

Toolkit for Establishing Laws to Control the Use of Lead in Paint

Module C.iii

Conducting blood lead prevalence studies

Content in this module was provided by the US Centers for Disease Control and Prevention



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Outline

- Why conduct lead prevalence studies?
- Examples of data that lead prevalence studies can provide
- How to do lead prevalence studies



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Many sources of lead can contribute to blood lead levels

- Gasoline (no longer a major source in most countries)
- Battery recycling
- Consumer products
- Some traditional medicines
- Unregulated or cottage industries
- Electronic waste, child labor
- Localized sources such as mines/smelters
- Lead paint

(Reference 1)



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What can environmental lead sampling tell you?

- Location of areas of lead contamination, enabling mapping of areas of high and low lead concentrations:
 - helps identify source(s) of exposure in population known to have high blood lead levels
 - identifies at-risk populations who should have blood lead levels checked
 - provides populations with measures to reduce or stop exposure
- Data can be used to direct and evaluate remediation efforts
- For information on methods see Module C.iv



Blood lead prevalence studies can link environmental sources to lead exposure

Examples are:

- Lead from paint – USA
- Tracking national prevalence of blood lead from all sources – USA
- Lead from mining in Nigeria
- Negative studies – Puerto Rico

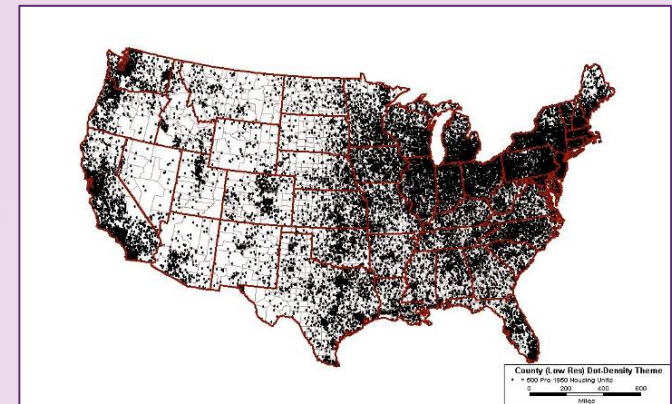


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Lead-based paint in housing - USA

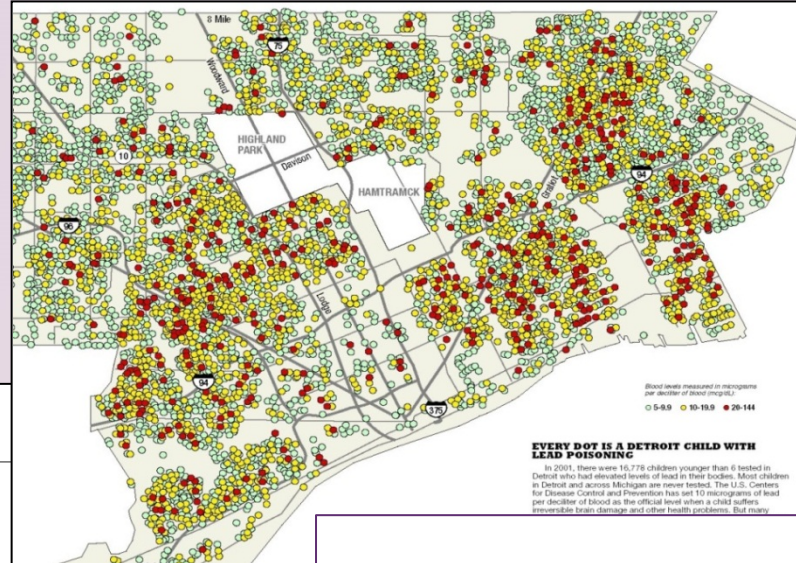
- Nearly 38 million housing units contain lead-based paint
- 23.2 million housing units (25% of the nation's housing) have significant lead-based paint hazards
- 1.1 million homes with significant lead-based paint hazards housed low income families with children under the age of 6

(Reference 2)



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Some prevalence studies in the USA

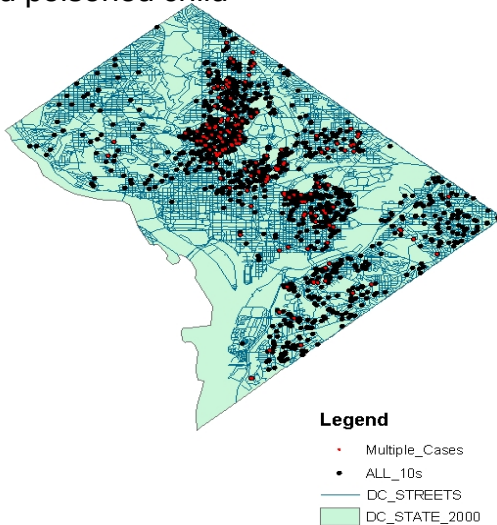


Detroit MI: every dot is a lead poisoned child. Green= 5-9 µg/dL, Yellow dot=10-20µg/dL, Red dot= 22-140µg/dL

(Reference 3)

Washington DC

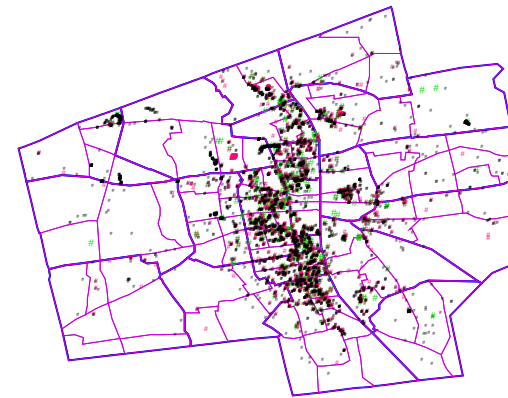
Red dots houses with more than one lead poisoned child



(Reference 4)

Brockton, Mass

Every dot is the address of a lead-poisoned child. Green dot = 1 child; Red dot = 2 children; Black dot = more than 2 children in last 10 years

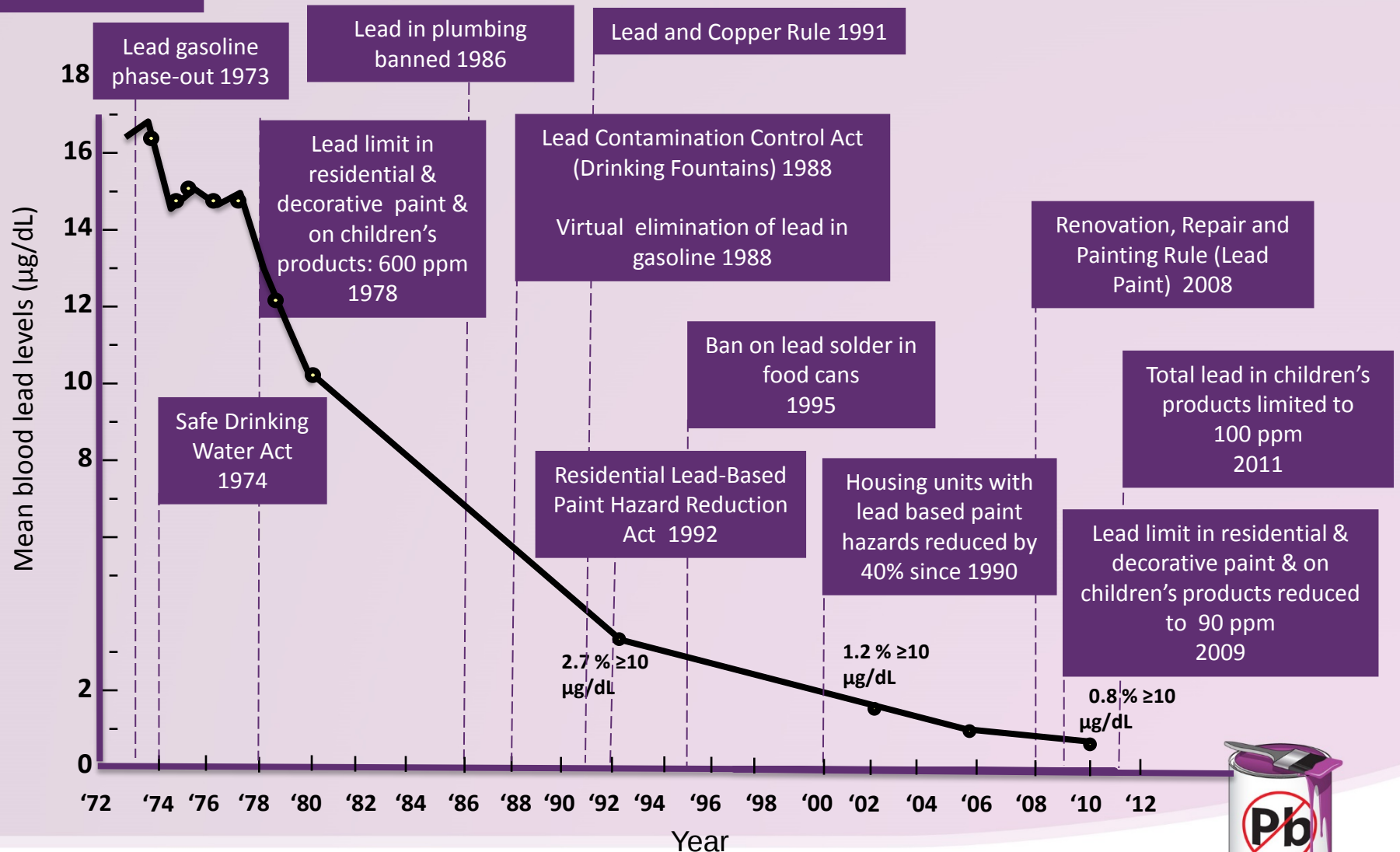


3 0 3 6 Miles



(Reference 4)

Prevalence studies can demonstrate impact of lead poisoning prevention policies (USA)



(Reference 5)



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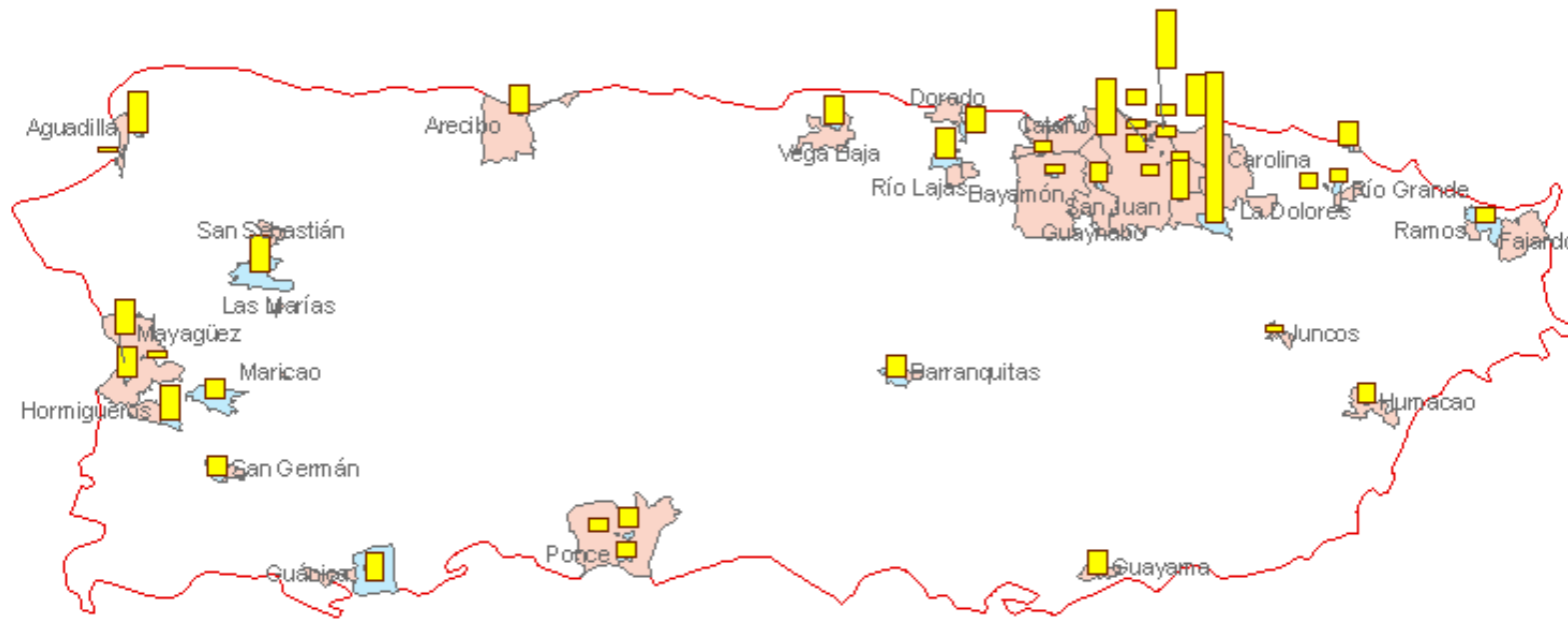
Negative studies

- Must have strong data to demonstrate the absence of a problem
- Need to consider all possible sources of lead when planning the study
- Study design should be powerful enough to have identified a problem if it existed
- Example from Puerto Rico shown in next slides



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Prevalence study sampling areas in Puerto Rico



- Island divided into clusters based on US census block groups (pink and blue)
- Clusters selected with a stratum using probability proportional to estimated population size (yellow block height indicates number of children 0-5 years old)
- Sample of households randomly selected within each cluster so that each household had equal probability of being selected.
- All eligible children in each selected household were enrolled in the study.



Blood lead level results in Puerto Rico

Blood Lead Level (BLL) ($\mu\text{g}/\text{dL}$)	Number of Children Sampled (N=440)	Percent
<5	425	96.6%
5–9	12	2.7%
10–14	2	0.5%
>14	1	0.2%

- Puerto Rico's weighted prevalence of blood lead levels (BLLs) $\geq 10 \mu\text{g}/\text{dL}$ is 1%; BLL $\geq 5 \mu\text{g}/\text{dL}$ is 3.4%

(Reference 7)



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Environmental results in Puerto Rico

Sample type	No. of Households Sampled (N=259)	Range of Results	No. of Households Exceeding Environmental Protection Agency (EPA) Action Level (%)	EPA Action Level
Soil	178	2.2 – 240 ppm	0	400 ppm
Water	257	< 3 – 22 µg /L	3 (1.2)	15 µg /L
Dust Floor Composite	235	< 0.5 – 180 µg/ft ²	1 (0.4)	40 µg/ft ²
Dust Window Composite	230	< 0.5 – 115.2 µg/ft ²	0	250 µg/ft ²



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Conclusions — Puerto Rico

- The prevalence of BLLs ≥ 10 $\mu\text{g/dL}$ among Puerto Rican children aged < 6 years was low (1%) and comparable to the 2007—2010 US national estimate
- Few environmental lead hazards were identified in the households surveyed
- Carefully-designed studies including blood and environmental samples can reliably identify communities with low risk for elevated blood lead levels



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Conducting blood lead prevalence studies related to lead paint

- Having reviewed the utility of blood lead studies, we will now consider the actual conduct of such studies
- Blood lead studies must be conducted in a scientifically rigorous manner to be reliable and of value, both for public health and regulatory actions
- These studies can be complemented by an environmental investigation – see Module C.iv



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Why conduct blood lead prevalence studies to evaluate the role of lead paint?

- Determine if lead paint is contributing to blood lead levels in the population
- Determine the degree and extent to which lead paint is contributing to blood lead levels in the population
- Establish a baseline before preventive action so that impact can be monitored
- Demonstrate efficacy of preventive or regulatory action



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Possible outcomes of blood lead prevalence studies

- Early identification and intervention for children with elevated blood lead levels
- Surveillance to monitor progress toward reduction of blood lead levels and elimination of exposure
- Development and strengthening of partnerships among the agencies responsible for eliminating childhood lead poisoning caused by lead paint exposure
- Research to further improve prevention methods



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Value of local/regional blood lead studies to identify high risk groups

- Inequitable lead exposures exist in many communities
- Developing capacity to respond to cases with elevated BLLs, targeting screening to at-risk subpopulations, and identifying lead “inequitable hotspots” are crucial to primary and secondary prevention efforts
- In the absence of national surveillance data, blood lead prevalence studies are advantageous



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Local/regional blood lead investigations

- Small area prevalence studies to assess blood lead levels are population-based and cross-sectional
- Provide an unbiased estimate of blood lead levels in a given geographic location
- Serve as a tool to understand risk factors for elevated blood lead levels
- Can supplement or complement local blood lead surveillance data and national surveys (e.g. US National Health and Nutrition Examination Survey (NHANES))



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Prevalence study design considerations

- Involve a statistician
- Identify a specific target population/study area
- Review available demographic, census and geographic data
- Determine the necessary sample size



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Prevalence study design considerations

- Adequate response rate
 - Sufficient numbers of participants for stable estimates of lead levels
 - Consider need for appropriate (modest) incentives to participate
- Information about non-responders
 - Determine if results are generalizable to the population of interest
- Field work
 - How best to approach the people you want to reach
 - Seek help of community leaders in planning & implementing study
 - Consider ethnicity & gender of field workers, language & literacy level of study materials



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Prevalence study design considerations

- Blood collection - venous or capillary samples
 - Venous samples need trained phlebotomist but less likely to be contaminated
 - Capillary samples perceived as less painful, do not require same level of training, but more prone to contamination
- Partnerships
 - Local public health unit, university, non-governmental organizations
- Resources for children with high blood lead levels
 - Provide information / training to local clinical and public health care providers on management of lead poisoning
 - Find out about availability of chelation therapy - facilitate provision



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Examples of study objectives

- Obtain an unbiased prevalence estimate of BLLs among children aged 1-5 years living in a specific geographic area
- Obtain a weighted geometric mean BLL, a measure of the BLL distribution (confidence interval or standard deviation) and a weighted prevalence of elevated BLLs (e.g., $\geq 5 \mu\text{g/dL}$ and $\geq 10 \mu\text{g/dL}$)
- Identify risk/protective factors and sources of exposure for lead
- This method is also useful to identify low prevalence areas. In this case, to obtain an unbiased estimate, use the actual result provide by the instrument not an imputation of values below the level of detection



Selection of the study area

- Study area is the geographic area where the study population is recruited and sampled
- A study area proximal to a point source is generally considered to be within 2.7 km of the point source.
- If the study area is quite large, such as a neighborhood, city, county, community, territory or state, a simple random sample is not logistically feasible
- Household is the primary sampling unit
- The study area must be divided into manageable portions, called clusters. A cluster is a group of households within a geographic area (e.g. census tract or block group)



Selection of the study population

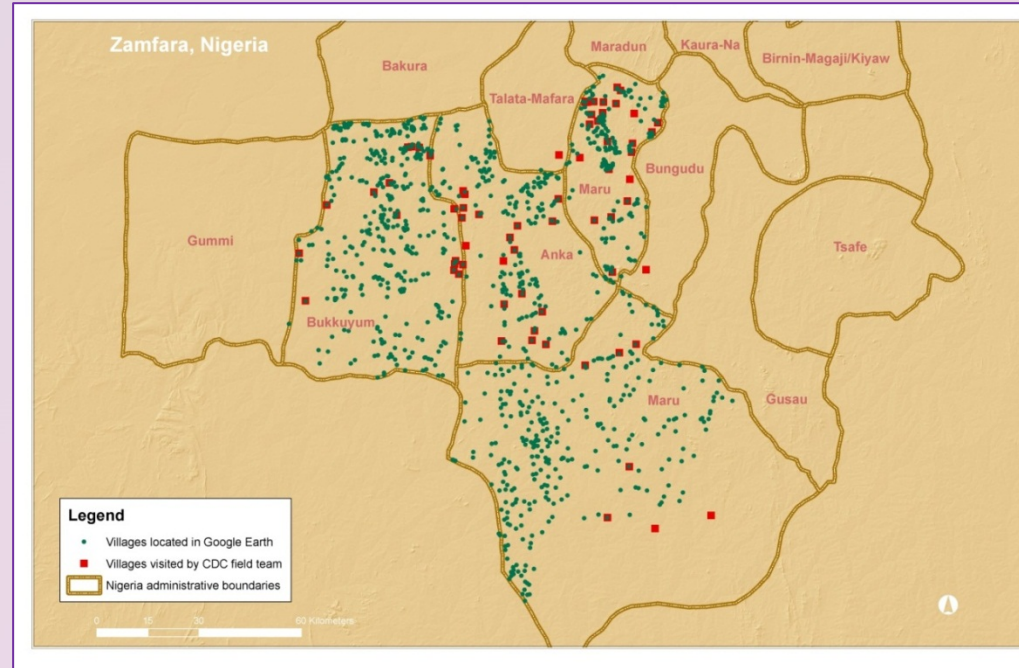
- Defined by, e.g.:
 - age
 - length of time at residence,
 - length of time in an area close to a point source,
 - parental participation in hobby / occupation,
 - member of a particular ethnicity known to frequently use lead containing products (eyeliner, traditional medicines etc.)



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Additional data that can be used

- Census data available
 - Can calculate estimates of the underlying population and create shape files using GIS to map the area at desired level of resolution
- Census data absent
 - Political boundaries
 - Geographic boundaries
 - LandScan® mapping of population distribution
(Reference 8)



LandScan map of 3 local government areas in Zamfara, Nigeria



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Study design considerations: Outline

The next few slides discuss the following design considerations:

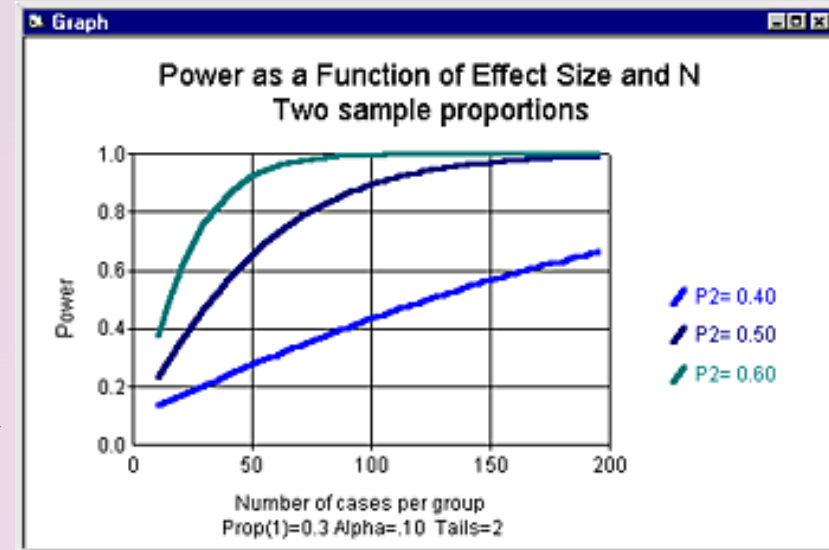
- Sample size
- Sampling methodology
- Response rate
- Data collection and entry



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Sample size and sampling methodology

- Statistical methods for determining number of participants
 - Power calculation
- Eligibility criteria
 - Factors of interest in study e.g. age, occupation
- Number of eligible participants in study area
 - Baseline population estimate
- Response rate
 - How many eligible participants will enroll and complete study?
 - Acceptance by population of interest



Reference 9



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Response rate

- Minimize the questionnaire burden in field to maximize the response rate (e.g. assess need to ask personal questions)
- Use a tracking form to account for all attempted and completed interview outcomes
- Collect information about non-responders to determine their similarity to responders
- Take into account differences between non-responders and responders in the analysis



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Data collection and entry:

Collection

- Paper forms vs. laptop/mobile device – depends on resources available at study area
- Visitation protocol – describes roles and activities of study team
- Maps – these should ideally should be generated at level of households/addresses, used for simple or cluster randomization



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Labels are essential

- Each data source has a corresponding label. It is very important to attach the appropriate label to the correct data source.
- A typical set of labels is as follows:
 - Consent-C
 - Child Questionnaire—CQ
 - Household Questionnaire—HQ
 - Dust Floor—DF-1 (Front Entrance)
 - Dust Floor—DF-1 (Child's Sleeping Area)
 - Dust Window—DW (Child's Sleeping Area)
 - Blood Sample—B
 - Soil—SO
 - Water—W
 - Environmental Sampling Form—ES
 - Extra 1—X1
 - Extra 2—X2



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Data collection and entry:

Data entry

- Can use readily available software to construct data template
 - e.g. Excel, Access, FAST software, GIS software
 - Analyse using free/low cost data analysis software e.g. EpiData or EpiInfo
 - Epiinfo can be downloaded at no cost at [\(http://wwwn.cdc.gov/epiinfo/7/\)](http://wwwn.cdc.gov/epiinfo/7/)
- Important to maintain a data dictionary to record the definitions of the variable labels as the data template is constructed



Field work considerations: Outline

The next few slides discuss the following field-work considerations:

- Study timeframe
- Field team composition, hours of work
- Safety and comfort
- Communicating about lead hazards



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Study timeframe

- Weather
 - Soil samples can be difficult to collect during rainy seasons or when the ground is covered with snow
- Holidays
 - Religious observations such as Ramadan or Christmas may make people less likely to participate in the study
 - Vacation times when many people may be away can also influence enrollment
- Work schedules
 - More families may be home on weekends or early evening if many mothers work



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Field team composition

- Gender
 - In some cultures women cannot be interviewed by men to whom they are not related
- Language
 - Field teams should predominately be composed of staff who speak the language/dialect of the study participants
- Experience
 - Field team leaders and investigators should have some field study experience but not necessarily related to lead



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Safety and comfort

- Clothing
 - Clothing should be business casual and not too revealing
 - Should be appropriate for climate e.g. high or low temperatures, high humidity
 - Consider need for sunscreen, insect repellants
- Universal precautions for sample collection and handling
 - Train all staff – even if not primarily responsible for sample handling
- Security
 - Seek advice about local security concerns
 - Notify local law enforcement as appropriate about locations of field teams



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Opportunity to communicate health education messages, e.g.

- Exposure to lead can seriously harm a child's health. Young children are particularly vulnerable to exposure from lead because of their hand to mouth activity and because they play in garden areas where lead can be in the soil.
- Exposure to lead can cause: damage to the brain and nervous system; slowed growth and development; learning and behavior problems; hearing and speech problems
- Lead can be found throughout a child's environment from the following sources ...
 - If the source is known or strongly suspected that source should be highlighted in the messages, e.g.:
 - How does lead get from the soil into your child?
 - Lead in dirt clings to fingers, toys and other objects that children normally put into their mouths. This is the most common way that lead in soil gets into your child. Lead in soil does not pass through unbroken skin. The more lead that is in your soil, the more harmful the soil can be to your children's health.
- The good news: lead poisoning is preventable.



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Sample collection and analysis considerations: Outline

The next few slides discuss the following sample-related considerations:

- Blood sample collection techniques
- Analytic instruments
- Quality assurance and control
- Reporting results and follow-up



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Blood collection and laboratory methods

- Capillary vs venous samples
- LeadCare II® portable blood lead analyzer uses capillary or venous samples and gives a result within a few minutes
- Bench laboratory methods can cover a wider range of blood lead values but there is usually a wait for the results
- Adequate quality control is essential
- Additional information is provided in Module C.i.



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Examples of analytical equipment



Graphite Furnace Atomic Absorption Spectrophotometry



Inductively Coupled Plasma Mass Spectrometry



LeadCare I



LeadCare II



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Laboratory quality assurance: LAMP

- A voluntary program that focuses on assuring the quality of blood lead, cadmium, and mercury levels.
- Each quarter the CDC provides blood samples which are analyzed by participating laboratories who return the results to CDC
- CDC provides detailed reports on the laboratories about how well they performed these analyses
- No charge for participation (Reference 10)

LAMP



Centers for Disease Control and Prevention (CDC)
Lead and Multi-Element Proficiency
4770 Buford Highway N.E., Mailstop F-18
Atlanta, GA 30341-3724 USA

Fax number: (770) 488-4097
E-mail address: LAMP@cdc.gov

Reporting results

- Parents/guardians

- Explain blood lead test results in person within 72 hours of blood draw including any necessary follow-up
- Environmental samples usually take longer to analyze but also should be reported to parents/guardian as soon as they are available

- Health care provider

- Blood test results should be reported to the health care provider as quickly as possible after notification of parents/guardians
- Very high blood lead levels ($\geq 65 \mu\text{g/dL}$) should be considered an emergency

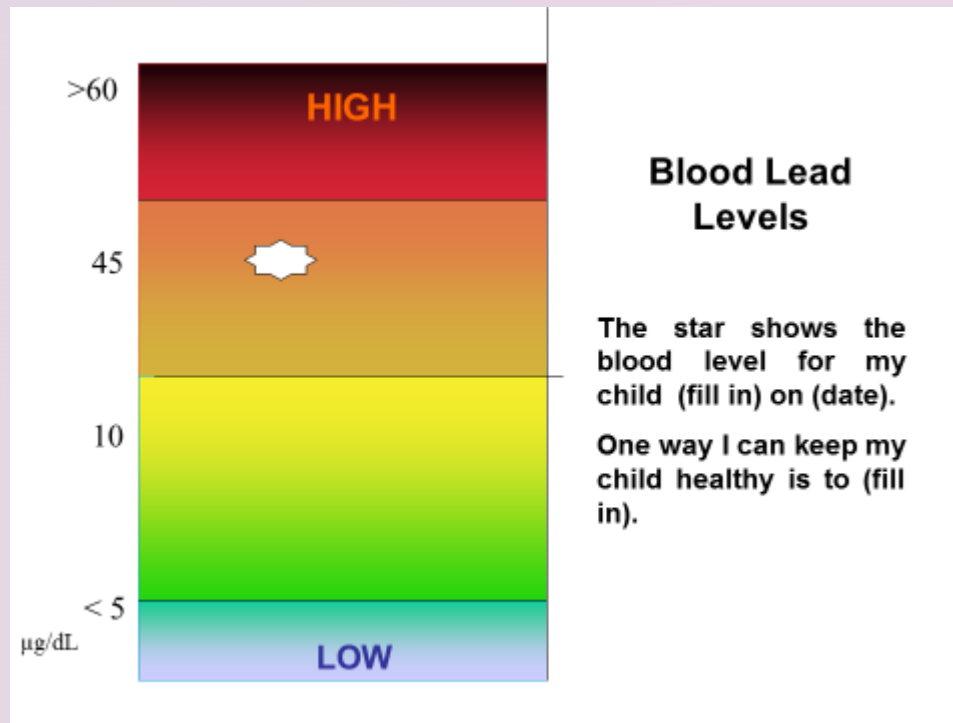
- Confidentiality

- All individualized test results are private and cannot be shared with anyone other than parents or health care providers.



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Reporting results (cont.)



- A form such as this one can be used to graphically explain blood test results. The “star” is moveable so the child’s actual result can be displayed. The form can be modified for use with environmental sample results



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Blood lead follow up

US CDC recommended actions based on BLL (Reference 11)

<Reference Value	≥Reference Value ≤45	≥45 ≤69	≥70
Lead education -Dietary -Environmental	Lead education -Dietary -Environmental	Lead education -Dietary - Environmental	Hospitalize and commence chelation therapy (following confirmatory venous blood lead test) in conjunction with consultation from a medical toxicologist or a pediatric environmental health specialty unit
Environmental assessment* for pre-1978 housing	Follow-up blood lead monitoring	Follow-up blood lead monitoring	Proceed according to actions for 45-69 µg/dL
Follow-up blood lead monitoring (see pages 23 - 24)	Complete history and physical exam Lab work: - Iron status Consider Hemoglobin or hematocrit Environmental investigation Lead hazard reduction Neurodevelopmental monitoring - Abdominal X-ray (if particulate lead ingestion is suspected) with bowel decontamination if indicated	Complete history and physical exam Lab work: -Hemoglobin or hematocrit -Iron status -Free erythrocyte protoporphyrin Environmental investigation Lead hazard reduction Neurodevelopmental monitoring Abdominal X-ray with bowel decontamination if indicated Oral Chelation therapy Consider hospitalization if lead-safe environment cannot be assured	

The scope of an "environmental assessment" will vary based on local resources and site conditions. However, this would include at a minimum a visual assessment of paint and housing conditions, but may also include testing of paint, soil, dust, water and other lead sources discussed previously. This may also include looking for exposure from imported cosmetics, pottery, food, toys, etc. which may be more important with low level lead exposure.



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Risk vs benefit of participating in a prevalence study

- There is minimal risk from blood draw
- Parents/guardians benefit by being informed of their child's blood lead status
- Knowing that a blood lead level is high can then trigger other services e.g. education, environmental assessment, medical treatment and follow up, & social services
- Data from studies can inform policy decisions to control or eliminate lead in children's environment



Other study benefits

- Opportunity to incorporate other public health topics of interest such as immunization status, housing conditions or nutritional assessment to the blood lead prevalence survey
- Opportunity to distribute educational material



Conclusions

- Conducting blood lead prevalence studies provides information to identify whether and where lead exposure is occurring, e.g. from lead paint
- These studies should be carried out in a scientifically rigorous manner
- The results of prevalence studies can be used to target lead poisoning prevention and other public health interventions



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References

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3. Fleming IW. Every dot is a Detroit child with lead poisoning. *The Detroit Free Press*, 21 January 2003
4. US Centers for Disease Control and Prevention, unpublished data
5. Brown MJB, Falk, H. US Centers for Disease Control and Prevention (US CDC), personal communication, 2015



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6. Dooyema et al. Outbreak of fatal childhood lead poisoning related to artisanal gold mining in northwestern Nigeria, 2010. Environ Health Perspect. 2012;120:601–607. <http://ehp.niehs.nih.gov/1103965/>
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8. LandScan®
http://web.ornl.gov/sci/landscan/landscan_data_avail.shtml



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9. e.g. www.power-analysis.com
10. LAMP: CDC's Lead and Multi-Element Proficiency Program. Atlanta (GA): Centers for Disease Control and Prevention; 2008
http://www.cdc.gov/labstandards/pdf/lamp/LAMP_Factsheet.pdf
11. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. Advisory Committee on Childhood Lead Poisoning Prevention. Atlanta (GA): Centers for Disease Control and Prevention; 2012.
http://www.cdc.gov/nceh/lead/acclpp/final_document_030712.pdf



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Additional sources

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<http://www.unep.org/chemicalsandwaste/noleadinpaint/toolkit>
- Using GIS to Assess and Direct Childhood Lead Poisoning Prevention. Atlanta (GA): Centers for Disease Control and Prevention; 2004.
<http://www.cdc.gov/nceh/lead/publications/UsingGIS.pdf>
- Hodge J, Nielsen J, Dignam T, Brown MJ. Small area surveillance to estimate prevalence of childhood blood and environmental lead levels. Atlanta (GA): Centers for Disease Control and Prevention; 2016
https://www.cdc.gov/nceh/lead/BLL_PrevalenceStudy_TrainingManual_Final_508.pdf



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Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention.



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