

Association between children's blood lead levels, lead service lines, and water disinfection, Washington, DC, 1998 - 2006

**MJ Brown, J Raymond, D. Homa, C. Kennedy, T. Sinks.
Environmental Research**

Centers for Disease Control and Prevention



Background

- 11/2000 – 6/2004: chloramine was used to disinfect DC drinking water – one of several factors leading to elevated Pb in drinking water.
- From 2001 into 2004: DC water system was out of compliance with the EPA LCR.
- 2/16 /2004: DC requested help from CDC.
- 2/26/2004: CDC & DC issued an alert
 - To prevent young children and pregnant/breast feeding women from drinking unfiltered tap water
 - To distribute water filters
 - To increase opportunities for blood lead level (BLL) testing.



Study Objectives

- Evaluate the effect of changes in water disinfection and presence of lead service lines (LSLs), on children's blood lead levels (BLLs) in Washington, DC.
- Specifically –
 - Did the presence of a lead service line impact a child's BLL during periods of time when 3 different strategies were used to disinfect D.C. drinking water?
 - January 1, 1998 – October 21, 2000: **chlorine**
 - November 1, 2000 – June 30, 2004: **chloramine alone**
 - July 1, 2004 - December 31, 2006: **chloramine + orthophosphate**
 - Did LSL replacement impact a child's BLL?



Data

- Childhood BLLs – D.C. CLPPP blood lead surveillance system of lab-based reporting.
 - Screening guidelines – all children should be screened at 12 & 24 mos. Screen children 13 to 72 months if not previously screened.
 - In DC in 2005: 14,477 eligible children were tested (~ 37% 0 to 72 months).
 - DC required **all** BLL tests be reported beginning in 2002.
- Lead Service Lines (LSLs)
 - 26,155 homes presumed by WASA
 - +/- adjustments for information about LSL replacement program.
 - 14,121 homes with partial or full LSL replacement

* ~ 12,000 missing 2003 BLL tests were identified in 2009.



Data Sources

- BLL test data:
 - Type of test (capillary or venous).
 - Multiple BLL tests/child to single BLL/child [67,831 children]
 - De-duplication
 - Eligibility criteria: age / valid DC address [63,854 children]
- Tax assessor data – age of housing
 - Pre-1950 / 1950 – 1978 / post-1978 [37,322 homes]



Analysis

- Association between LSL and BLL
 - Logistic regression (LR) to compute odds ratios for BLL quartiles
 - LR odds of a BLL 10+ (not shown)
 - Controlled for age of housing
 - Separate models for each disinfection period
- Association between lead service line replacement and BLL
 - LR to compute odds ratios for BLL (<5 ug.dL, 5 – 9 ug/dL, 10+ug/dL)
 - No LSL vs partial LSLR
 - LSL vs partial LSLR
 - Insufficient number of homes with total LSLR



Analytic Data Set

Characteristic	Valid address (n=63,854)	No valid address (n=3977)
BLL < 5 ug/dL	51, 592 (80.8%)	3, 321 (83.5%)
5-9 ug/dL	10, 197 (16.0%)	576 (14.5%)
10+	2, 065 (03.2%)	80 (02.0%)
Housing pre-1950	28, 238 (44.2%)	
1950-1978	7, 651 (12.2%)	
1979+	1, 433 (02.2%)	
unknown	26, 532 (41.6%)	



Analytic Data Set

Characteristic	Address validated (n=63,854)	Not validated (n=3977)
LSL – partial replacement	738 (1.2%)	
full replacement	183 (0.3%)	
not replaced	9,938 (15.6%)	
no LSL	52,995 (83.0%)	
Chlorine	17,509 (27.4%)	1,137 (28.6%)
Chloramine alone	23,837 (37.3%)	2,706 (68.0%)
Chloramine + OP	22,508 (35.3%)	134 (03.4%)



Odds Ratios (with 95% CI) for having a LSL by BLL quartiles

BLL quartile cut points (ug/dL)	Chlorine (1/1/1998 – 10/31/2000)	Chloramine (11/1/2000 – 6/30/2004)	Chloramine + orthophosphate 7/1/2004 – 12/31/2006)
< LOD	1.0	1.0	1.0
2 to < 3ug/dL up to 16mos old	1.0 (0.7, 1.3)	1.2 (1.0, 1.3) 1.6 (1.2, 2.0)	1.1 (0.9, 1.2)
3 to < 5ug/dL up to 16mos old	1.1 (0.8, 1.4)	1.6 (1.4, 1.8) 2.2 (1.7, 2.7)	1.3 (1.1, 1.4)
5+ug/dL up to 16mos old	1.4 (1.1, 1.9)	2.5 (2.2, 2.9) 3.6 (2.8, 4.6)	1.7 (1.5, 1.9)

Brown et al, Env Res; 2010 Table 2;. ORs are relative to lowest quartile by disinfection type. Models control for age of housing



Odds Ratios and 95% confidence intervals for BLL categories given partial LSL replacement

BLL	Partial Replacement	No LSL	OR	Partial Replacement	LSL	OR
<5	598	17,025	1.0	598	2,434	1.0
5 to 9	105	1,592	1.9 1.5, 2.3	105	406	1.1 0.8, 1.3
10+	27	236	3.3 2.2, 4.9	27	81	1.4 0.9, 2.1
totals	730	18,857		730	2,921	

Brown et al. Env Res: Table 3. Data are limited to 7/1/2004 – 12/31/2006;
 On left side partial lead pipe replacement is compared to never having a LSL.
 On the right side, partial lead pipe replacement is compared to always having
 A lead service line.



Days Since Lead Service Line Replacement

Blood Lead Level and n (ug/dL)	Mean days
<5 n=769	323
5 through 9 n=120	344
10+ n=32	307



Strengths

- Lab based reports of BLL for 63,854 children
- Comparison of LSL vs no-LSL controls for temporal trend in declining BLL in DC.
- Age of housing a surrogate for leaded paint hazard
- 1338 homes reclassified as +LSL
- Evaluated the impact of 12,168 missing lab test results from 2003.



Limitations

- No individual information:
 - water consumption
 - household water treatment
 - [Pb] in homes.
- Single measure:
 - exposure (LSL or PR-LSL)
 - effect (BLL).
- Cannot evaluate:
 - x-sectional data – neither immediate/short term or chronic/long term impact
 - total LSL Replacement.
- Misclassification of LSL
- BLL surveillance data are incomplete



Conclusions

- Children in DC homes with LSL had higher BLLs and persisted after controlling for age of housing.
- Association was strongest during *chloramine alone* period and among children up to 16 months of age.
- Partial lead service line replacement did not diminish the association between BLL and LSLs.



Recommendations

- To reduce BLLs – control or eliminate all sources of Pb before exposure occurs.
- Changes in water disinfection practices require careful consideration.
- Residents of properties with LSLs having plumbing work done should use bottled or filtered water until [Pb] in drinking water are below 15 ppb.
- Prompt and effective action by utilities should be taken when out of compliance with the LCR.



Childhood Lead Poisoning Prevention Still More to Do.

- Nigeria
- Multiple sources of exposure
- Lead safe homes for all kids
 - ~ 250K children with BLL10+ ug/dL
 - ~ 750K children with BLL 5 -9 ug/dL
- CDC is reconsidering its *level of concern* 10+ ug/dL

Grinding gold ore
In Nigeria.

