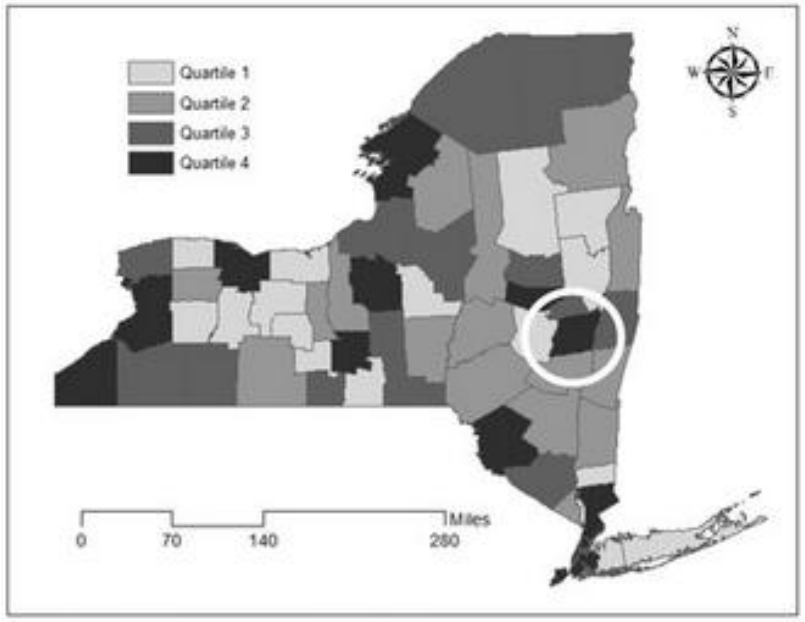
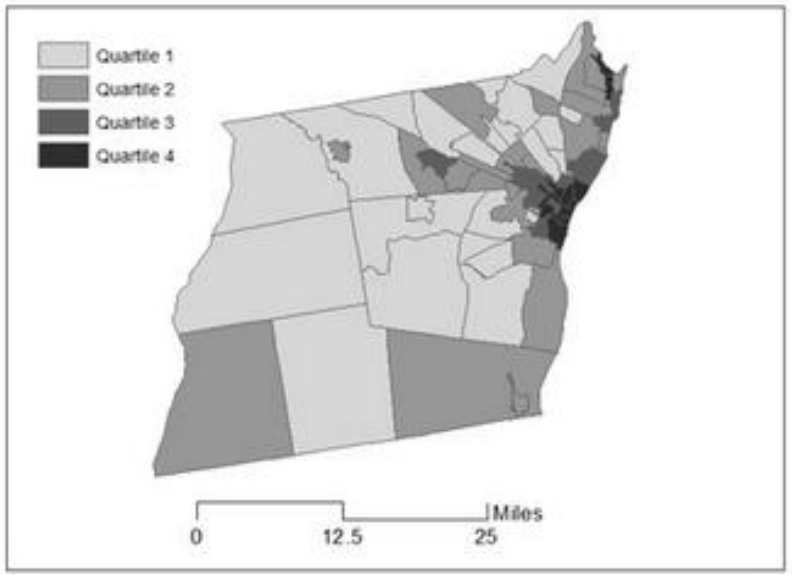
Most Lead Risk Indicators are at the Census Geography



(2a) New York State, Quartile Risk by County



(2b) New York State, Albany County, Quartile Risk by Tract

Identifying Jurisdictions at Risk of Containing Housing Units With Deteriorated Paint: Results and Targeting Implications for the US Department of Housing and Urban Development
https://journals.lww.com/jphmp/fulltext/2021/11000/identifying_jurisdictions_at_risk_of_containing.3.aspx

Race/Ethnicity, Household Education Level, Household Income Level, Census Region, Housing Tenure

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Exterior Housing Based Lead Risk Index (LRI)

Quantifying our intuition that homes in disrepair are more likely to pose a lead-exposure risk to residents.

Based on 2 pieces of public information

- Exterior Address-Level Housing Conditions as Identified by Center for Economic Information's **Neighborhood Housing Conditions Survey**
- **Year of Building Construction**

Provides consistent, systematic, warranted information that can be used to

- Better understand the scale of need
- Focus attention and resources where need is most pronounced

Trained / Tested on Pediatric Blood Lead Observations

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ERAs of Housing Construction based on Lead Paint is in our LRI

Pre-1952: Assume lead paint was used on exterior and interior of home

1952: US paint industry ends promotion and production of interior lead paint

1953 – 1977: Assume lead paint was used on exterior of home

1978: End of residential lead paint production in the US

1978 – present: Assume lead paint was not used on home surfaces

nb. other important sources of lead risk exist in and around the house. But we do not attempt to incorporate them in our LRI.

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Introducing the CEI's **Neighborhood Housing Conditions Survey (NHCS)**

- In-person "windshield" survey
- Data recorded via web-based database
- Average time: 3-5 min/home
- Cost: ~$8/home
- Designed as a "benchmarking tool" for Urban Blight Studies

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Introducing the CEI's **Neighborhood Housing Conditions Survey (NHCS)**

- Training Program
  - Two days in class
  - One day in field
- Certification through field examination
  - Absolute mean diff <1
- 3 Month "refresher course"
- Post-survey clean-up and verification

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Introducing the CEI's **Neighborhood Housing Conditions Survey (NHCS)**

- 25 Categories of Observation
- 15 Categories of Home, grounds, and Infrastructure conditions

- 5-level Ordinal Rating System
- <3 indicates code violation

- Kennedy (2011) innovates the use of NHCS for Public Health

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Category	1	2	3	4	5	U/R=6	N/A=7
Roof Rating	Hole-sagging-rot, F & S	No hole-sagging-rot, F&S	Serious deterioration	Slight deterioration	No deterioration	Cannot be seen	If it is a vacant lot
Foundation & Walls	Hole, bulges, +25% gone	Slight leaning, +25% rot	No leaning, -25% replace	Needing some paint	Well protected		If it is a vacant lot
Windows & Doors	Open to entry, W&D miss	No entry, few openings	Some broken, needing paint	No broken, need paint	No broken, no painting		If it is a vacant lot
Porches	Serious leaning, rot, unsafe	Slight leaning, rot, safe	Evidence of lean, paint need	No leaning, paint needed	No leaning or paint needed		If it is a vacant lot
Exterior Paint	+50% need paint, +2wks	50-10% need paint +2wk	-10% need paint, no rot	No peeling, some fading	Paint in great shape		If it is a vacant lot
Private Sidewalks & Drive	+1 trip & miss, grvl, weeds	No trip, +cracks, all replaced	+50% needs to be replaced	Few cracks, some patching	No cracks present		If they are not present
Lawn & Shrubs	3' high, shrubs cover entries	1-3' high, shrubs unkempt	1' high, shrubs some shape	-1' high, weeds, shrubs ok	-6" high, shrubs great		
Vehicles	+3 auto,disabled,unlicensed	1-3 auto,<1dis or unlicensed	1 auto, parked in yard, drive	1auto unlicensed, disabled	No vehicles in yard, dis, unl		
Litter	Trash & brush, dump truck	Trash & brush, pick up load	Trash & brush,1-5trashbags	Trash & brush, 1 trash bag	No Trash & brush present		
Open Storage	Would fill 2 car garage	Would fill 1 car garage	Would fill a storage shed	Cluttered appearance	No unacceptable items		
Sidewalk	+1 trip & + ½ missing	½-1/4 missing, 1 trip	No trip, cracks,-1/4 replace	Cracks present, no replace	No cracks, in good shape		If it is not present on propty
Curb	No curb, but exists on block	+1/2 curb needs replacing	-1/2 curb needs replacing	Some wear, no replace	No wear, in good shape		If it does not exist on block
Street Lights	No street lights on block	+8 houses apart, tree issue	+6 houses apart, tree issue	5 houses apart, some tree	5 houses apart, no tree		
Catch Basins	Severe condition; dangerous, H_2O	Severe condition; no danger	Leaf, trash, blocking drain	Some leaf, trash, still works	No blocking, good cond.		No catch basin present
Street Condition	+7 potholes, serious hazards	6-3 potholes, deteriorated	-2 potholes, just patching	No pot holes just cracks	No cracks, smooth surface		

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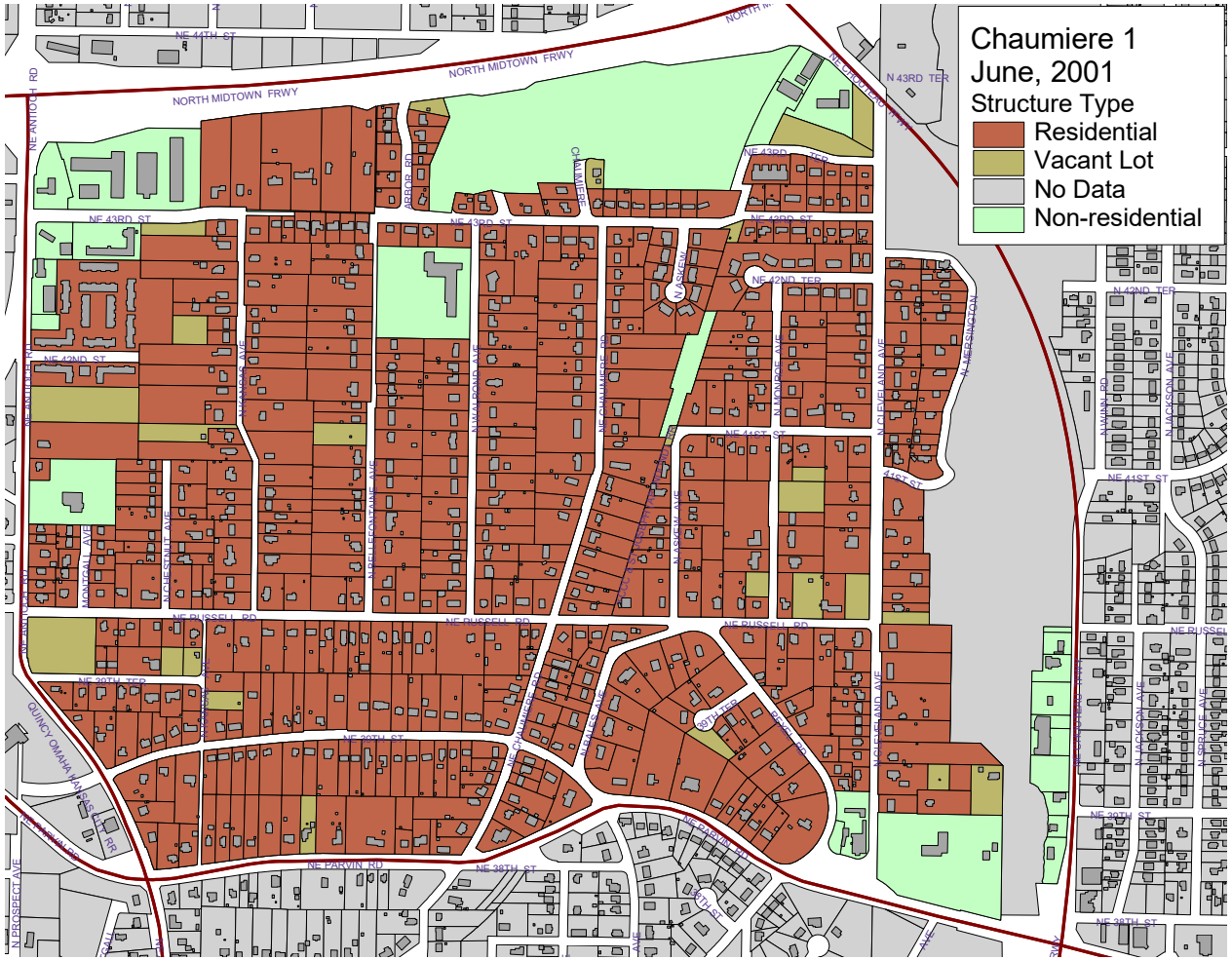
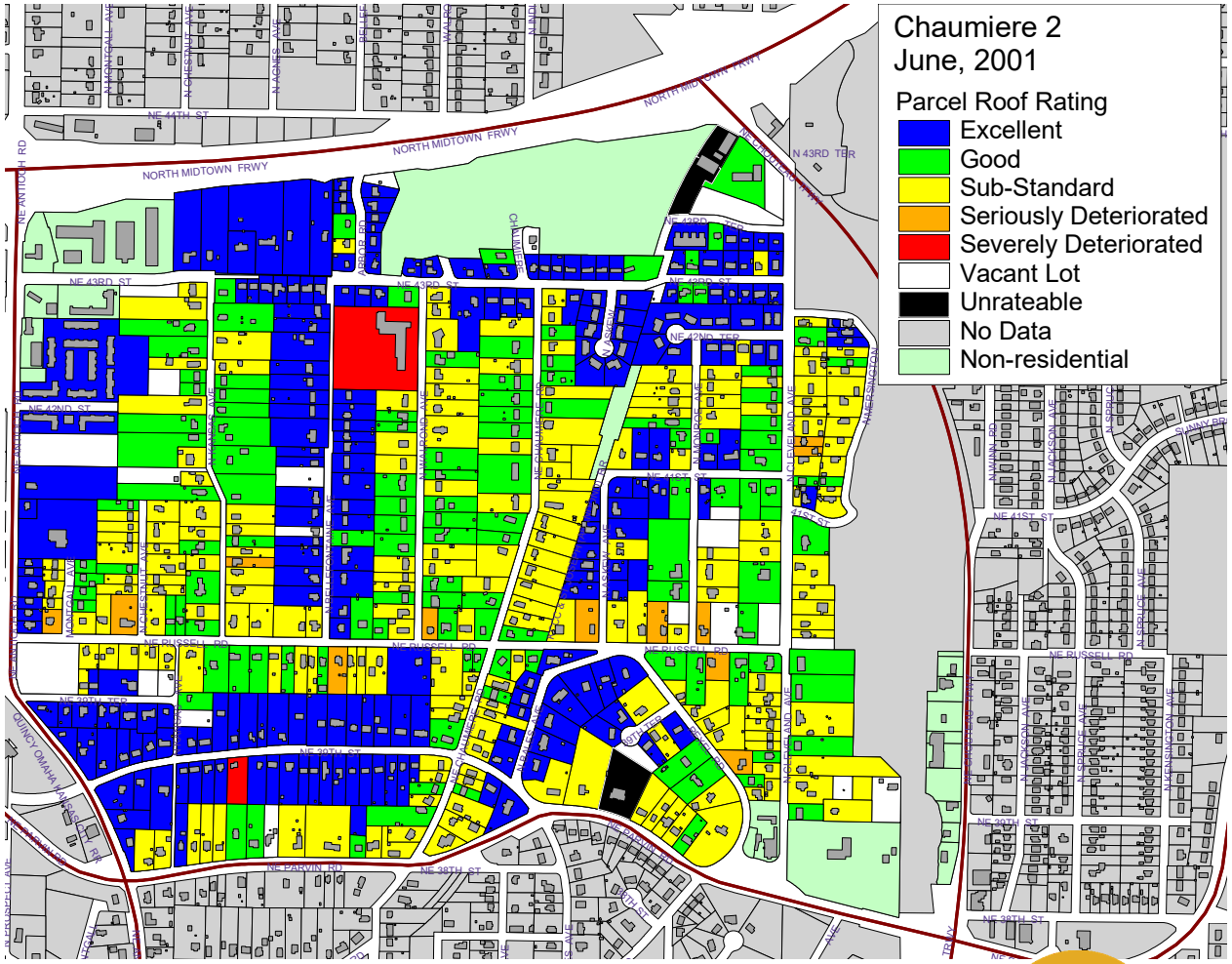
Neighborhood Housing Conditions Survey as a Baselining tool





From 2001 KCMO Neighborhood Housing Survey

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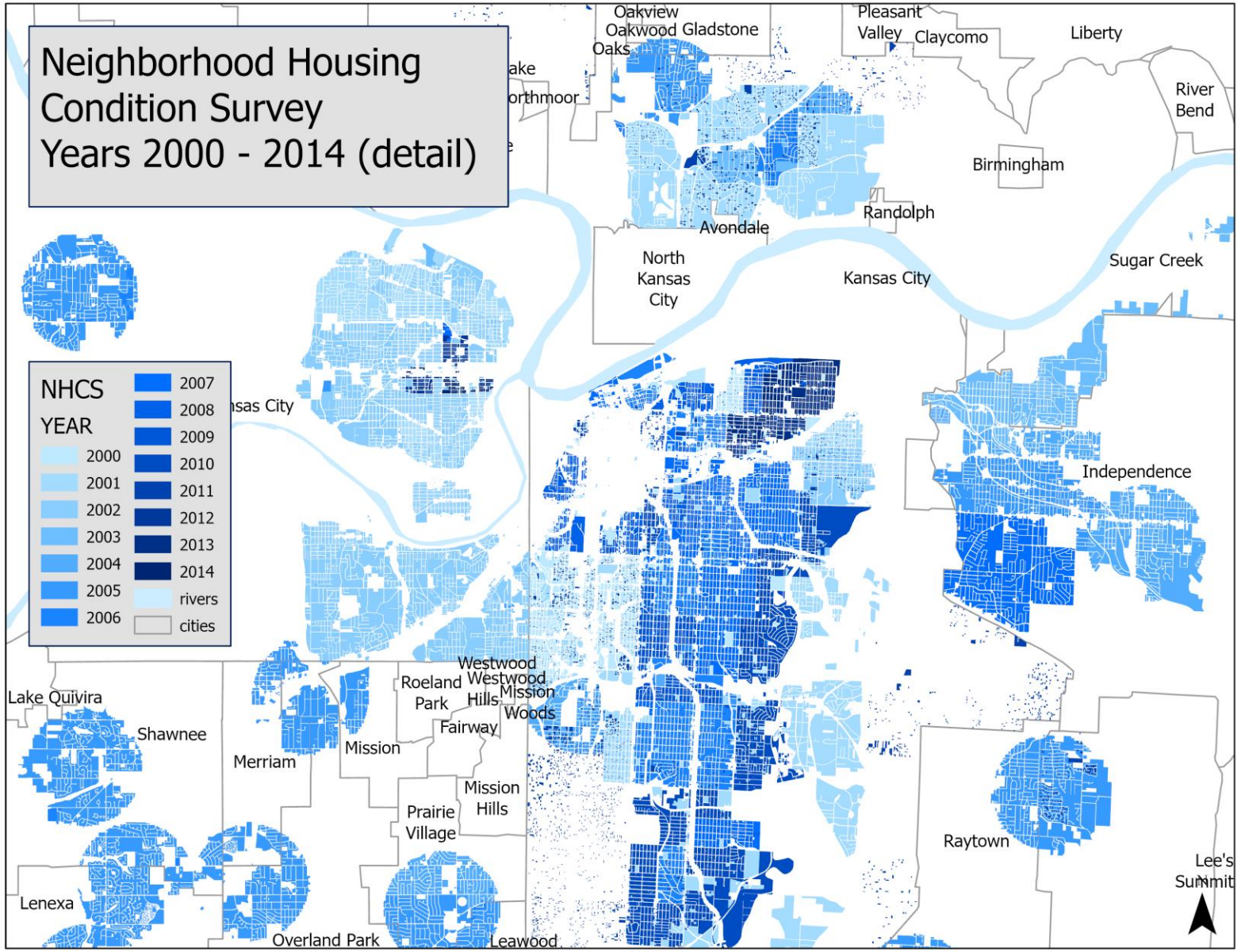
Historical Footprint (detail) of Neighborhood Housing Conditions Survey



Darker Blues reflect more recent surveys and a higher likelihood of resurveys.

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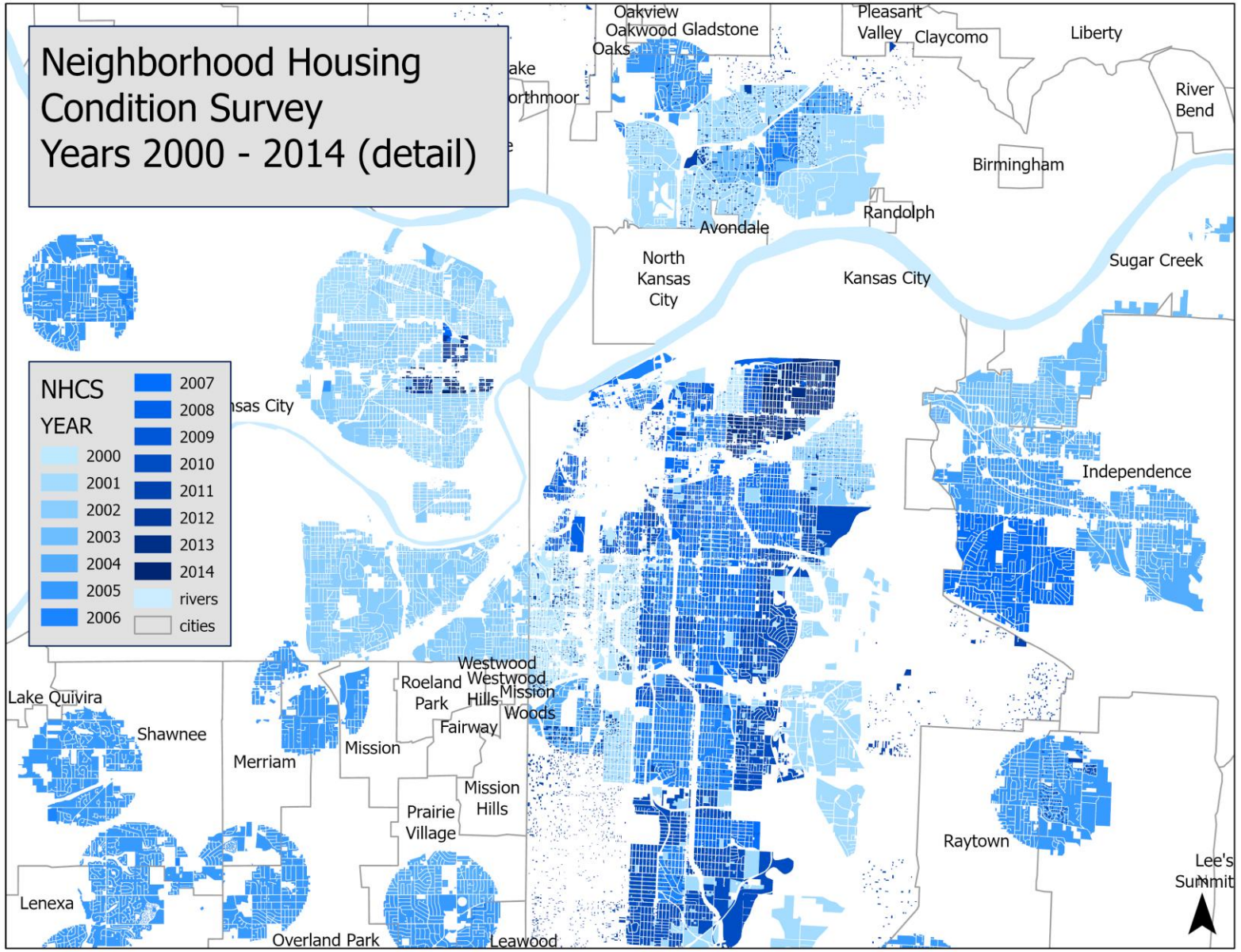
Initial Analysis of Neighborhood Housing Conditions Survey



$$BPb_i = \alpha + \sum_{j=1}^{8} \beta_j C_{ji} + \sum_{j=9}^{20} \beta_j H_{ji} + \sum_{j=21}^{25} \beta_j P_{ji} + \epsilon_i$$

Oldest homes with Substandard ext. paint +.95µg/dl

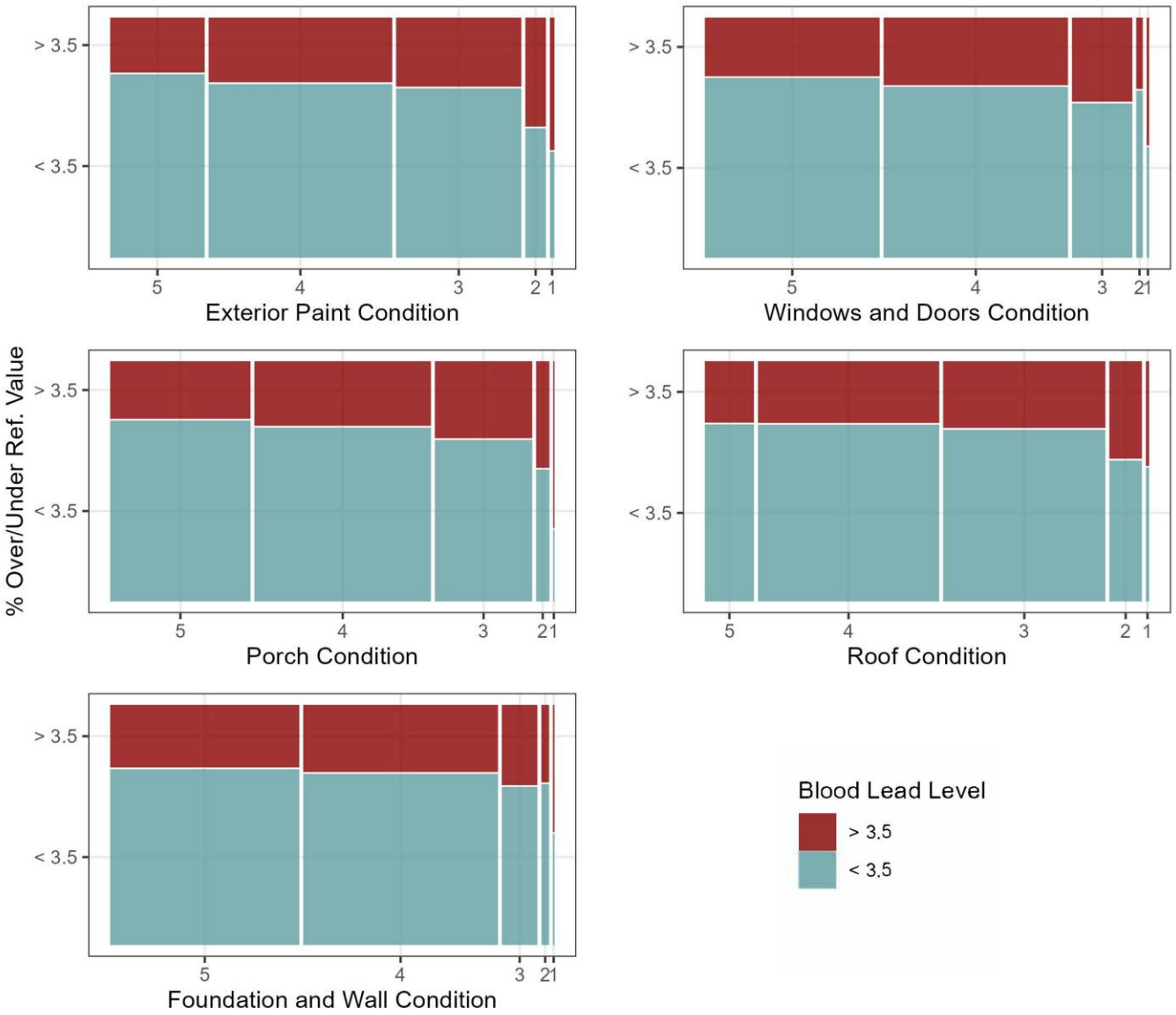
1953-1977 homes with Substandard ext. paint +.59µg/dl

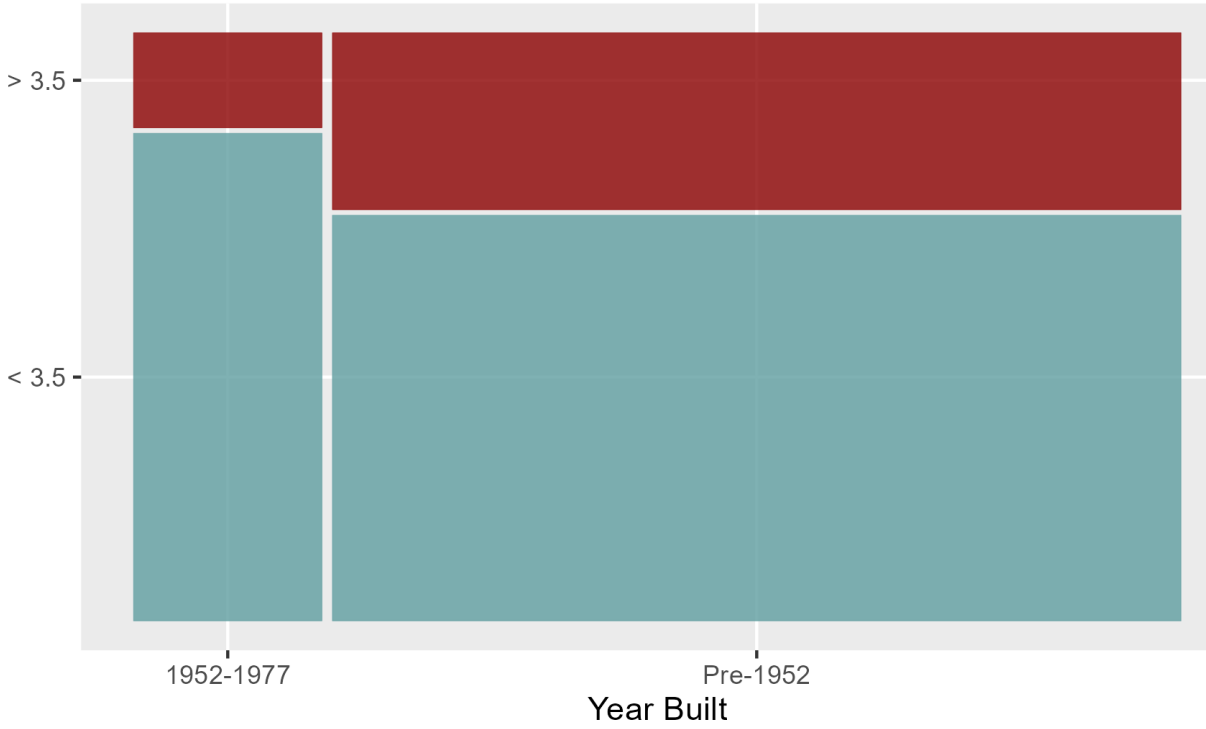
Oldest Homes with Sev. Deteriorated ext. paint: +1.34µg/dl

1953-1977 homes with Sev. Deteriorated ext. paint: -.04µg/dl

n= 8,077
from Wilson (2021)

Looking at relationships to develop our lead risk index





N = 6,589

From Wilson et al (2023)

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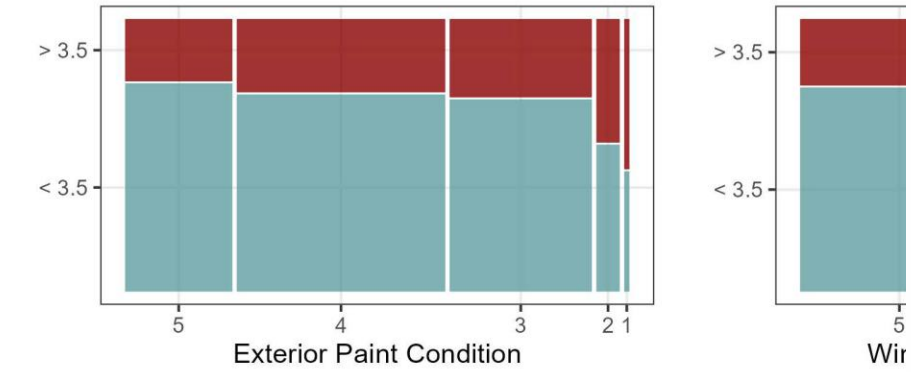
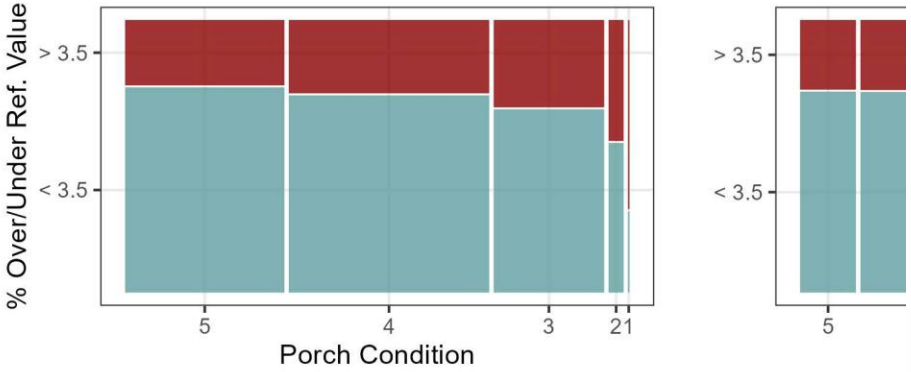
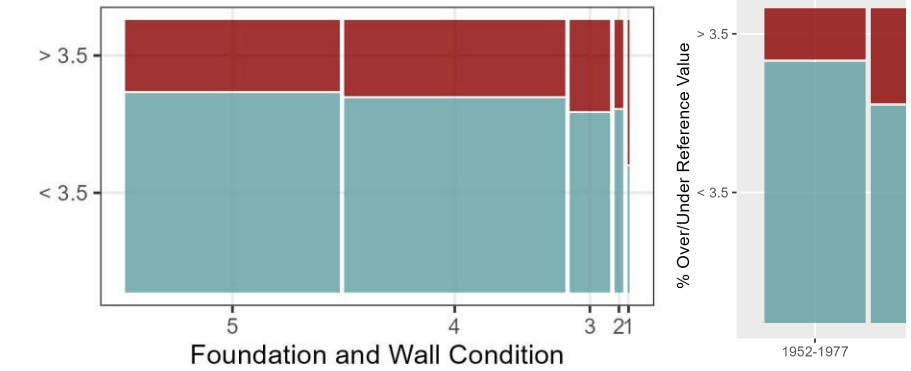
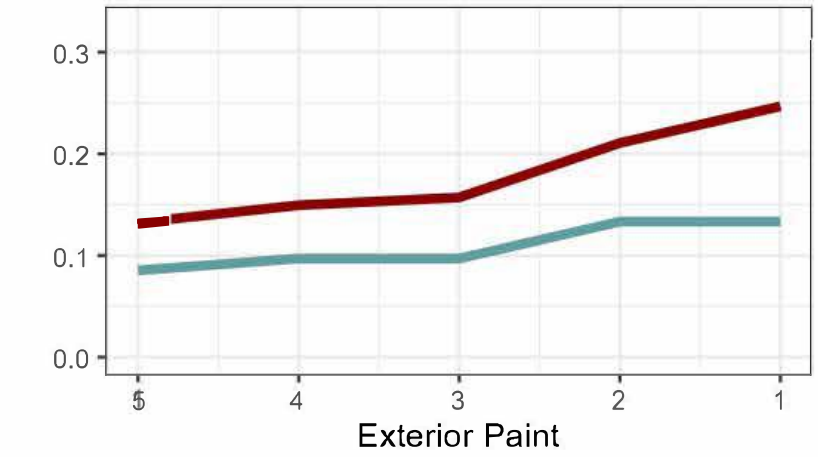
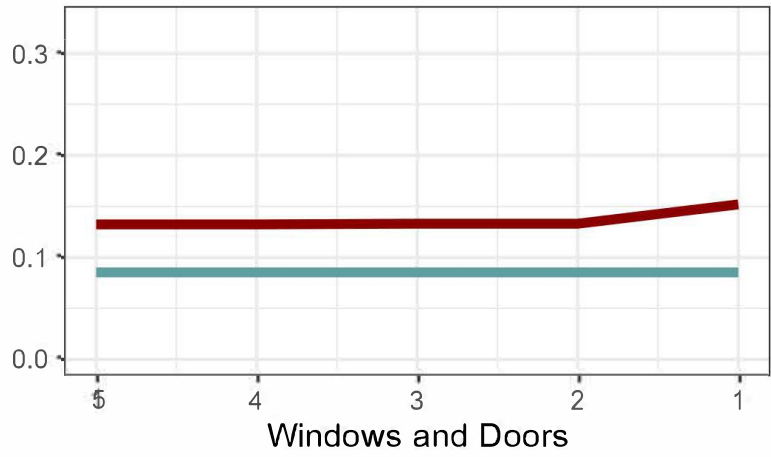
Looking at relationships

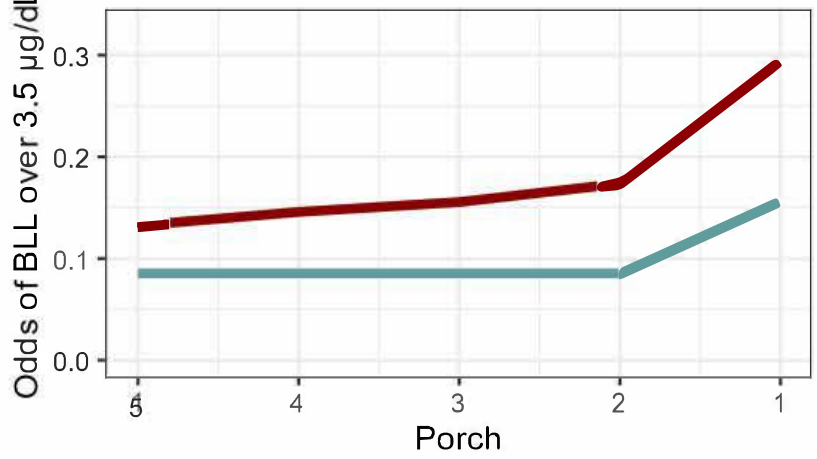


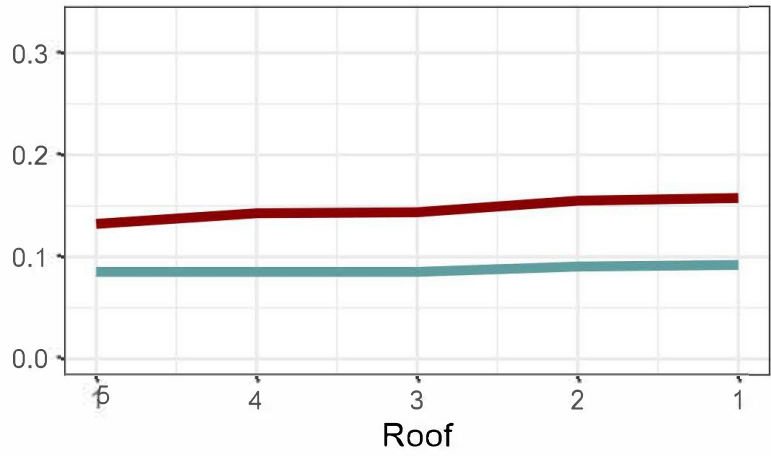


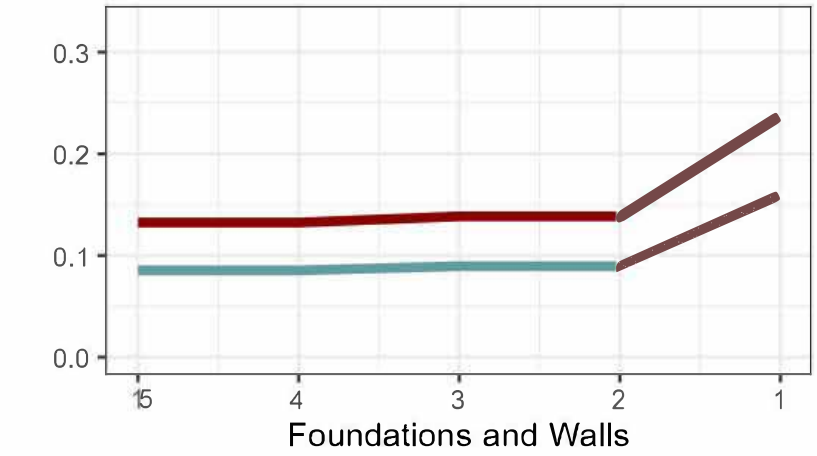


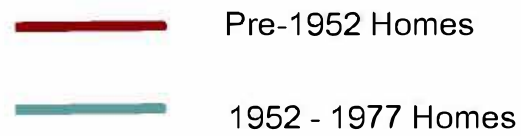












N = 6,589

From Wilson et al (2023)

Calculating the Lead Risk Index

Era of Home Construction	Value	Condition of Housing Category	Value
1978 or later	0	Excellent or Good	0
1953–1977	1	Substandard	1
1952 or before	2	Seriously Deteriorated	2
		Severely Deteriorated	3

The next step is to calculate the Lead Risk Index.
For Home 1 the LRI is calculated as (2*3) + (2*1) + (2*1) + (2*2) + (2*1) = 16.
For Home 2 the LRI is calculated as (2*2) + (2*3) + (2*0) + (2*1) + (2*0) = 12.
…

$$LRI_i = \sum_{j=1}^{5} era_i * condition_{ij}$$

Home (i)	Year of Home Construction	Windows and Doors	Exterior Paint	Porch	Roof	Foundation and Walls	LRI
11	2	3	1	1	2	0	16
22	2	2	3	0	1	0	12
33	1	0	3	0	2	1	6
44	1	0	2	1	0	0	3
55	0	0	0	0	1	0	0

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Training the Lead Risk Index: Logistic Lasso Regression Results

Variable	Observations	Lasso Coefficient Estimate	Variable	Observations	Lasso Coefficient Estimate
(Intercept)		−1.909			
LRI Contrasts			**Child-focused Variables**		
LRI 1	368	·	Test Before 2005	1983	1.52
LRI 2	1399	0.3109	18–36 months	1709	0.4067
LRI 3	36	·	37–72 months	2987	·
LRI 4	899	0.1289	**Public Walks Contrasts**		
LRI 5	21	·	Ordinal Rating 2	2162	·
LRI 6	548	0.127	Ordinal Rating 3	1082	·
LRI 8	488	·	Ordinal Rating 4	35	
LRI 9	2	·	Ordinal Rating 5	51	
LRI 10	205	0.0859	**Curbs Contrasts**		
LRI 12	88	·	Ordinal Rating 2	25	
LRI 14	60	0.4393	Ordinal Rating 3	10	
LRI 16	48	·	Ordinal Rating 4	69	·
LRI 18	16	·	Ordinal Rating 5	358	·
LRI 20	8	·	**Streetlights Contrast**		
LRI 22	7	1.3288	Ordinal Rating 2	300	·
LRI 24	1	·	Ordinal Rating 3	21	·
LRI 26	1	·	Ordinal Rating 4	2	·
LRI 30	1	·	Ordinal Rating 5	4	·

$$LRI_i = \sum_{j=1}^{5} era_i * condition_{ij}$$

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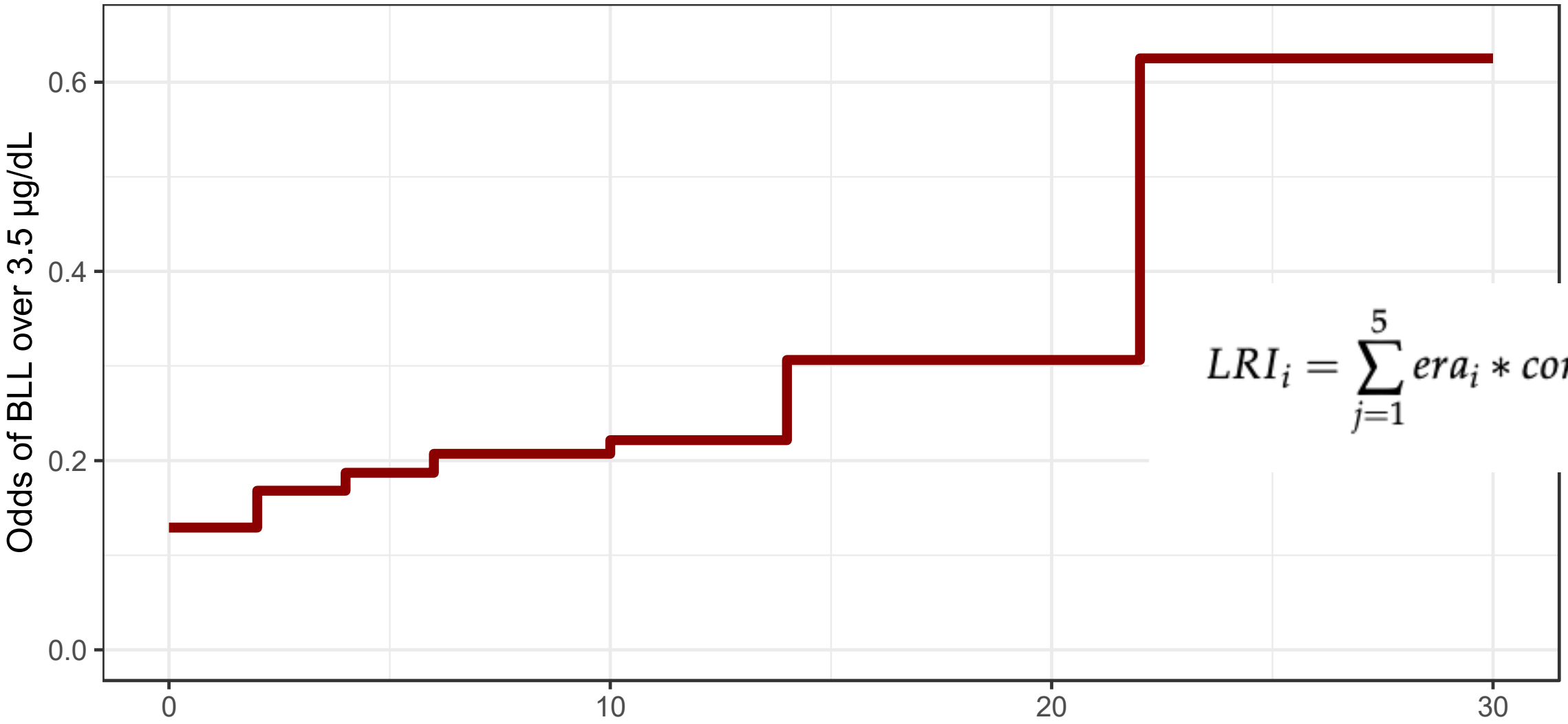
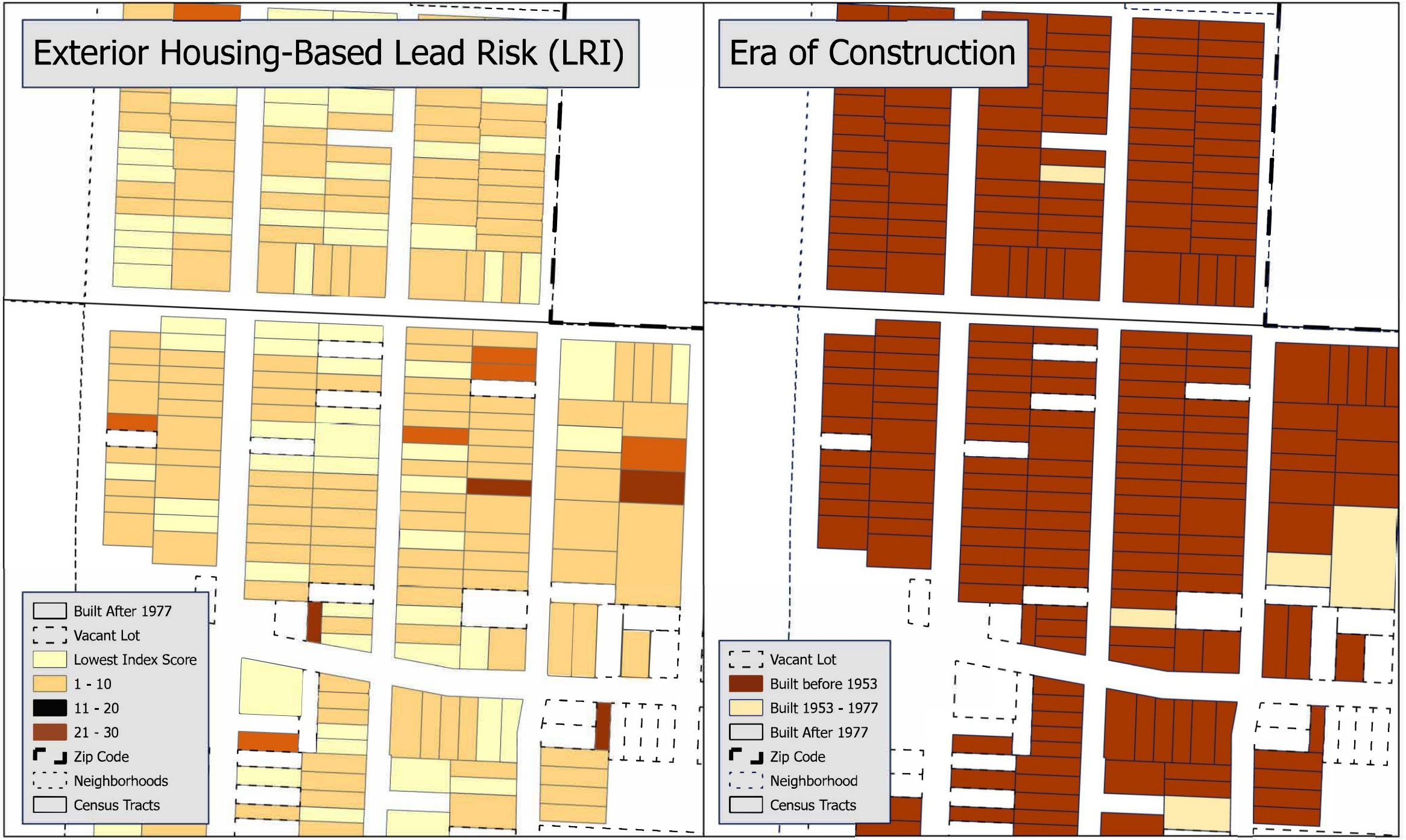
Visualizing the Lead Risk Index



$$LRI_i = \sum_{j=1}^{5} era_i * condition_{ij}$$

From Wilson et al (2024)


Exterior Housing-Based Lead Risk (LRI)
Built After 1977
Vacant Lot
Lowest Index Score
1 - 10
11 - 20
21 - 30
Zip Code
Neighborhoods
Census Tracts
Era of Construction
Vacant Lot
Built before 1953
Built 1953 - 1977
Built After 1977
Zip Code
Neighborhood
Census Tracts

Limitations and Next steps for the LRI and the NHCS

NHCS Based on Kansas City building codes and building types

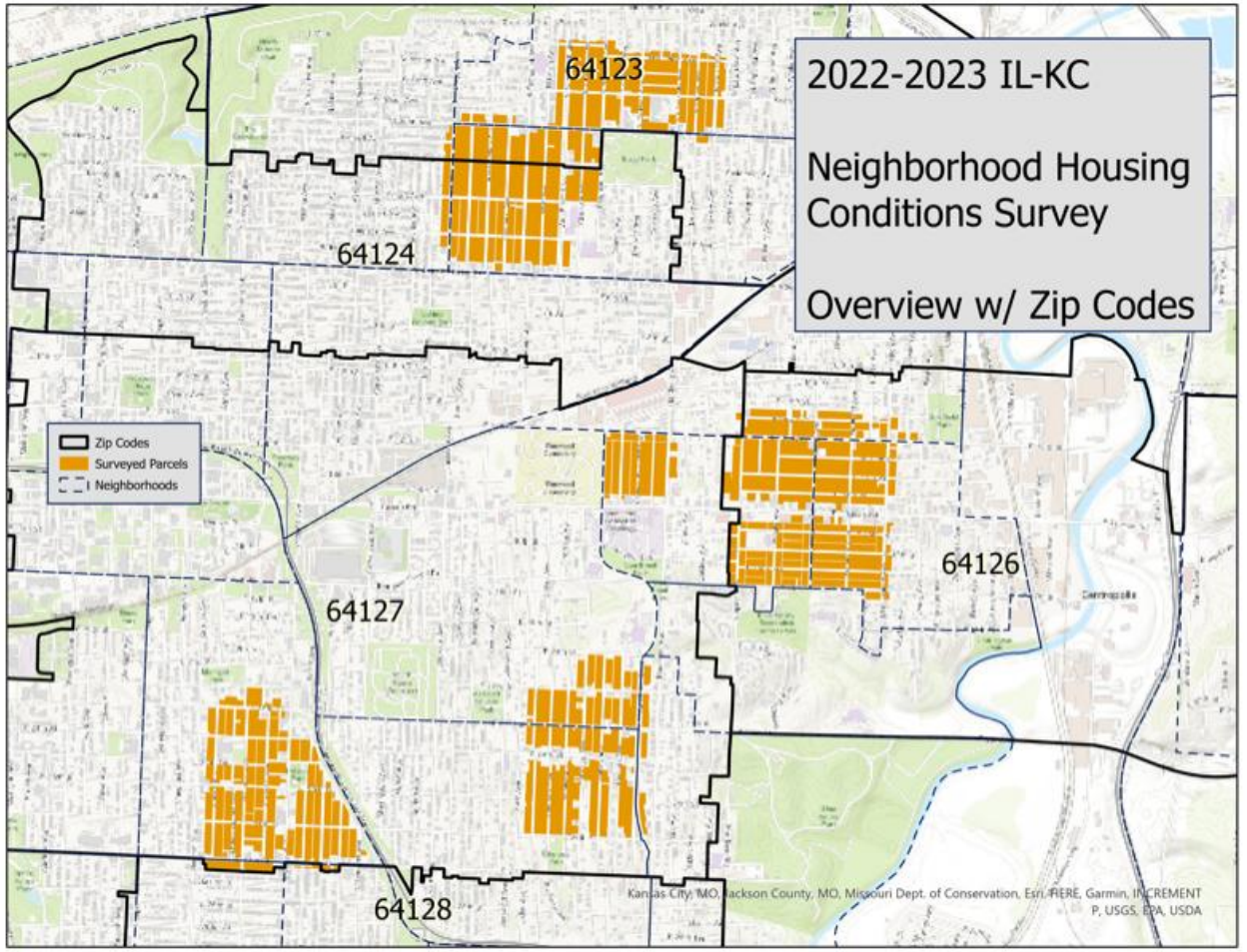
NHCS Complements does not replace traditional community outreach activities

LRI does not replace home assessments

Humans on the ground are important!

- It is public health surveillance
- A type of community engagement
- Find information about the built environment we didn't know we were looking for

Be thoughtful if/when sharing these maps



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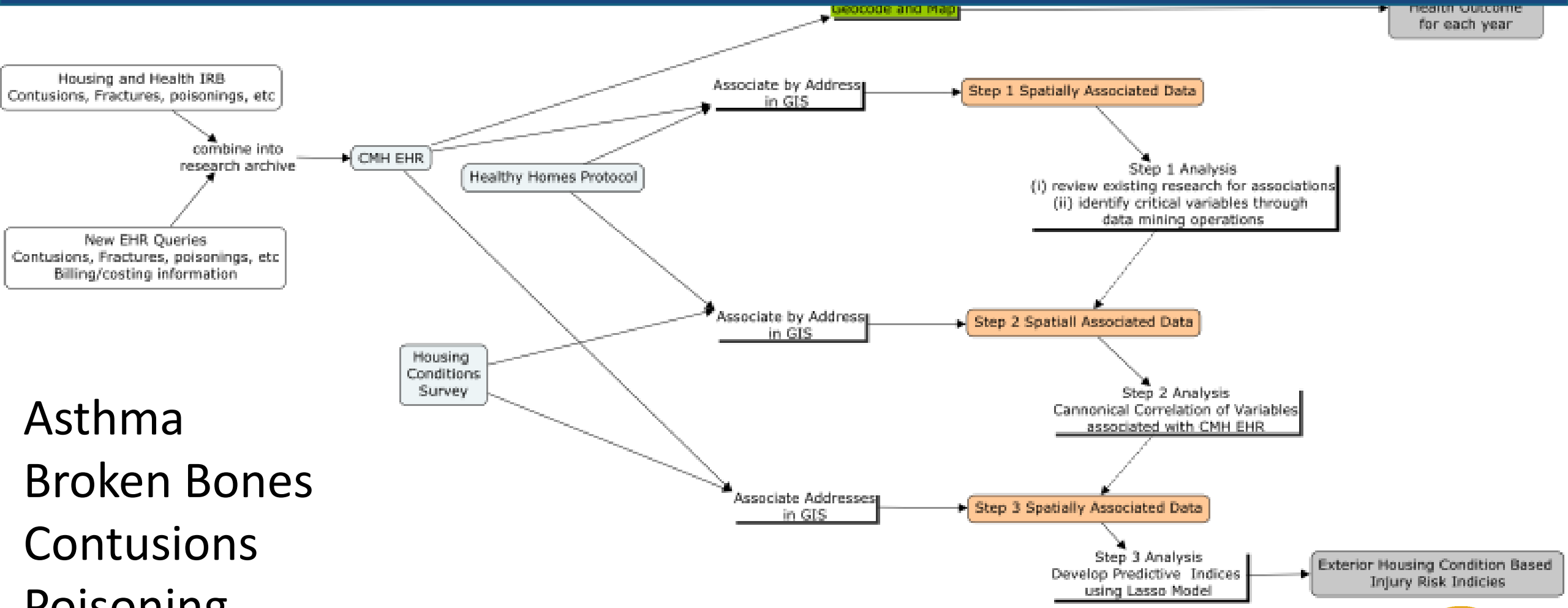
Working to Develop New Predictive tools Using the NHCS



Asthma
Broken Bones
Contusions
Poisoning

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Summary of Major Points

Collaboration and data sharing make this work possible

Address-level work embodies a powerful range of tools that help us overcome some of the issues associated with GIS

Our Neighborhood Housing Conditions Survey allows us to see meaningful differences at a meaningful level

We can use this information to prevent kids from getting sick in the first place, help economize on the use of resources and estimate benefits for programs that have gone unrecognized

Address-level analysis has the possibility to expand our understanding of the impact of the built environment on health outcomes

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Thank You!

Please, don’t hesitate to contact us with your thoughts and/or comments.

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