Update on Children's Health and Healthy Homes

Kevin Kennedy

Healthy Indoors Training and Consulting, Lawrence, Kansas

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The problem with those of us who work on health impacts of buildings is we're in a chasm

My work has been to cross this chasm and find ways to translate research into practice to improve children's health

Healthy Indoors Training and Consulting, Lawrence, Kansas

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The goal of my work is to prevent children from being canaries

The Haldane Canary-resuscitator to detect a build-up of carbon monoxide in building and mines

https://blog.scienceandindustrymuseum.org.uk/canary-resuscitator/

3

Little Jeremy ≠ Big Jeremy: The impact is Greater on Children

Per pound of body weight, children:

- Eat more food
- Have a higher metabolism
- Drink more liquid
- Breathe more air
- Have higher respiration rate

Children's Environmental Health, CDC.gov

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Children more susceptible to exposure:

- Natural defenses are less developed
- crawl and play close to the ground- different breathing zone
- More likely to put their hands in their mouths – a lot
- Have more years of life to develop disease than adults

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https://www.pexels.com/creative-commons-images/ Pexel photos are free for use

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Jeremy Accumulates Risk

Lives in poverty

Lead paint in his bedroom

Home has roaches

Squalid neighborhood

https://www.pexels.com/creative-commons-images/
Pexel photos are free for use

Mom works 2 jobs

Highway runs through neighborhood

Does not have access to fresh produce

Nearest park is 5 miles away

Children's Environmental Health Tracking:
https://ephtracking.cdc.gov/showChildEHMain.action

Child Opportunity Index:
https://www.diversitydatakids.org/maps/

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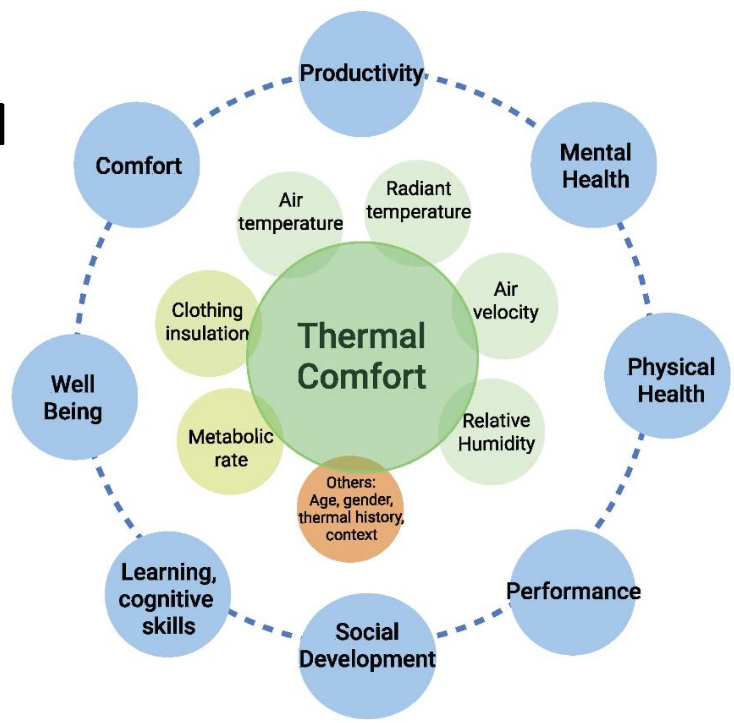
Jeremy's comfort in his home is more complicated involving a large interaction of a combination of factors



Lala, Betty and Aya Hagishima, A Review of Thermal Comfort in Primary Schools and Future Challenges in Machine Learning Based Prediction for Children, Buildings 2022, 12(11), https://doi.org/10.3390/buildings12112007

A model representing the factors affecting the thermal comfort of children

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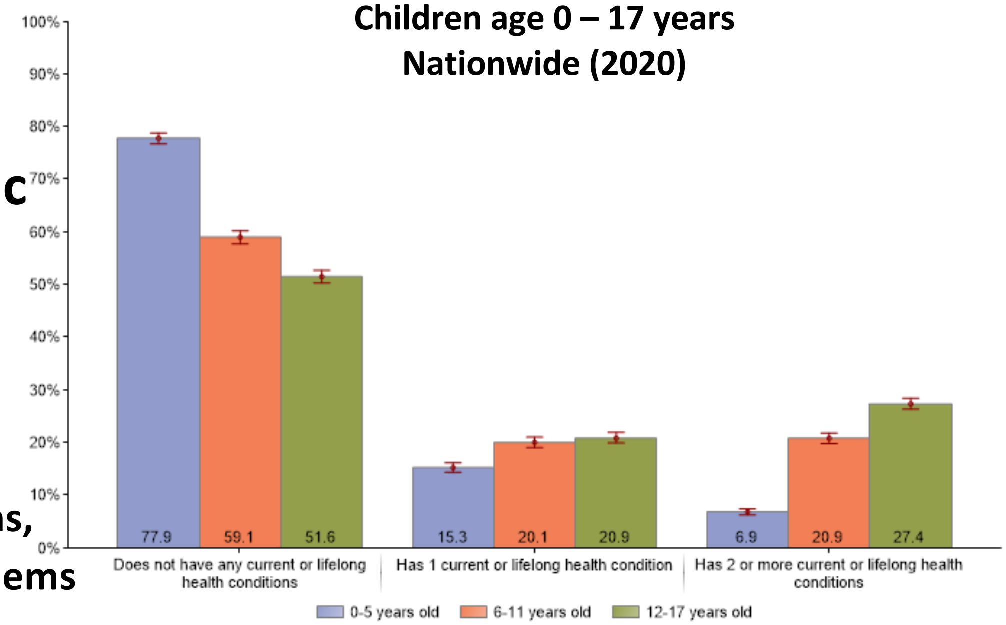
~40% of school-aged children and adolescents have at least one chronic health condition

Asthma
Obesity
Diabetes
other physical conditions,
behavior/learning problems

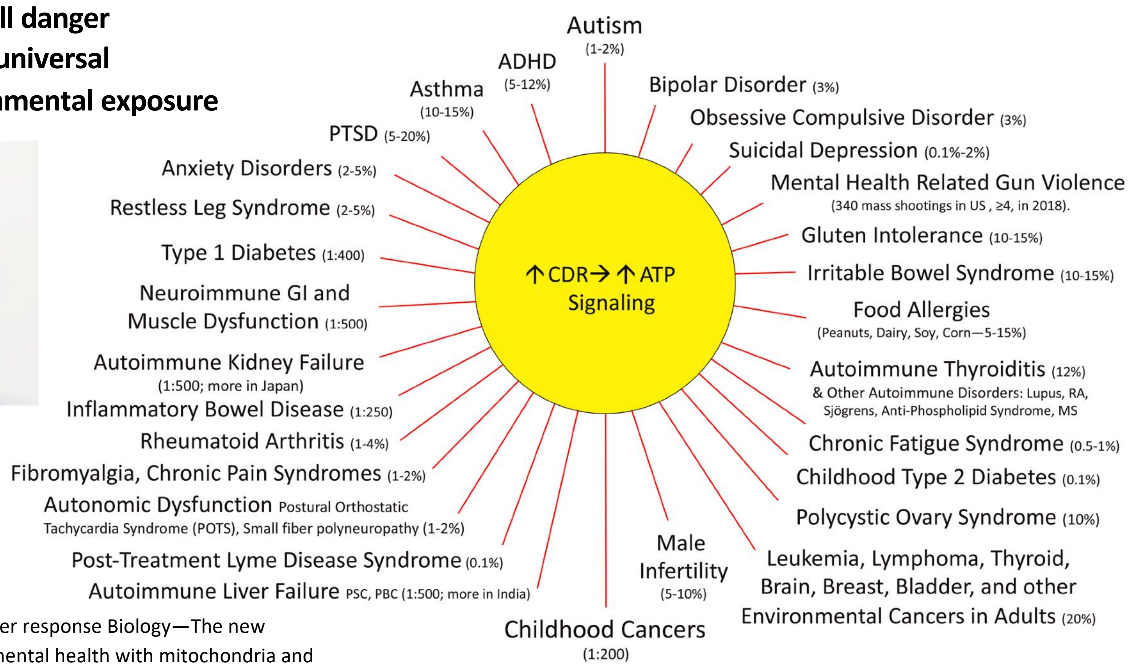
Number of current or lifelong health conditions
Children age 0 – 17 years
Nationwide (2020)



Child and Adolescent Health Measurement Initiative. 2020-2021 National Survey of Children's Health (NSCH) data query. Data Resource Center for Child and Adolescent Health supported by the U.S. Department of Health and Human Services, Health Resources and Services Administration (HRSA), Maternal and Child Health Bureau (MCHB). Retrieved [06/08/24] from [www.childhealthdata.org].

Chronic Health Disorders that have Increased 2-100 times since the 1980s

A description of "cell danger response" (CDR), a universal response to environmental exposure



Naviaux, Perspective, Cell danger response Biology—The new science that connects environmental health with mitochondria and the rising tide of chronic illness, Mitochondrion, 51 (2020) 40–45

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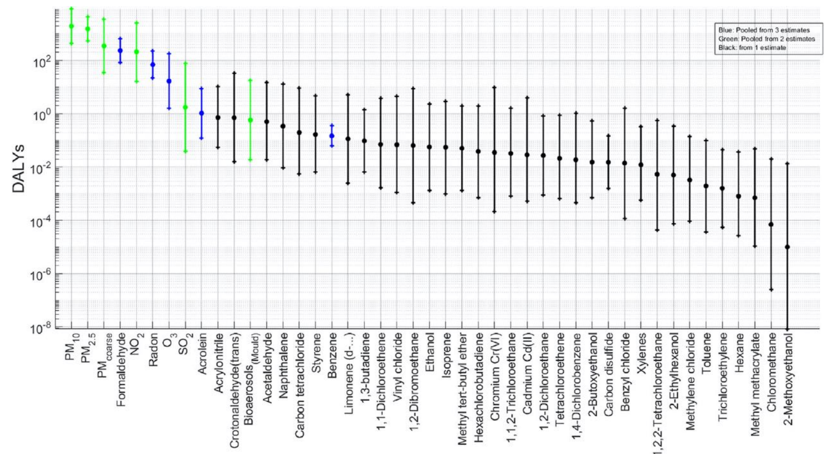
Preliminary Assessment of health impacts of indoor air contaminants using Daily Adjusted Life Years (DALY) Metric

DALY: Disability Adjusted Life Year:

-Sum of years of life lost and time lived with a disability attributable to a cause

-One DALY represents the loss of the equivalent of one year of full health

Est. value about $700,000 by EPA and HHS



igure 3. Pooled DALYs. Highest to lowest median. Central estimate and 95% C.I. of distribution in black.

Giobertti Morantes, Benjamin Jones, Max Sherman & Constanza Molina (2023) A preliminary assessment of the health impacts of indoor air contaminants determined using the DALY metric, International Journal of Ventilation, 22:4, 307-316, DOI: 10.1080/14733315.2023.2198800

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Potential Health Effects of Combustion Pollutants on Jeremy

- Carbon monoxide (CO)
- Nitrogen oxides (NOx),
- Particulate matter (PM),
- Air toxics- (ammonia, formaldehyde, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs)

If Jeremy's family is low-income, the impact is even greater

- CO- Poisonous gas and cardiovascular risk
- NOx- make children sick, especially those with asthma and allergies. It worsens asthma symptoms and wheeze and may also increase lower respiratory tract infections and reduce lung function
- PM- irritation to eyes, nose and throat, and respiratory effects in children. Also asthma, cancer, autoimmune conditions
- Air toxics- can cause cancer, birth defects and other serious health harms

The Health Impact of Combustion in Homes. American Lung Assoc. 2023

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The conversion to a decarbonized economy will provide immense benefits to the millions of children like Jeremy

Less exposure should lead to fewer children:

- born preterm or with low birth weight
- with cognitive and behavioral disorders
- With mental-health problems
- With risk of asthma and other respiratory illness
- With long-term risk of cardiovascular disease
- With risk of cancer

Our focus should be making the future better for Jeremy

These health benefits translate into improving children's ability to learn and contribute productively to society

Frederica Perera, Pollution from Fossil-Fuel Combustion is the Leading Environmental Threat to Global Pediatric Health and Equity: Solutions Exist, Int. J. Environ. Res. Public Health 2018, 15, 16; doi:10.3390/ijerph15010016

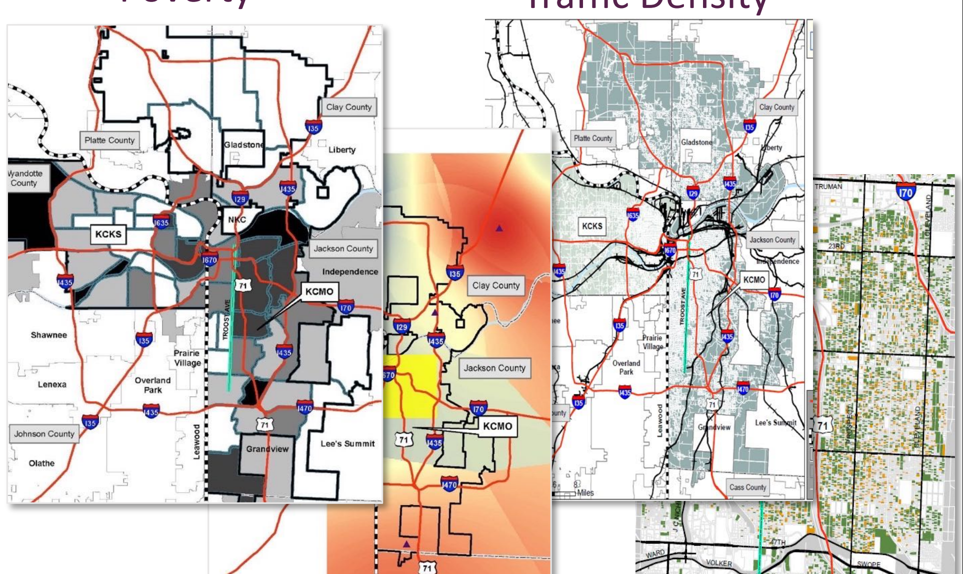
Many communities are actively using data from their community to evaluate health impacts on their citizens

Example community-based risk factor data sets include:

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

Poverty

Traffic Density



Air Pollution

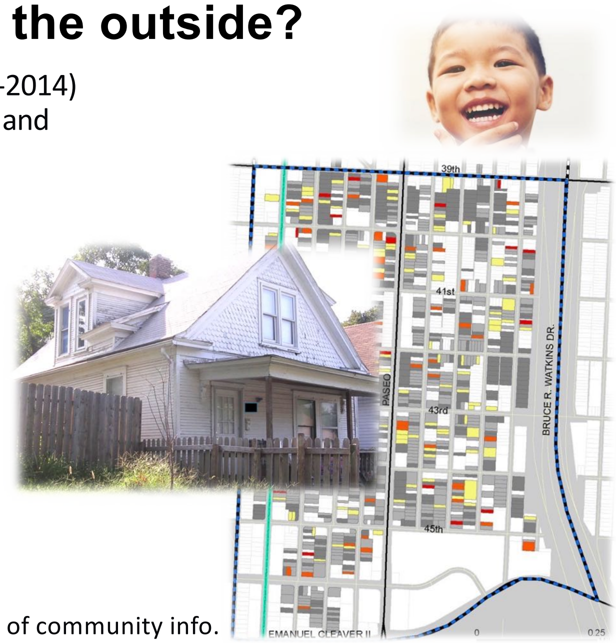
Housing Cond.

Maps from KC Health CORE (KC Health Community-Organized Resource Exchange) files

What can we tell about the inside of a family’s house from looking at the outside?

We have created a large historic records data base (2000-2014) combining community data and pediatric health system and public health dept. data from a large metropolitan area (Kansas City) ***at the ADDRESS LEVEL***:

Asthma acute care visits –
~300,000+ records (2000-2015)
Lead testing data –
~300,000+ records (2000-2021)
Injury events –
~1,200,000+ records (2000-2013)



With 230,000 Neighborhood Housing Conditions Surveys

Geodatabase is part of community info. system to study health disparities

KC HEALTHCORE
COMMUNITY-ORGANIZED RESOURCE EXCHANGE

Children’s Mercy Kansas City Environmental Health; Center for Economic Information, UMKC; Kansas City, Missouri Dept. of Public Health

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What can we tell about the inside of Jeremy’s house from looking at the outside?

How We Use Big Data

Can we identify community factors that lead to health disparities using large health datasets

- The process of geo-coding and matching by individual parcel addresses
- Joining this data to other community data represented at the street address
- Develop statistical models for characterizing exposure risks that have led to health impacts in children

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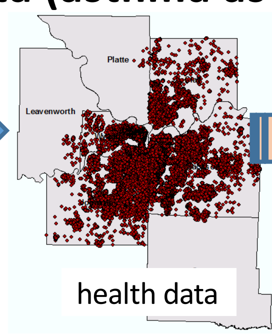
- Windshield, drive-by survey
- Data recorded via web-based database
- 15 Exterior features each rated on 1-5 ordinal scale
- Average time: 3-5 minutes
- Cost: ~$8 US/home

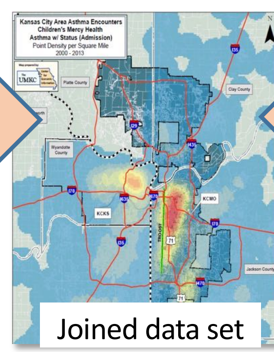
Building Specific Ratings:

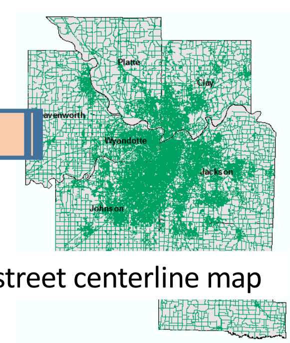
Category	1	2	3	4	5
Roof Rating	Hole-sagging-rot, F & S	No hole-sagging-rot, F&S	Serious deterioration	Slight deterioration	No deterioration
Foundation & Walls	Hole, bulges, +25% gone	Slight leaning, +25% rot	No leaning, -25% replace	Needing some paint	Well protected
Windows & Doors	Open to entry, W&D miss	No entry, few openings	Some broken, needing paint	No broken, need paint	No broken, no painting
Porches	Serious leaning, rot, unsafe	Slight leaning, rot, safe	Evidence of lean, paint need	No leaning, paint needed	No leaning or paint needed
Exterior Paint	+50% need paint, +2wks	50-10% need paint +2wk	-10% need paint, no rot	No peeling, some fading	Paint in great shape

Geocoding health data (asthma as example) in 3 phases

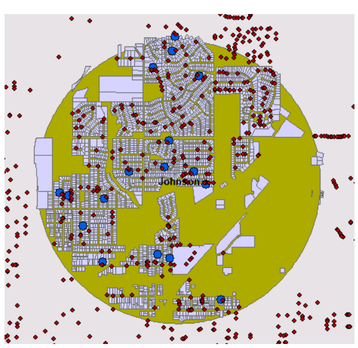
Phase I –
Geocoding health data to metropolitan statistical area street centerline map file



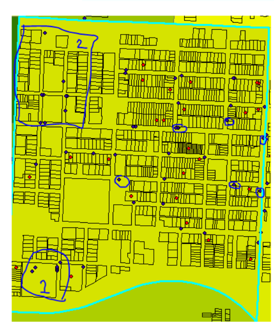




Phase II –
Geocoding health data to parcel address from target datasets. (i.e. NHCS, weatherization, etc)



Phase III –
Manual correction of unmatched health encounters to parcel (street address) geography



GROUP 1:

LEGAL_DESC 1300-30 PARK & 1301-31 PARK 1308-46 OLIVE 2301-
2300-18 E 14TH ST FREEWAY PLAZA HOMES HOUSING PROJECT FLORA
12 BLK 1 & LOTS 1 THRU 24 BLK 2 & WILSONS SUB OF WM PROCTOR MC ELR

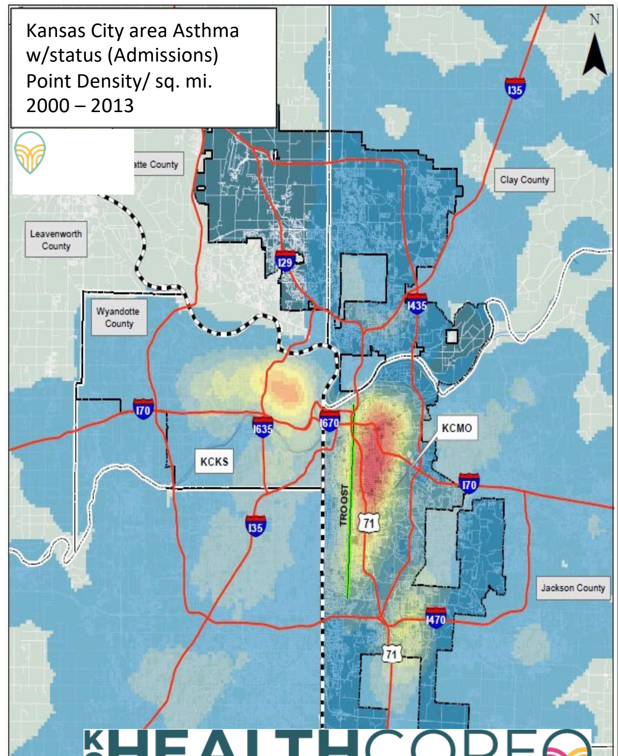
ADDRESSES: 1326 PARK (1), 1315 PARK AVE (3), 1312 OLIVE ST, 1316 OLIVE (3)
OLIVE (1), 1301 OLIVE (1)

Wilson B, Wilson N, Martin S. Using GIS to Advance Social Economics Research: Geocoding, Aggregation, and Spatial Thinking. Forum Soc Econ. Published online January 14, 2019

Data set includes ~300,000 records asthma acute care records from pediatric health system serving a large metropolitan area (Kansas City) with >90% of pediatric market share

Asthma acute care records include:

- Hospital Admissions
- Emergency Dept. visits
- Urgent Care Visits
- After Hours Care
- Outpatient visits



Research grant funding through U.S. Housing & Urban Development Office of Lead Hazard Control and Healthy Homes Technical Studies Grants

Program grant funding from the Health Forward Foundation of Greater Kansas City

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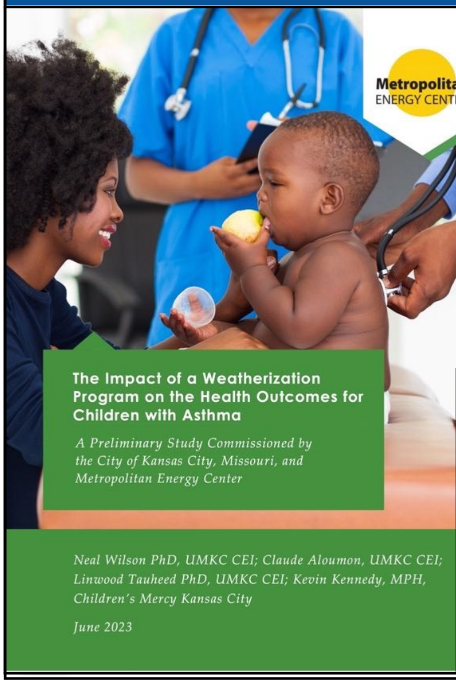
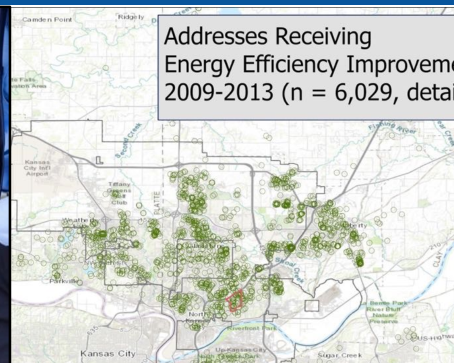
Summary of Pearson's Chi-square Association – Neighborhood housing conditions data vs. asthma acute care visits and various injury events based on diagnosis code (ICD-9)

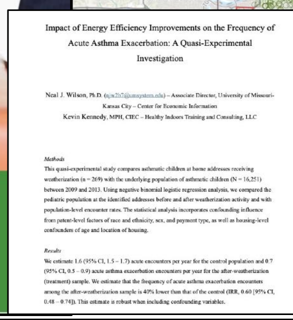
Focusing on 2001 data with 63,274 exterior housing conditions surveys

Independent Variable	Total N	Asthma N (%)	P-Value	Falls N (%)	P-Value	Face Contusions	P-Value	Wrist Sprain	P-Value	Ankle Sprain	P-Value
Roof Condition	63,274	3.6% Asthma	.000	0.2% Falls	.045	0.5% Cont.	.000	0.1% Wrist	.618	0.2% Ankle	.306
Foundation Condition	63,274	3.3% Asthma	.377	0.2% Falls	.154	0.6% Cont.	.009	0.1% Wrist	.585	0.2% Ankle	.768
Window/Door Condition	63,274	4.0% Asthma	.000	0.3% Falls	.000	0.6% Cont.	.000	0.1% Wrist	.289	0.2% Ankle	.747
Porch Condition	63,274	4.1% Asthma	.000	0.3% Falls	.000	0.6% Cont.	.000	0.1% Wrist	.185	0.1% Ankle	.185
Exterior Paint Condition	63,274	3.8% Asthma	.000	0.2% Falls	.001	0.6% Cont.	.000	0.1% Wrist	.563	0.2% Ankle	.683
Lawn Condition	63,274	3.9% Asthma	.000	0.3% Falls	.005	0.6% Cont.	.000	0% Wrist	.652	0.2% Ankle	.895
Yard Litter Condition	63,274	4.8% Asthma	.000	0.4% Falls	.001	0.7% Cont.	.007	0% Wrist	.668	0.1% Ankle	.556
Items Stored in Yard	63,274	3.9% Asthma	.007	0.5% Falls	.000	0.4% Cont.	.182	0% Wrist	.252	0.3% Ankle	.210

Impact of Weatherization on Acute Asthma Exacerbation in Children- A Quasi-Experimental Study







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

Neal J. Wilson, Ph.D. (njw2h7@umsystem.edu) – Associate Director, University of Missouri-Kansas City – Center for Economic Information
Kevin Kennedy, MPH, CIEC – Healthy Indoors Training and Consulting, LLC

Methods

This quasi-experimental study compares asthmatic children at home addresses receiving weatherization (n = 269) with the underlying population of asthmatic children (N = 16,251) between 2009 and 2013. Using negative binomial logistic regression analysis, we compared the pediatric population at the identified addresses before and after weatherization activity and with population-level encounter rates. The statistical analysis incorporates confounding influence from patent-level factors of race and ethnicity, sex, and payment type, as well as housing-level confounders of age and location of housing.

Results

We estimate 1.6 (95% CI, 1.5 – 1.7) acute encounters per year for the control population and 0.7 (95% CI, 0.5 – 0.9) acute asthma exacerbation encounters per year for the after-weatherization (treatment) sample. We estimate that the frequency of acute asthma exacerbation encounters among the after-weatherization sample is 40% lower than that of the control (IRR, 0.60 [95% CI, 0.48 – 0.74]). This estimate is robust when including confounding variables.

eTable Weatherization Improvements for all program participants and for those homes with asthmatic children as residents

	All Weatherized Homes (N = 6,029)	Weatherized Homes w/ Asthmatic Children (N = 214)
AIR SEALING; INSULATION	2,270 (37.7%)	87 (39.9%)
AIR SEALING (only)	1,315 (21.8%)	66 (30.3%)
INSULATION (only)	1,179 (19.6%)	31 (14.2%)
AIR SEALING; INSULATION; WINDOW(s)	184 (3.1%)	12 (5.5%)
WINDOW(s) (only)	477 (7.9%)	8 (3.67%)
AIR SEALING; WINDOW(s)	89 (1.5%)	4 (1.8%)
AIR SEALING; INSULATION; DUCT SEALING	58 (1.0%)	2 (0.9%)
DUCT SEALING (only)	91 (1.5%)	2 (0.9%)
INSULATION; WINDOW(s)	56 (0.9%)	2 (0.9%)
AIR SEALING; DUCT SEALING	43 (0.7%)	1 (0.5%)
AIR SEALING; INSULATION; DOOR(s)	19 (0.3%)	1 (0.5%)
AIR SEALING; INSULATION; WINDOW(s); DOOR(s)	18 (0.3%)	1 (0.5%)
AIR SEALING; WINDOW(s); DOOR(s)	12 (0.2%)	1 (0.5%)
AIR SEALING; DOOR(s)	19 (0.3%)	0 (0.0%)
DOOR(s) (only)	45 (0.8%)	0 (0.0%)
DOOR(s); AIR SEALING	1 (0.02%)	0 (0.0%)
HEAT PUMP (only)	1 (0.02%)	0 (0.0%)
INSULATION; DOOR(s)	5 (0.1%)	0 (0.0%)
INSULATION; DUCT SEALING	5 (0.1%)	0 (0.0%)
INSULATION; WINDOW(s); DOOR(s)	11 (0.2%)	0 (0.0%)
WINDOW(s); AIR SEALING	3 (0.1%)	0 (0.0%)
WINDOW(s); AIR SEALING; INSULATION	1 (0.02%)	0 (0.0%)
WINDOW(s); DOOR(s)	103 (1.7%)	0 (0.0%)
NA	24 (0.4%)	0 (0.0%)
Total	6029	214

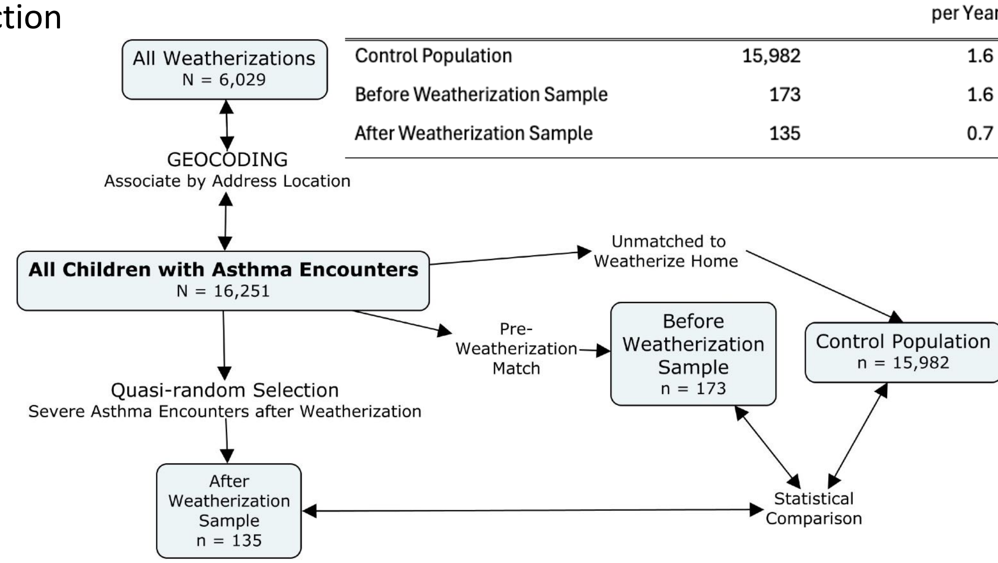
Impact of Weatherization on Acute Asthma Exacerbation in Children- A Quasi-Experimental Study

Quasi-Experimental Structure

- A comprehensive collection of pediatric asthma encounters
- ARRA program was "open enrollment"
- Clean Title to Home
- Home in adequate condition for work
- Not advertised as a health intervention

Frequency of Acute Asthma Exacerbation Encounters by Dataset

	Children in Dataset	Acute Asthma Encounters per Year (sd)
Control Population	15,982	1.6 (7.5)
Before Weatherization Sample	173	1.6 (4.5)
After Weatherization Sample	135	0.7 (1.1)



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This material is based upon work supported, in whole or in part, by the Department of Energy - Office of Energy Efficiency and Renewable Energy under Grant Award Number DE-EE0000758 from the American Recovery and Reinvestment Act (RECOVERY ACT) of 2009.

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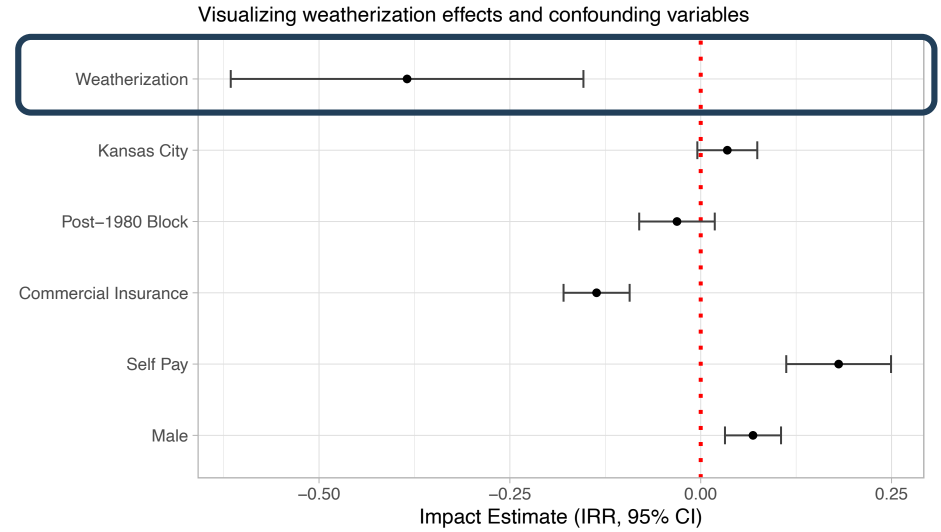

This visualization shows the large decrease in acute asthma frequency is robust when accounting for confounding variables. If the error bars around the estimate include the zero line, we can disregard the estimate as statistically insignificant.

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	Comparison with all encounters (16,251 Children)				Asthma Observations at weatherized Home Before and After Intervention (78 Children)			
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
Weatherization	0.6	0.47 - 0.76	0.62	0.49 - 0.77	0.28	0.15 - 0.50	0.29	0.16 - 0.52
Housing								
Kansas City			1.03	1.00 - 1.08			1.11	0.33 - 4.09
Post 1980 Block			0.97	0.92 - 1.02			0.56	0.29 - 1.07
Payment Type								
Commercial Insurance			0.86	0.83 - 0.90			1.07	0.58 - 1.95
Self Pay			1.18	1.10 - 1.26			0.99	0.32 - 3.11
Sex								
Male			1.07	1.03 - 1.11			0.61	0.33 - 1.09

In the "all encounters" model the incident rate ratio (IRR) associated with weatherization is 0.62. This means 38% fewer acute care Asthma visits for a child in a weatherized home (other things held constant) per year than those who lived in un-weatherized homes. This finding is robust when accounting for variation in the age or location of the home, how the encounter was paid for (proxy for income) and the sex of the child.

This material is based upon work supported, in whole or in part, by the Department of Energy - Office of Energy Efficiency and Renewable Energy under Grant Award Number DE-EE0000758 from the American Recovery and Reinvestment Act (RECOVERY ACT) of 2009.

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4. Naviaux, Perspective, Cell danger response Biology—The new science that connects environmental health with mitochondria and the rising tide of chronic illness, Mitochondrion, 51 (2020) 40–45

The Health Impact of Combustion in Homes. American Lung Assoc. 2023

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Questions

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