

# Lead Particulate Deposition from Housing Demolition

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**National Healthy Homes Conference**

**Denver, CO**

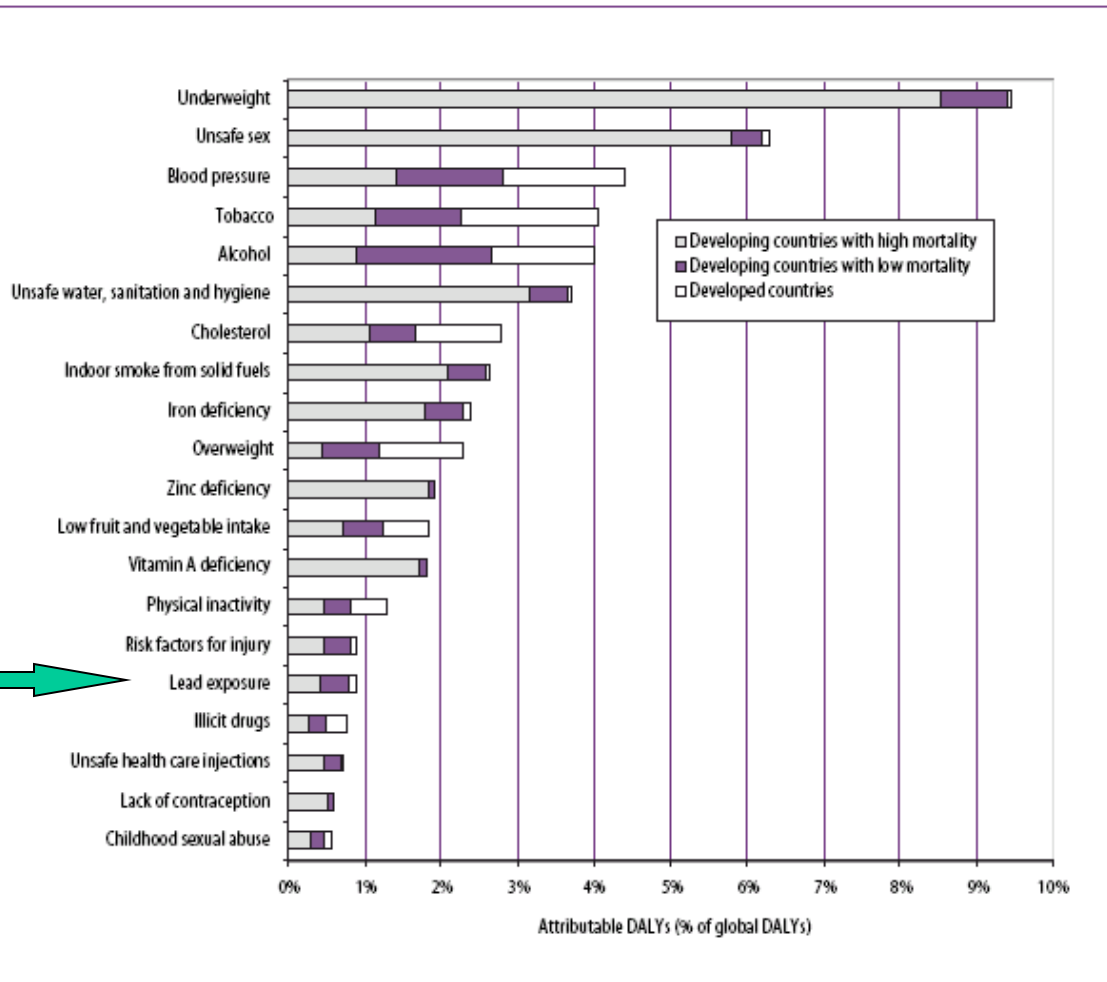
**June 2011**

# Introduction

- Magnitude of remaining lead exposure
- Description of demolition studies in Baltimore (MF) and Chicago (SF) and methods
- New dust suppression methods in Baltimore
- Results of lead in air, soil, settled dust and dustfall measurements
- Implications for housing demolition work
- Conclusions

# Global Distribution of Burden of Disease Lead = 16<sup>th</sup> in DALYs (WHO 2002)

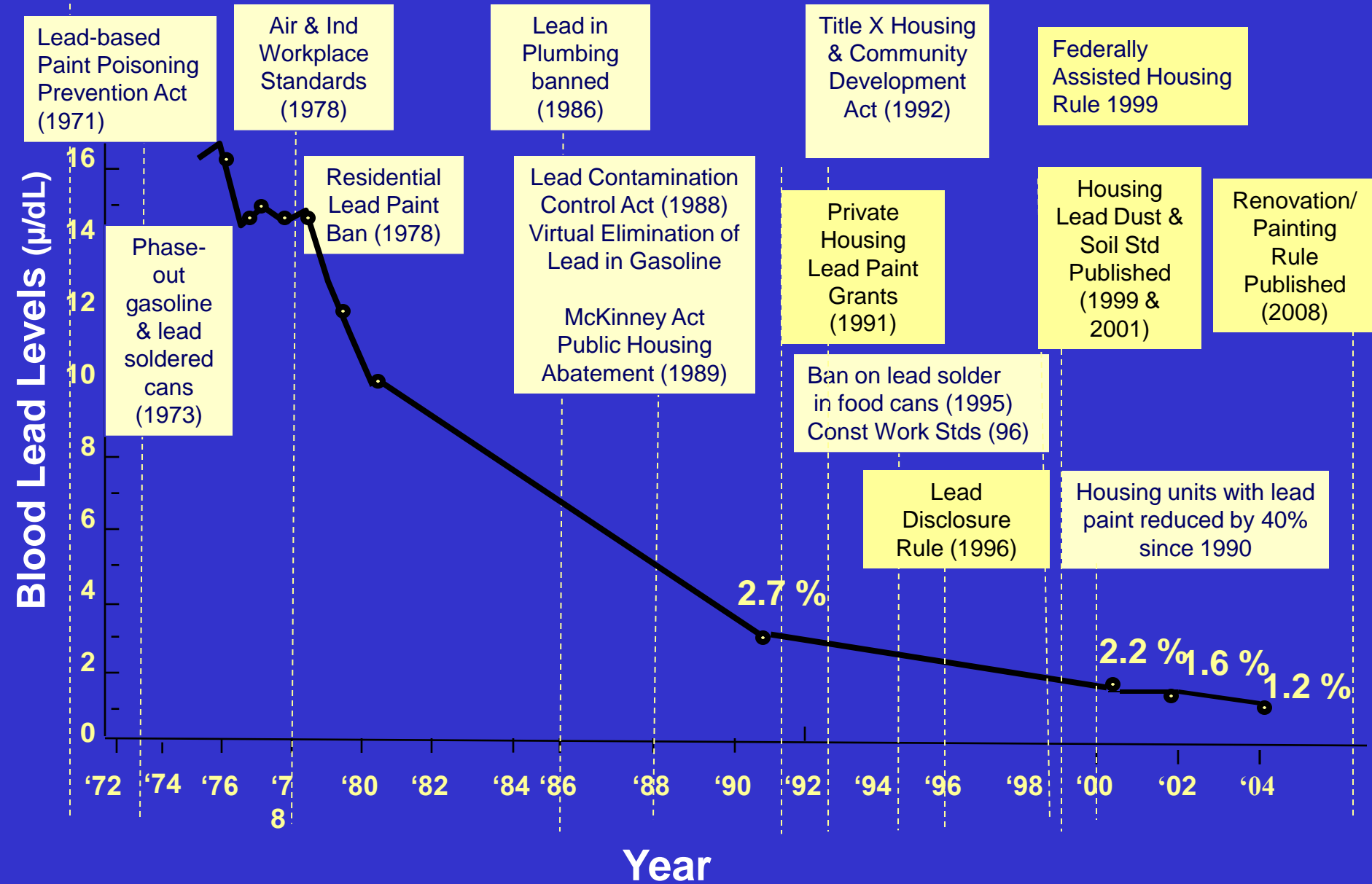
Figure 4.9 Global distribution of burden of disease attributable to 20 leading selected risk factors



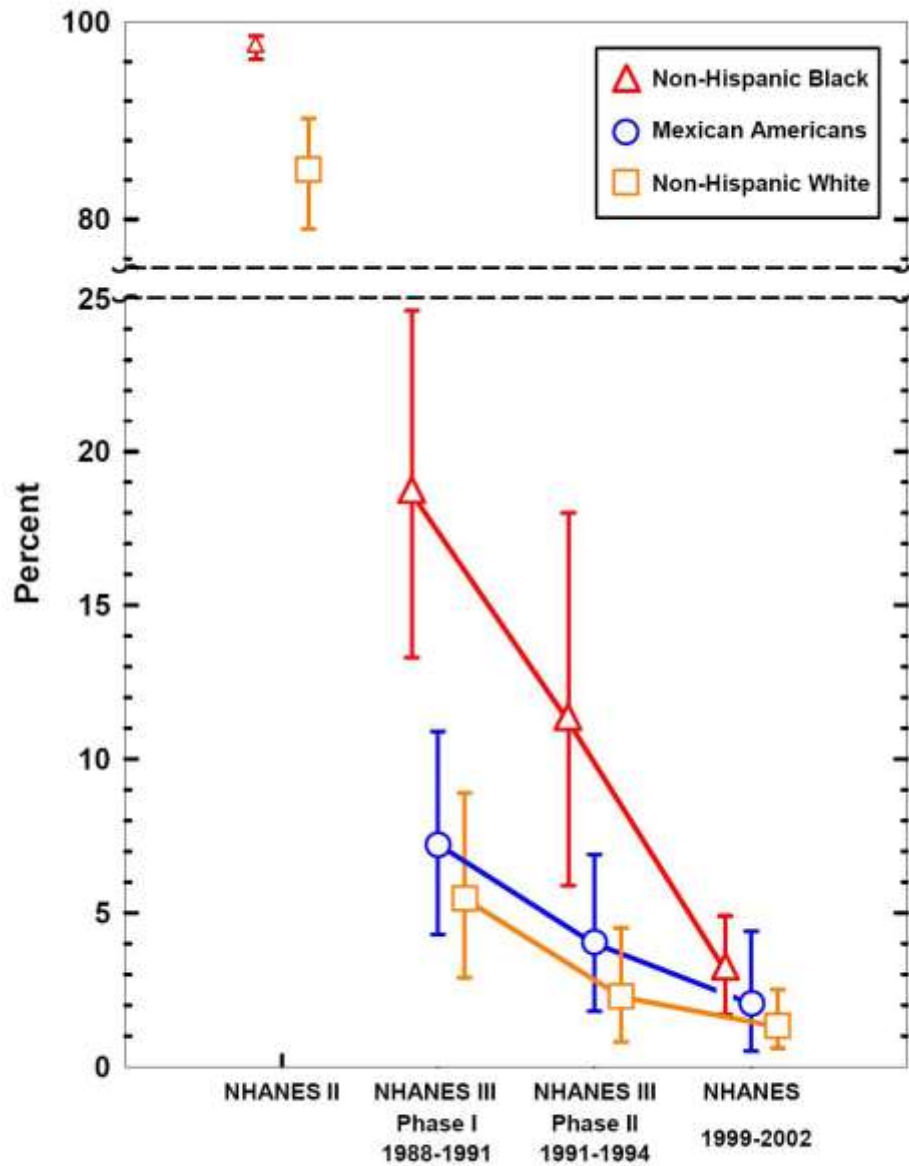
# Existing Lead Standards

- Paint
- Interior Settled Dust
- Soil
- Water
- Dinnerware
- Exterior Airborne Dust
  
- None for Exterior Settled Dust or Demolition

# US Policies & Blood Lead 1971-2004

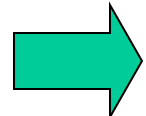
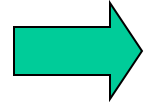


Percent of U.S. Children Aged 1-5 Years with Blood Lead Levels  $\geq 10 \mu\text{g/dL}$ , with 95% Confidence Intervals, NHANES II, NHANES III Phases 1 and 2, and NHANES 1999-2002



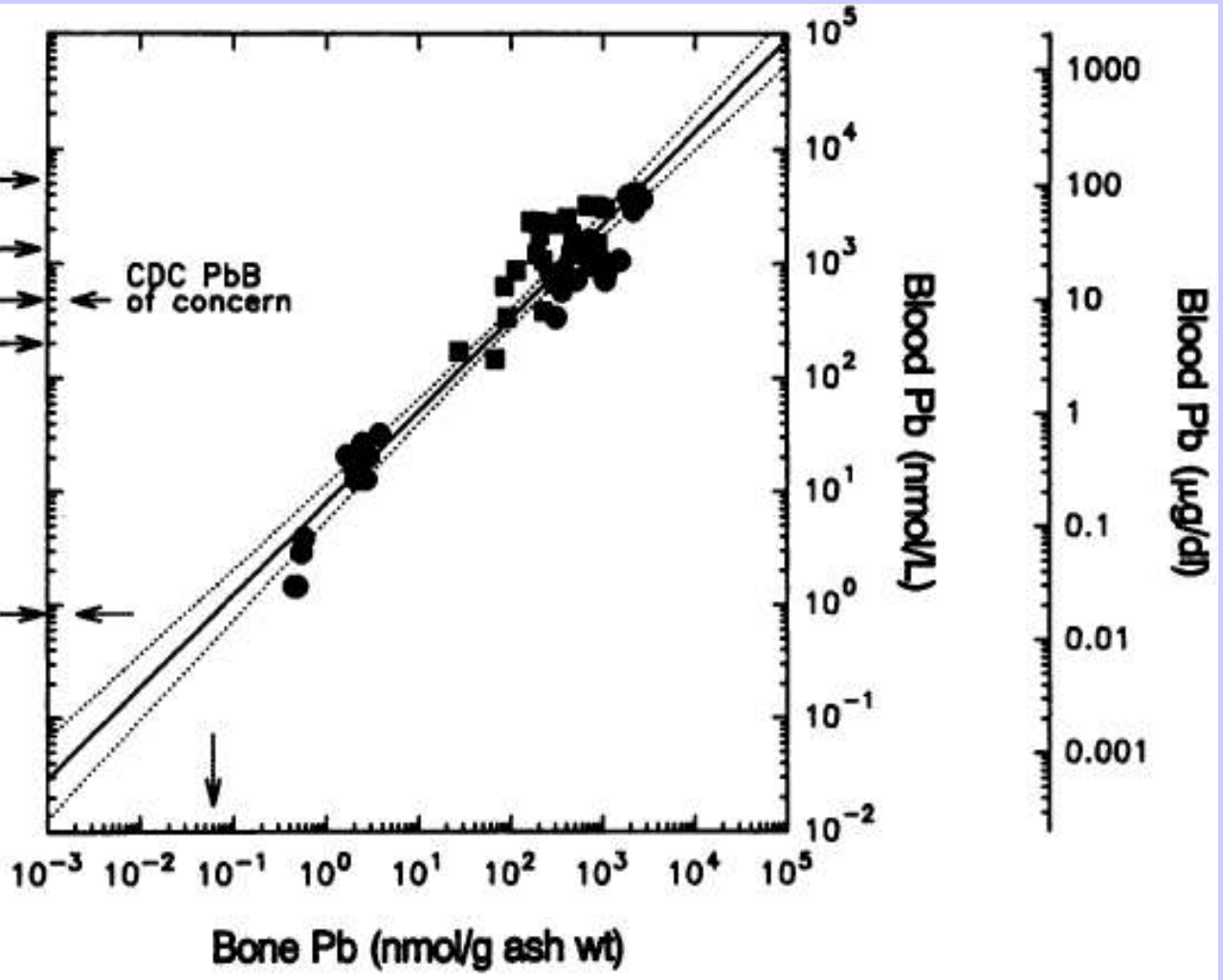
**Has the Lead Problem Already  
Been Solved?**

Childhood PbB Levels



Death →  
Chelation →  
Developmental toxicity →  
Baseline in contemporary humans →  
Natural PbB level →

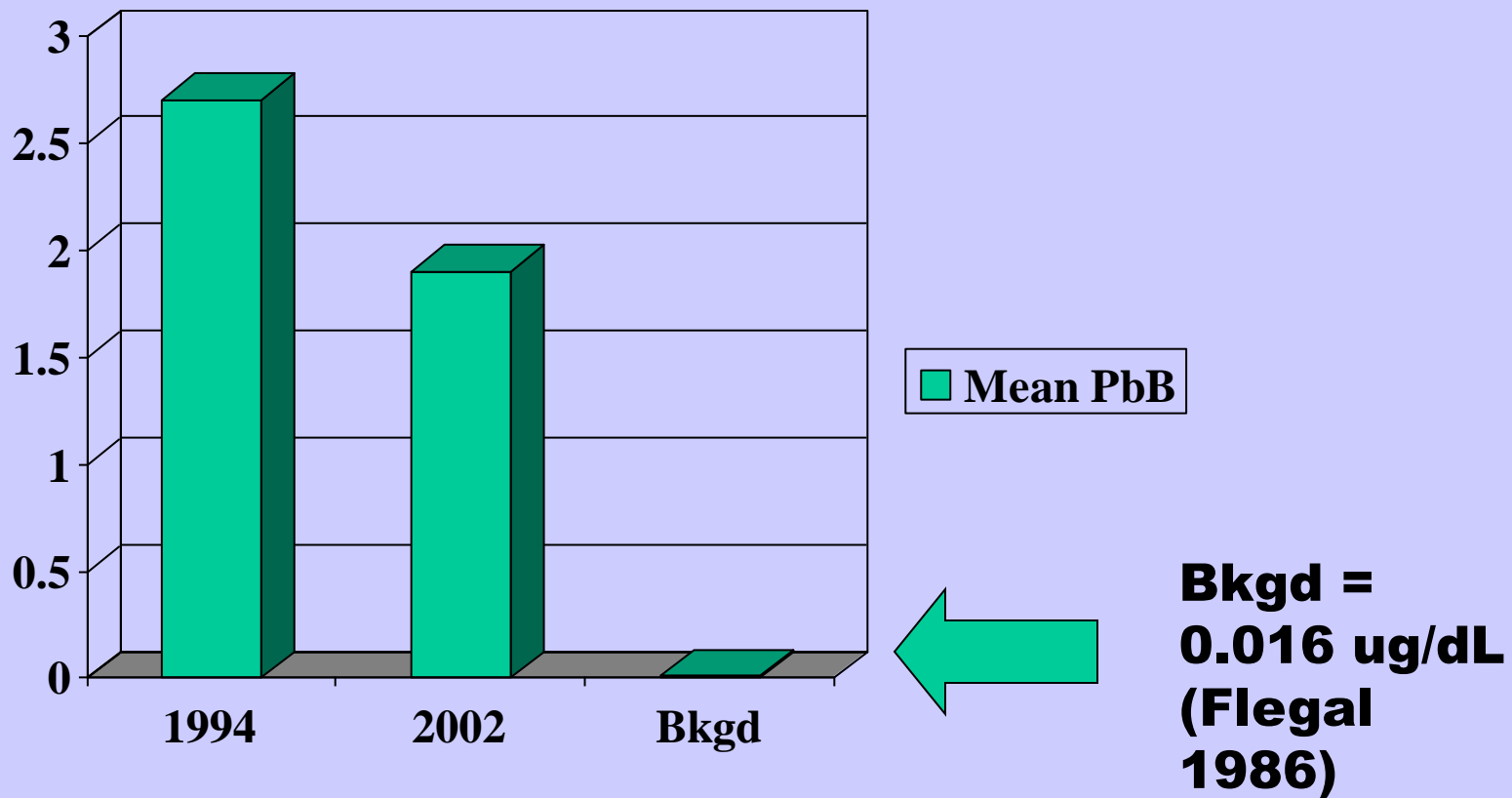
CDC PbB of concern



■ = Bone lead levels in humans

● = Bone lead levels in laboratory rats

# US Childhood PbB Compared to “Natural” Background PbB



# The Lead Experience

- A Public Health Success Story
- A “Pyrrhic Victory”
- Future Challenges are Large
  - How Large Are They?

# Settled Dust Lead & Paint Lead

- Current definition of lead paint = 1 mg/cm<sup>2</sup>
- Sand a one square foot area into dust
- Spread the dust over a 10 ft x 10 ft room
- Resulting lead dust loading = 9,300 ug/ft<sup>2</sup>
- Current US Government Limit = 40 ug/ft<sup>2</sup>

# How Much Lead Paint Is Left?

- 7.5 billion square feet interior
- 29.2 billion square feet exterior
- Total = **36.7 billion square feet**
- Implications for demolition and lead dust

Source: HUD National Survey of Lead and Allergens, 2000

# Comparison of Baltimore and Chicago Sites

- **Total Structures in Baltimore Site**
  - Over 500 buildings in one area demolished/3 months
  - Typically 3 housing units/bldg
  - Avg age is pre-1910, likely to have lead paint
  - Lead in air, soil, ext. settled dust (wipe) and dustfall
- **Total Structures in Chicago Site**
  - 100 Scattered single family units/one to two days
  - Likely to have lead paint
  - Lead in dustfall, as well as particulate matter, silica, other metals, asbestos)

# Summary of Baltimore and Chicago Demolition

	<b>Housing Type</b>	<b>Decon- struction</b>	<b>Water Use</b>	<b>Contain- ment</b>
<b>EBDI</b>	Multiple Row Homes	Some	2-4 fire hoses	Jersey Barrier/ Covered Fencing
<b>Chicago</b>	Single Family Detached	None	None or irregular – 1hose	6 foot fence

# Chicago



# Chicago



# Chicago (no dust suppression or site containment)



# Chicago

(limited dust suppression)



# Debris Removal Chicago (no dust suppression)



# Chicago (note observer)



# # of demolitions occurring in Chicago

- Between 1996 and 2003, 12,236 demo permits issued: average of 1529/year
- In 2006, 4,500 demo permits issued for single-family homes and duplexes

McMillen, Daniel P., *Teardowns: Costs, Benefits, and Public Policy Land Lines*: July 2006, Volume 18, Number 3.

June 25, 2007 Press release from Urban Habitat Chicago,  
[www.urbanhabitatchicago.org/projects/deconstruction-advocacy/UHC-deconstruction-press-rel.pdf](http://www.urbanhabitatchicago.org/projects/deconstruction-advocacy/UHC-deconstruction-press-rel.pdf) and Delta Institute publication *Gaining Ground*, Vol 4, No 1, March 2009,  
<http://www.delta-institute.org/enewsletter/volume4/issue1/GainingGround4.1.2.php>  
accessed 4/24/09

# Baltimore 2006 EBDI Site



## Operations Protocol

*Operations Protocol for Salvage, Deconstruction, Demolition and Site Preparation Activities*

# **EBDI Demolition Protocols (1)**

- Roles & Training in Lead Safe Work Practices
- Designation of Full Time Dust Suppression Manager
- Salvage and Deconstruction
- Community Organization Meetings & Notification
- Independent Advisory Panel
- Walk-off mats and HEPA vacuums for nearby residents
- Demolition, Debris Removal, Transport
- Landscaping, greening of lots, street and sidewalk cleaning
- Environmental Monitoring & Reporting

# EBDI Demolition Protocols (2)

- Jersey Barriers
- Fencing with Poly
- Sediment control
- Fire Hoses
  - At least 2 hoses during active demolition
    - one above, one below
  - 1 hose used on debris when equipment is moving over it
  - 4 hoses on many occasions to reduce dust
- Deconstruction & salvage if feasible given structural soundness of buildings

# EBDI Project Area



# Dust Fall Measurement ( $\mu\text{g Pb}/\text{m}^2/\text{hr}$ ) (APHA Method 502)



# Study Description (continued)

- Compile weather information
- In subset of 20 sites, we sampled duplicates for particle size distribution, silica, asbestos, 39 metals with ICP-MS.



# Jersey Barriers and Fencing Baltimore



Photo 16: Image taken at the 1700 block of E. Eager Street and 1000 block of McDonough Street intersection. View from south to the north.

# Typical Chicago Sample locations

Demo background  
> ¼ mile away



# Community Involvement

- This study included both environmental data collection and interaction with community residents.
- In Chicago, staff from the Metropolitan Tenants Organization (MTO) interviewed community residents.
- In Baltimore, numerous community meetings to provide results

# Lead Dustfall (as modified by Farfel et al.)



# Data Collected in Both Cities

Variable	Chicago	Baltimore
Rain in 24 hours prior to demolition	X	X
Relative Humidity	X	X
Temperature	X	X
Pressure	X	X
Wind Speed	X	
Wind Direction	X	X
Use of a Hose	X	X
Presence of a Fence	X	X
Type of Demolition Activity	X	x
Type of Building Material	X	No variability (brick row homes)
Number of Elevations	X	No variability (3 stories)
Number of Dwellings	X	No variability
GPS Positions for Each Sample and for Unit	X	Fixed site locations
Type of Street	X	
Demolition Equipment used	X	x

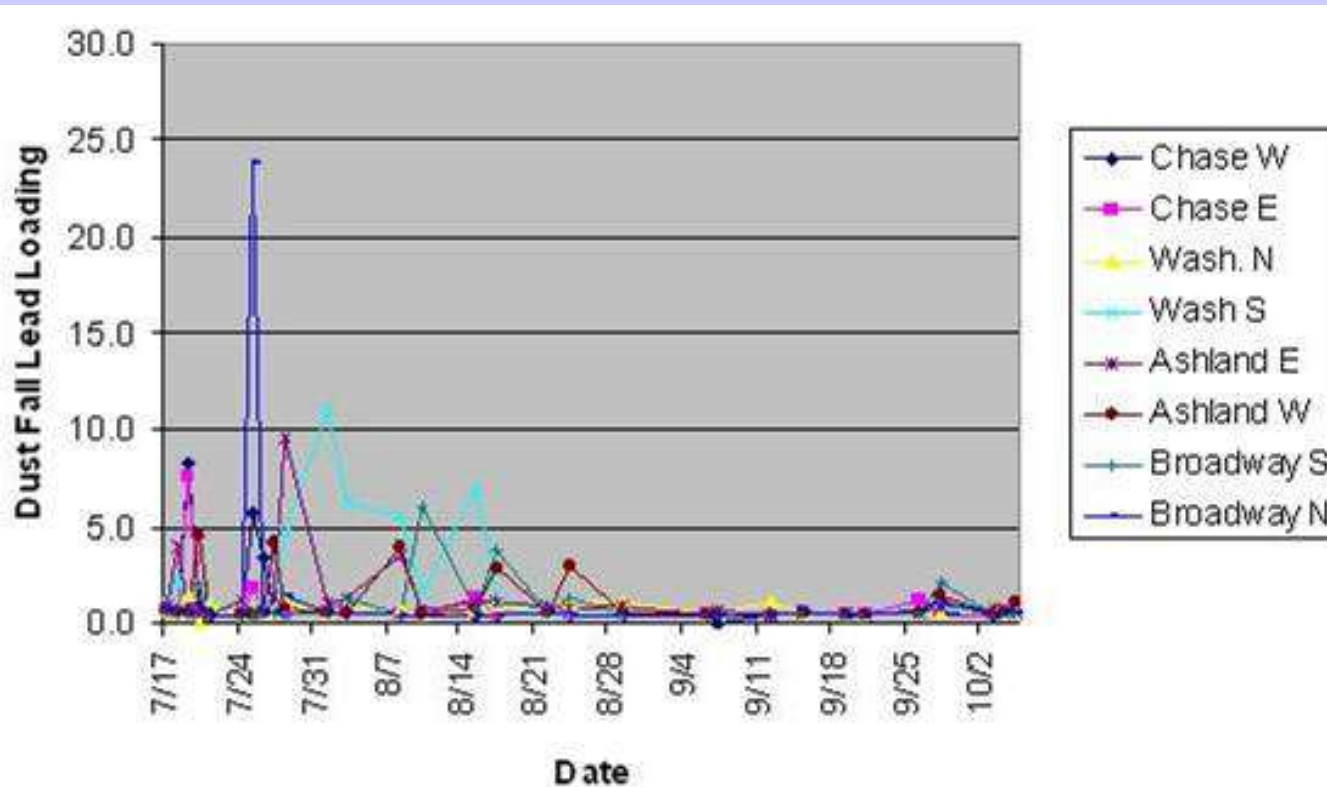
# Baltimore Results - 1

<b>Media</b>	<b>No. Samples</b>	<b>Geometric Mean</b>	<b>95% CI</b>	<b>Federal Standard</b>
Airborne Lead During Demolition ( $\mu\text{g}/\text{m}^3$ )	239	<1.0 (all samples below detection)	--	1.5 (quarterly average)
Soil Lead Before Demolition ( $\mu\text{g}/\text{g}$ )	16 (matched)	449	(294, 686)	400 (play areas) 1200 (yard)
Soil Lead After Demolition ( $\mu\text{g}/\text{g}$ )	16 (matched)	166	(102, 269)	400 (play areas) 1200 (yard)

# Baltimore Results - 2

<b>Media</b>	<b>n</b>	<b>GM</b>	<b>95% CI</b>	<b>Fed Guidance</b>
<b>Settled PbD Before Demolition</b>	12	74 $\mu\text{g} / \text{ft}^2$	(24, 233)	800  (troughs)
<b>Exterior Settled PbD After Demo &amp; Cleaning</b>	12	44 $\mu\text{g} / \text{ft}^2$	(21, 90)	800  (troughs)
<b>Ambient Dustfall Pb (1 mile away)</b>	36	<5.71 $\mu\text{g} / \text{m}^2 / \text{hr}$	---	None
<b>Demolition Dustfall Pb</b>	238	7.64 $\mu\text{g} / \text{m}^2 / \text{hr}$	<5, 257	None

# Lead in Dust Fall by Date and Sampling Site (Baltimore)



- Peak of 23.85  $\mu\text{g}/\text{m}^2/\text{hr}$  observed at Broadway North during a day when several houses collapsed.

# Chicago Results

## Lead Dustfall

Measure	Type of Sample	N	GM	GSD	Min	Max	% below DL
Lead Dust Fall ( $\mu\text{g}/\text{ft}^2/\text{hr}$ )	Perimeter	261	6.23	8.79	0.0927	2,974.06	5.4
Lead Dust Fall ( $\mu\text{g}/\text{ft}^2/\text{hr}$ )	Non-Perimeter	158	2.13	8.37	0.0924	2,588.92	13.3
Lead Dust Fall ( $\mu\text{g}/\text{ft}^2/\text{hr}$ )	Street-level background at demo	44	0.33	3.12	0.0922	13.92	38.6
Lead Dust Fall ( $\mu\text{g}/\text{ft}^2/\text{hr}$ )	Street-level background non-demo	28	0.18	3.46	0.0231	4.20	21.4
Lead Dust Fall ( $\mu\text{g}/\text{ft}^2/\text{hr}$ )	Rooftop background non-demo	36	0.09	2.43	0.0229	0.67	30.6

# Chicago Results (% Lead in Dustfall)

Measure	Type of Sample	N	GM	GSD	Min	Max	% below DL
% Lead in Dust	Perimeter	258	0.28	5.95	0.0004	15.71	5.0
% Lead in Dust	Non-Perimeter	155	0.19	4.82	0.0005	8.00	12.9
% Lead in Dust	Street-level background at demo	43	0.05	8.94	0.0003	4.30	39.5
% Lead in Dust	Street-level background non-demo	28	0.13	3.52	0.0088	4.27	21.4
% Lead in Dust	Rooftop background non-demo	34	0.03	3.26	0.0021	0.19	26.5

# Chicago Variables Associated with Lead Dustfall ( $p < 0.05$ )

- Painted primary exterior surface;
- Presence of a garage to demolish;
- Whether a water hose was present for dust suppression;
- Whether the housing was primarily residential vs mixed commercial and residential; and,
- Whether the samples were downwind of the demolition site

# Non-Significant Variables

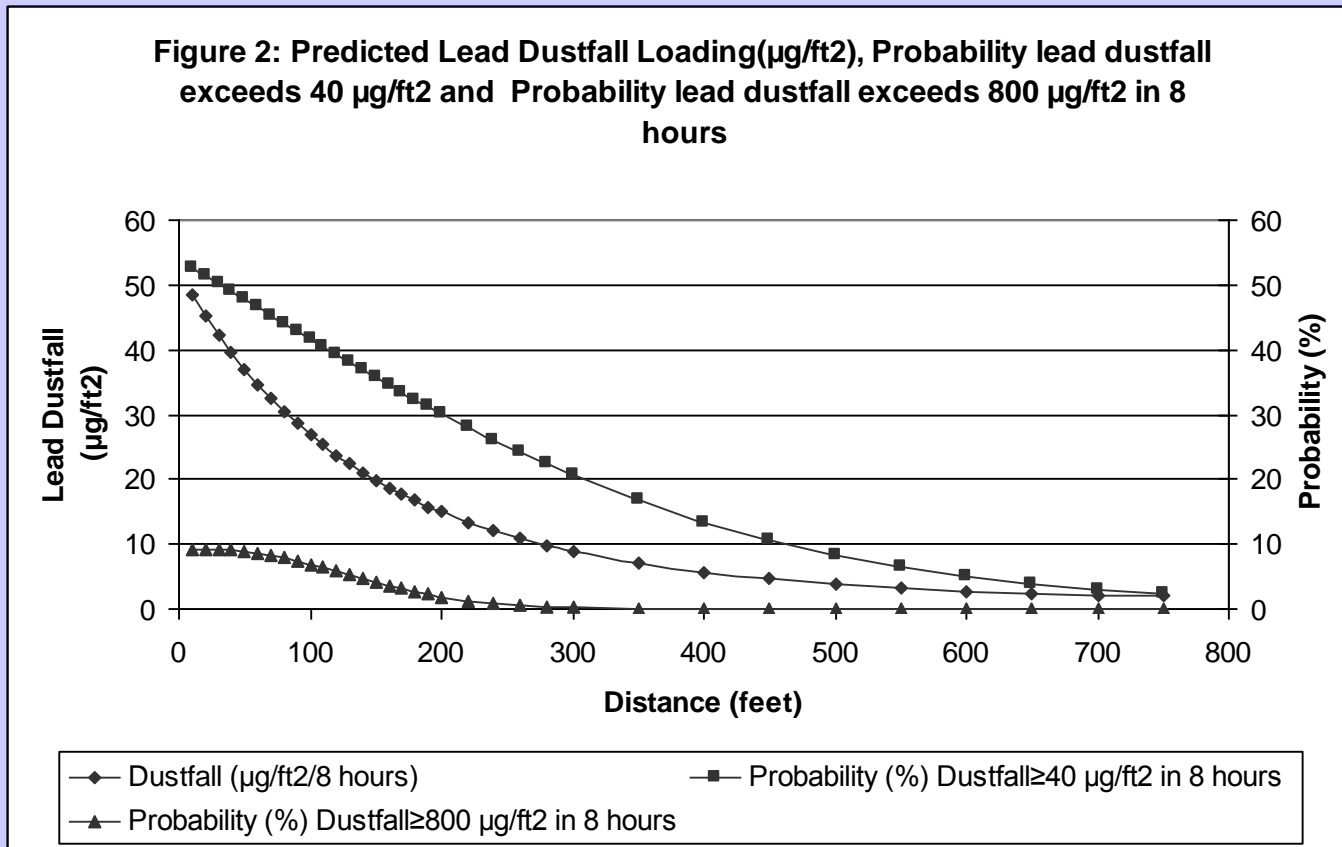
- Whether the secondary exterior surface was painted;
- Whether the exterior was brick or stone;
- Whether the day's activity consisted primarily of razing the building vs debris removal;
- Whether a fence was present;
- Whether the ground was saturated and whether the demolition was on a main street or a side street.

# **Dustfall Reliability**

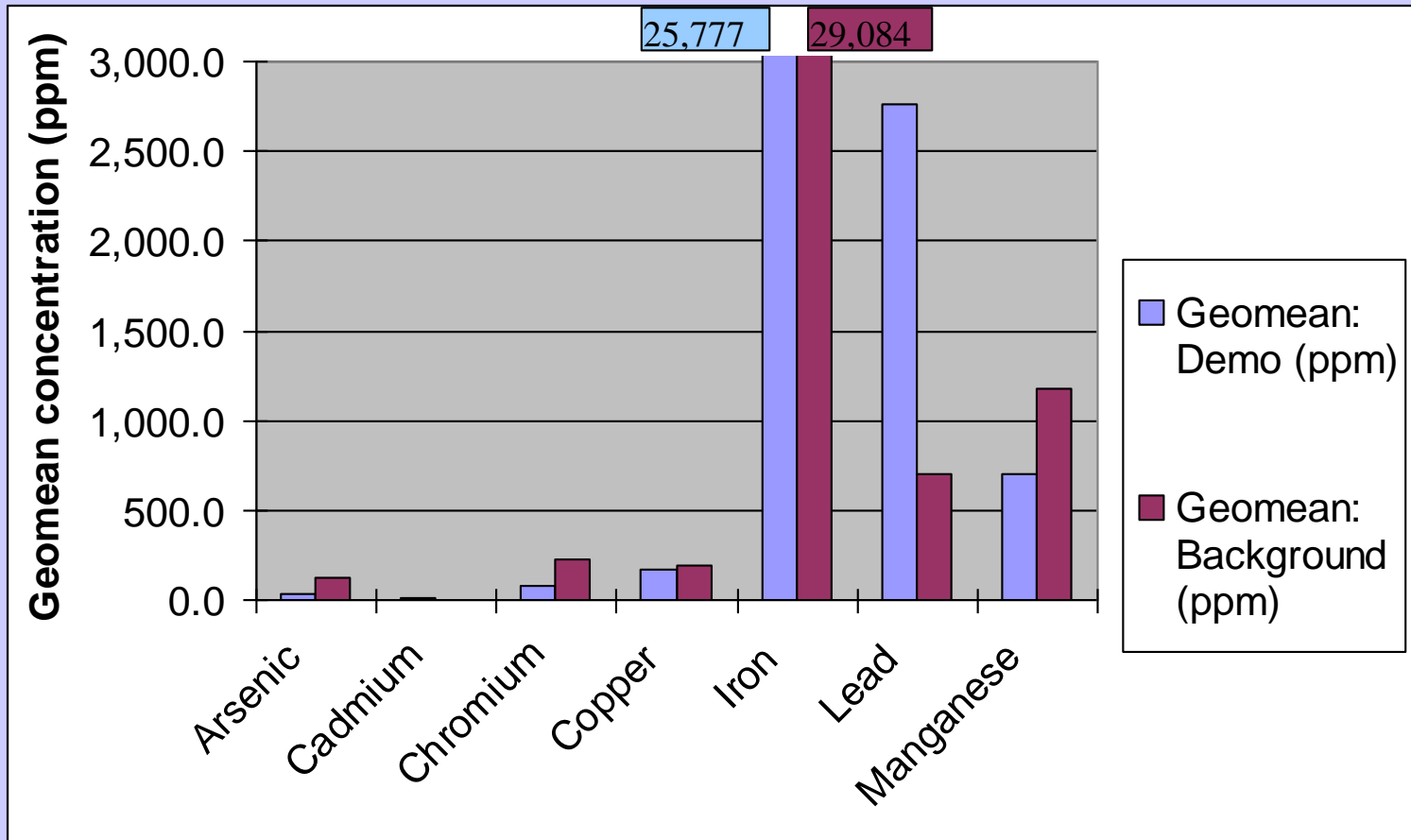
## **Assessed with Side-By-Side Duplicates**

- Reliability is the degree to which a measurement can be replicated
- Values range from 0 (worst) to 1 (best).
- Reliability for lead dust fall = 0.96.
- However, the reliability for total dustfall and percent lead in dust are much lower (0.81 and 0.59, respectively).

# Probability of Exceeding Interior Floor PbD ( $40 \mu\text{g}/\text{ft}^2$ ) and Exterior PbD Guidance ( $800 \mu\text{g}/\text{ft}^2$ ) After 8 hrs



# Comparison of Lead & Other Metals (Dustfall)



# Comparison of Baltimore and Chicago Pb Dustfall & Percent

Measure	Site	N	% Below DL	GM	GSD	25 <sup>th</sup> percent-ile	50 <sup>th</sup> percent-ile	75 <sup>th</sup> percent-ile
Lead Dustfall (µg/ft <sup>2</sup> /hr)	Baltimore	238	66%	0.25	3.57	1.28	2.01	4.49
	Chicago	261	5%	6.01	4.47	2.76	9.48	35.98
Percent Lead (%)	Baltimore	226	65%	0.25	3.54	0.23	1.21	2.85
	Chicago	258	5%	5.94	4.49	0.17	0.47	1.41

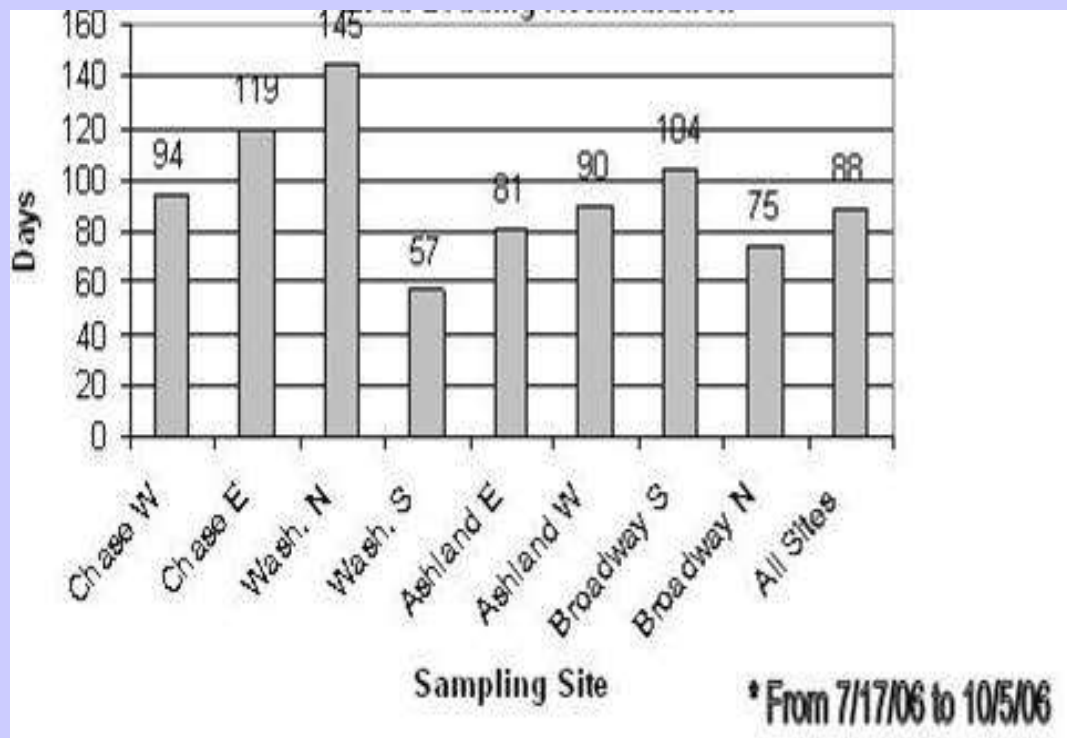
# Background Lead Dustfall About Twice as High in Chicago

Site	N	% Below DL	GM	GSD	25 <sup>th</sup> percentile	50 <sup>th</sup> percentile	75 <sup>th</sup> percentile
Baltimore	36	97%	0.34	1.55	-	-	-
Chicago	28	21%	0.15	3.22	0.11	0.31	0.50

# Exterior Pb Dustfall Standard?

- Currently does not exist
- Existing exterior dust lead cleanup standard from US Dept of Housing & Urban Development =  
800 ug/ft<sup>2</sup>
- Assume 1 hour = 8,600 ug Pb/m<sup>2</sup>/hr
- Assume no loss to wind, rain, re-entrainment
- Estimate number of days of demolition that would be required to exceed the HUD guideline

# Days of Demolition for Dust Fall Lead Loading to Reach HUD Standard (Baltimore)



- For Chase West it would take 94 days of full time eight hour a day demolition to reach  $800 \mu\text{g}/\text{ft}^2$
- For Broadway North it would take 75 days of continuous demolition eight hours per day to exceed  $800 \mu\text{g}/\text{ft}^2$

# Days of Demolition for Dust Fall Lead Loading to Reach HUD Guidance Level (800 ug/ft<sup>2</sup>) in Chicago

- Max dustfall lead = 32,000 ug Pb/m<sup>2</sup>/hr
- 1 hour std = 8,600 ug Pb/m<sup>2</sup>/hr
- Standard would be exceeded in only **16 minutes** of demolition activity
- Occupied houses in Chicago are within 3-5 meters of demolition



- **Calling for a Global Ban on Lead Use in Residential Indoor and Outdoor Paints, Children's Products, and All Nonessential Uses in Consumer Products**
- **Policy Date: 11/5/2007**  
**Policy Number: LB-07-01**

# Future Challenges

- Non-essential uses of lead continue to proliferate
- Primary Prevention is essential, but reactive approach still dominates
- Recalls are ineffective
- Need to address both legacy sources and emerging exposures

# Recommendations

- Notification- Everyone within 400 feet of a single family housing demolition should be notified, not just the immediate neighbors.
- The notification should include expected dates of the demolition and information on lead poisoning and things that residents can do to ameliorate the impact of the lead dust on their families.
- Post a sign on the property starting the day before the demolition. The sign should inform passer-bys of the demolition.
- Special consideration for child-care facilities, parks and schools.
- Increase use of water to suppress the dust
- Standards should be set to ensure that dust suppression with adequate water is being used.
- Following demolition, streets and sidewalks should be cleaned.

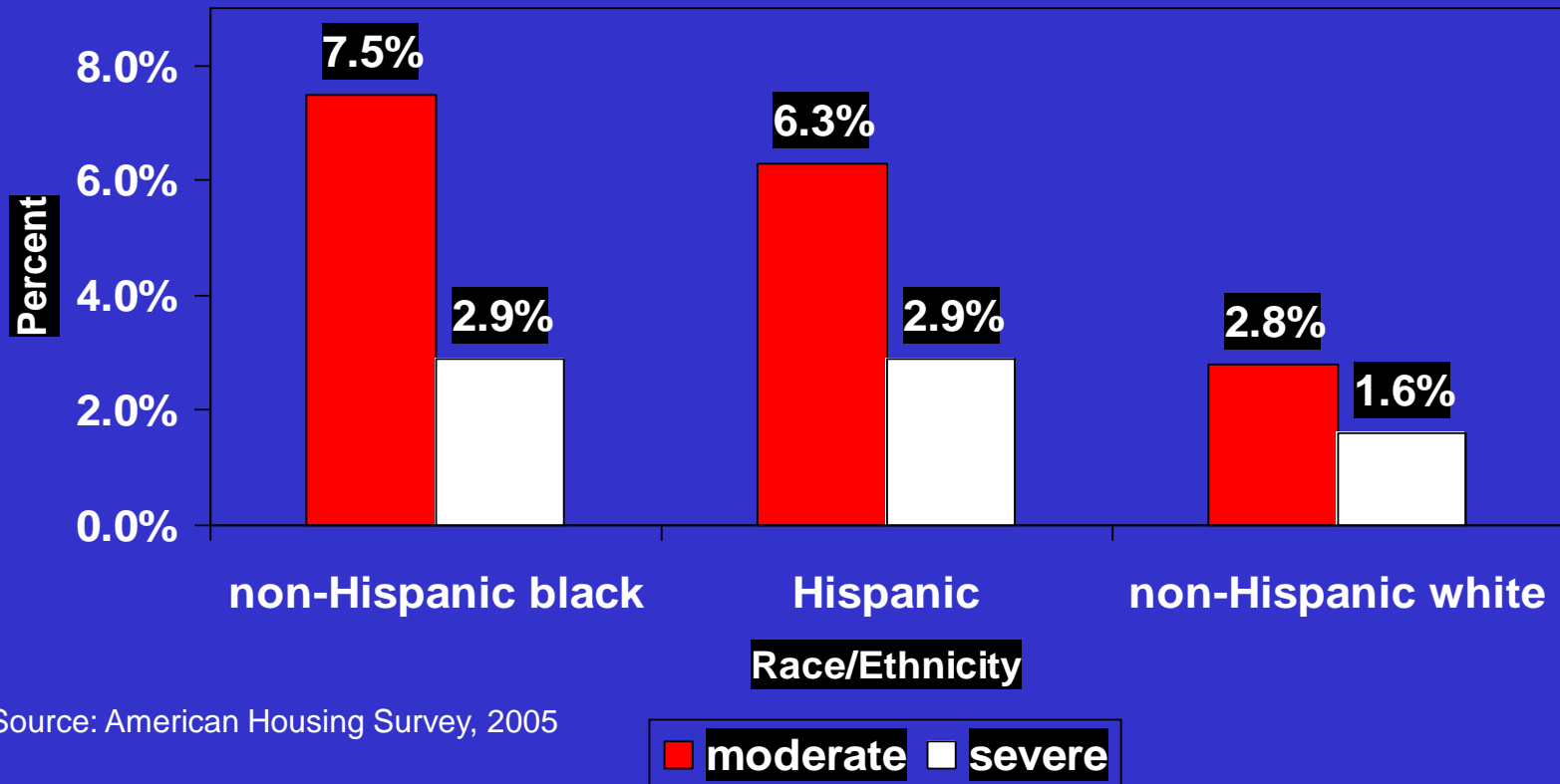
# Conclusions

- Large amounts of lead-contaminated dust are generated from housing demolition
- It can be controlled using simple dust suppression to protect the public health.
- Dustfall lead loadings were significantly higher in Chicago than Baltimore.
- Although Baltimore was a bigger demolition project, more extensive dust suppression techniques were effective.

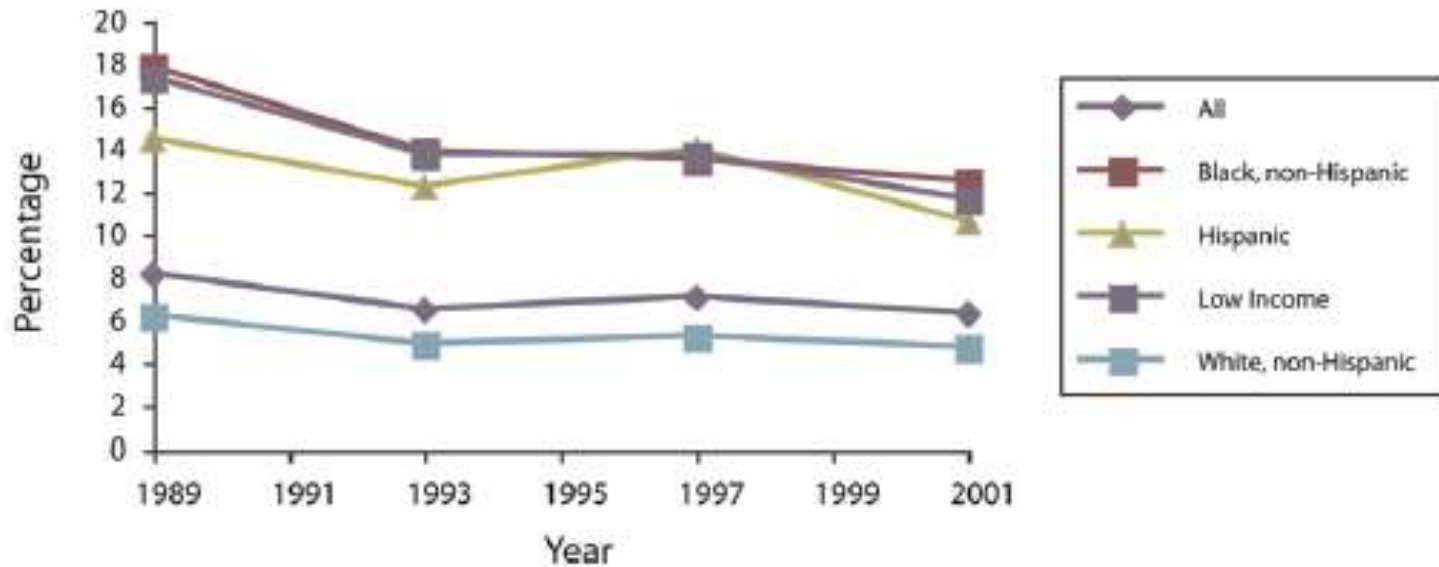
# Conclusion

- The Lead Experience:
- One of the Best Public Health Success Stories, but
- Primary Prevention Remains a Large Challenge
- Dust from Housing Demolition Requires Control

# Race/Ethnicity and Substandard Housing



Source: American Housing Survey, 2005



**FIGURE 4—Percentage of housing with severe or moderate physical problems by race, ethnicity, and income: American Housing Survey, 1989–2001.**

**Jacobs DE, 2011. Environmental Health Disparities in Housing. Am J Public Health. E-pub May 5, 2011**

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# **Opening the Window: A Study of the Effectiveness of Window Replacement for Lead Hazard Control**

National Healthy Homes Conference  
June 20, 2011

Jonathan Wilson  
Deputy Director



## The Issue:

# Should Agencies Advocate for Window Replacement?

- Windows have the highest levels of interior lead based paint
- Window paint is prone to more deterioration
- Window replacement is a costly treatment
- Energy programs consider it more cost-effective to repair windows



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## The Question:

Twelve (12) years after lead hazard control, are dust lead levels in dwellings with windows replaced lower than dwellings without windows replaced, after controlling for other factors that influence dust lead?





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## The Design:

- Original sampling plan
  - Study sites: Chicago, Cleveland, Minnesota, and Vermont (2008-2009)
  - 240 units that had lead hazard control between 1995-1997
  - All units had baseline dust samples
  - ½ - Replacement (3+); ½ Non-replaced
  - Non-replaced windows were lead-safe at clearance (primarily stabilized, limited number stripped or with vinyl enclosures)



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## 12 Yr Data Collection Plan:



Vermont

- Visual assessment of building condition and paint condition
- Dust lead wipes from floors (exterior, entry and interior), window sills, and troughs
- Soil tests from perimeter and play area
- Brief questionnaire of use and cleaning



## Study Population:

- 189 units deemed eligible (of 200 sampled)
- 124 buildings (primarily small rentals)
- By treatment:
  - All replaced: 77
  - Partial: 32
  - < 3 replaced: 80
- By site:
  - Chicago: 38
  - Cleveland: 36
  - Minnesota: 43
  - Vermont: 72



Minneapolis



## Demographics:

- **Building Age:**
  - Pre-1910: 53%
  - 1910-19: 20%
  - 1920-69: 27%
- **Exterior**
  - Masonry: 37%
  - Wood: 34%
  - Other: 29%
- **Income:**
  - < \$20K: 64%
  - \$20-<30K: 17%
  - \$30K+: 19%



Cleveland



# Summary Statistics:

DUST LEAD	Floors				Window Sills			
	Non-Replace		All Replace		Non-Replace		All Replace	
Phase	N	GM ( $\mu\text{g}/\text{ft}^2$ )	N	GM ( $\mu\text{g}/\text{ft}^2$ )	N	GM ( $\mu\text{g}/\text{ft}^2$ )	N	GM ( $\mu\text{g}/\text{ft}^2$ )
Baseline	80	21.2	77	19.3	80	328	76	152
Clearance	74	10.8	77	8.2	73	30	76	14
6-Months	69	10.3	69	6.5	68	91	68	38
1-Year	70	9.1	71	5.4	69	86	70	39
2-Years*	28	11.1	13	2.8	28	64	13	43
3-Years*	23	9.5	12	1.5	23	59	12	30
6-Years*	30	3.5	17	1.8	30	47	17	24
12-Years	80	1.7	77	2.2	80	54	76	16



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## The Statistical Test:

After controlling for confounders, does the effect of window treatment vary by post-intervention phase? If not, is there a significant ( $p < 0.05$ ) effect of window treatment on dust lead levels (floor and sills)?



Cleveland



# Basic Results:

1. Effects do not vary by phase
2. Dust lead significantly different (lower) at window replacement units than non-replacement units

Figure 1: Adjusted geometric mean floor dust lead loading by window replacement group from pre-intervention to 12-years post-intervention

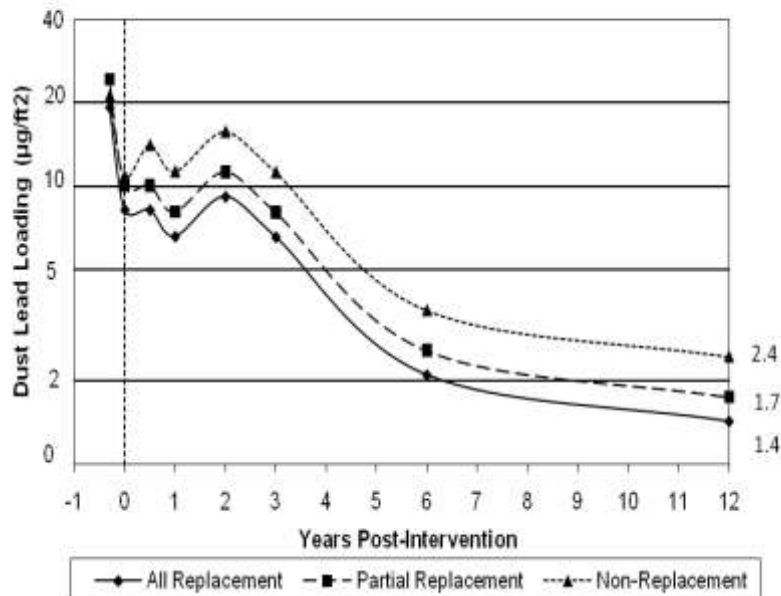
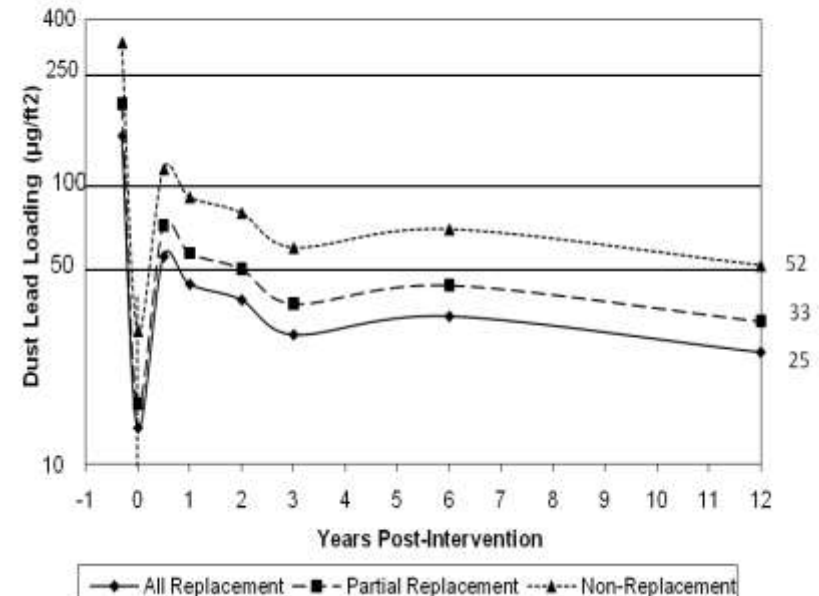


Figure 2: Adjusted geometric mean sill dust lead loading by window replacement group from pre-intervention to 12-years post-intervention





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## Key Findings:



Chicago

- Floor dust lead 41% *lower* with window replacement than non-replacement
- Sill dust lead 51% *lower* with window replacement than non-replacement



# Confounders:

## Floors

- Painted/ Non-carpeted
- Poorer floor condition
- Clearance floor dust
- 12 Yr exterior entry dust
- No exterior LHC work
- Exterior bldg deterioration
- Neighborhood pt source
- Season (Summer)
- Chicago/Cleveland/Minn

## Sills

- Poorer sill condition
- Baseline sill dust
- 12 Yr exterior entry dust
- Roof/gutter deterioration
- Single-family homes\*
- Season (Summer)
- Chicago/Cleveland



# The Site Effect:

<b>DUST LEAD (12Years)*</b>	<b>Floors</b>		<b>Window Sills</b>	
	Non-Replace	All Replace	Non- Replace	All Replace
<b>Site</b>	<b>GM (<math>\mu\text{g}/\text{ft}^2</math>)</b>		<b>GM (<math>\mu\text{g}/\text{ft}^2</math>)</b>	
Chicago	9.0	5.3	129	63
Cleveland	3.7	2.2	71	34
Minnesota	3.2	1.9	52	25
Vermont	1.9	1.1	38	19

\*Model adjusted data



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Chicago

Vermont





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# Costs/Benefits Replacement v. Repair

	Size of Housing Unit		
	800 ft <sup>2</sup> Attached 7 Windows	1200 ft <sup>2</sup> Detached 10 Windows	1800 ft <sup>2</sup> Detached 16 Windows
Net Window Replacement Cost	(\$1,953)	(\$2,790)	(\$4,464)
Lifetime Earnings Benefits per unit <sup>1</sup>	\$1,671	\$1,671	\$1,671
Appearance Value	\$700	\$1,000	\$1600
Energy Efficiency Value	\$1,301	\$1,951	\$3,250
Net Economic Benefit/Unit	\$1,719	\$1,832	\$2,057



## Conclusions Part I:

- Floor and sill dust lead levels were substantially and significantly reduced from baseline to 12 years for all three windows groups
- Geometric mean dust lead levels fell below 3  $\mu\text{g}/\text{ft}^2$  on floors and 50  $\mu\text{g}/\text{ft}^2$  on window sills for the majority of homes at 12 years
- The treatments carried out by original grantees in the LHC Grant program have been effective for at least 12 years



## Conclusions Part II:

- Multiple factors influence post-treatment dust lead levels including exterior dust lead, neighborhood point sources, building condition, and an undefined local effect as well as the level of window treatment
- Any community lead hazard control strategy should address all sources including exterior and neighborhood sources
- Window replacement alone may not eliminate all lead-based paint hazards, but complete window replacement is likely to have a significant positive impact especially in high risk communities



## Conclusions Part III:

- Replacement of all windows at a dwelling unit results in significant reductions in long-term dust lead levels when compared to lesser treatments
- Older windows have high levels of interior lead based paint and are sources of energy loss
- The financial benefits of complete replacement for a dwelling (resident/owner) exceed the costs
- Public and private sector initiatives are needed to promote window replacement to achieve such benefits



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# Questions

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