Childhood Lead Poisoning

Why you might be smarter than your parents

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Elemental Exposure-General Truisms

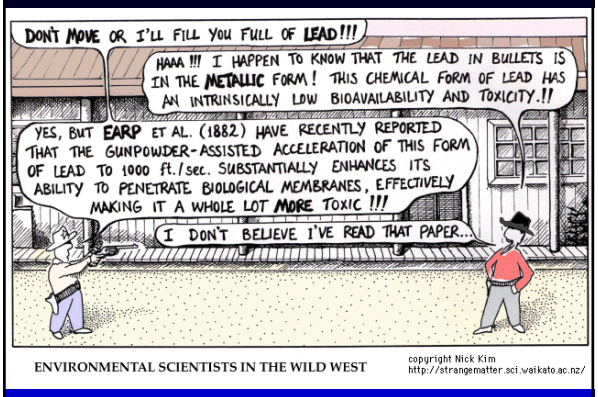
- **Most are not toxic**
- **Nutritional = less toxic (Zn, Cd)**
  - **Homeostasis**
- **Abundance ↑ = toxicity ↓**
- **Every truism has exceptions**

Speciation Considerations

- Can greatly influence toxicity
- Ability to differentiate limited, improving
  - Cr^{+3} = nutrient, Cr^{+6} = carcinogen
  - Toxicity $As^{+3} > As^{+5} >>$organic As

or

?



Exposure Routes

- Ingestion—most common
- Inhalation—more dangerous

Mechanisms of Action

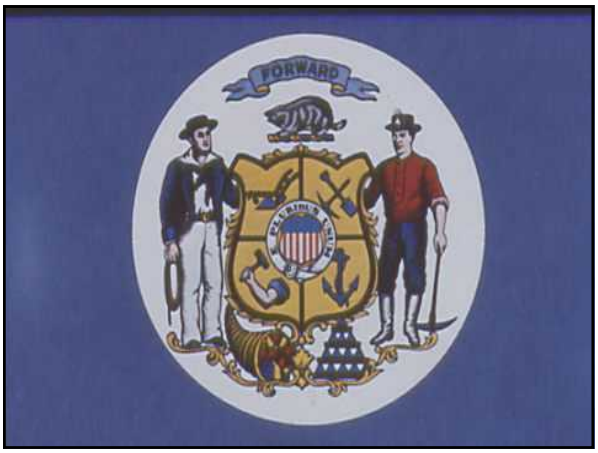
- Binding to SH groups
  - alters protein shape
- Substitution for nutritional element

Assessment

- Contamination biggest concern
  - serum Al: 1970 = 1,000 µg/L, 2002 = 2 µg/L
- Best sample will be element and species dependent
  - correlation w/disease often limited
  - Blood, urine, serum typical
  - Hair is generally NOT valid
- Analytical methods
  - Atomic spectrometry (AA, ICP-MS)
  - Electrochemical (ion-specific electrodes, ASV)
  - XRF

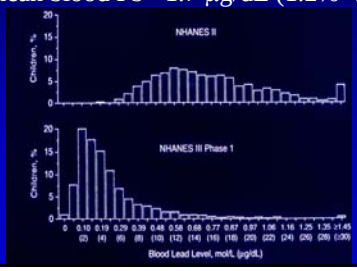
Lead and Exposure

- Many uses-now~85% batteries
- Widely dispersed in environment
  - U.S., huge reservoir in housing
- Well-characterized env. toxin
- Many toxic effects
- Young children most impacted
  - Subclinical effects



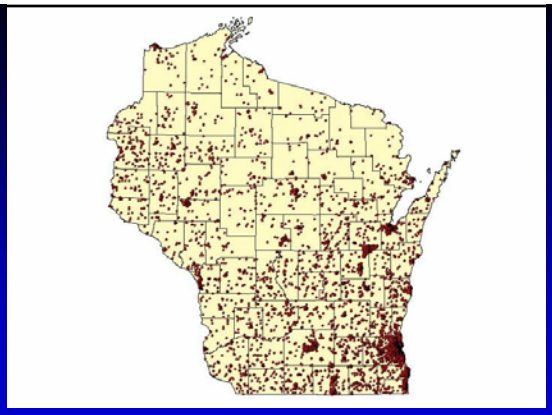
Major Public Health Success

- Existing blood Pb threshold for action = 10 µg/dL
- 1976-80, mean blood Pb ~14.9 µg/dL (88%>10)
- 2002, mean blood Pb ~1.7 µg/dL (1.2%>10)



But…Still a Big Problem

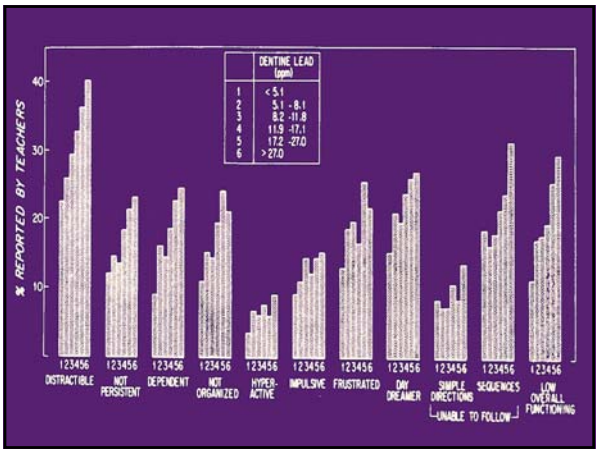
- Nationally, 1.2% still >10, ~180,000 kids
- WI 4.7% entering school had Pb >10 (2006)
- 2111 kids (2.6% tested) >10, ~5/day (2006)

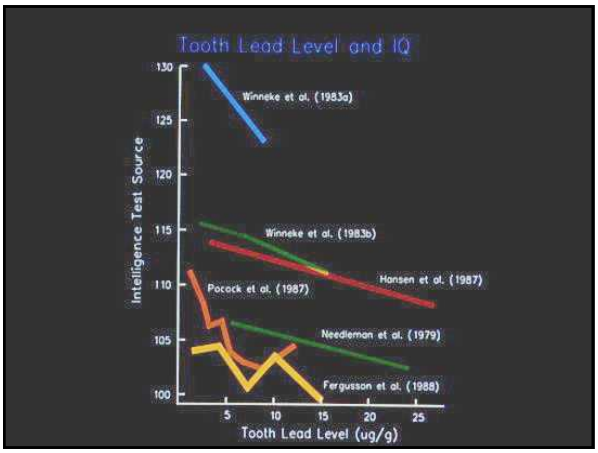


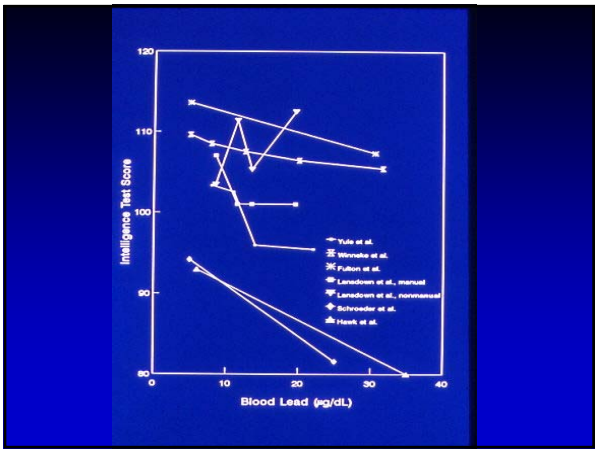
Locations associated with Pb-poisoned children, 1996-2006 (WI DHFS)

The Lead-Learning Link

- Low-level Pb effect studies began 1970's
- Linked IQ, cognitive problems with Pb
- Studies replicated worldwide
- Early study populations still followed
- Demonstrated links to delinquency, violence, etc.
- IQ ↓ as Pb ↑ may be steepest at lower [ ]







Confounding Variables

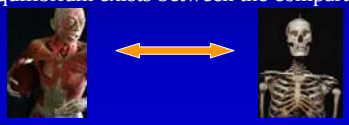
- Studies control for many other influences
- Examples include:

Parental education level(s)	**Maternal age at birth**
Smoking during pregnancy	**Birth weight**
Birth order	**Feeding style (breast or bottle)**
HOME* score	**Maternal IQ**
Gender of child	**Socio-economic status**
Race of child	**Immunization history**
Parental occupation(s)	**Alcohol consumption**

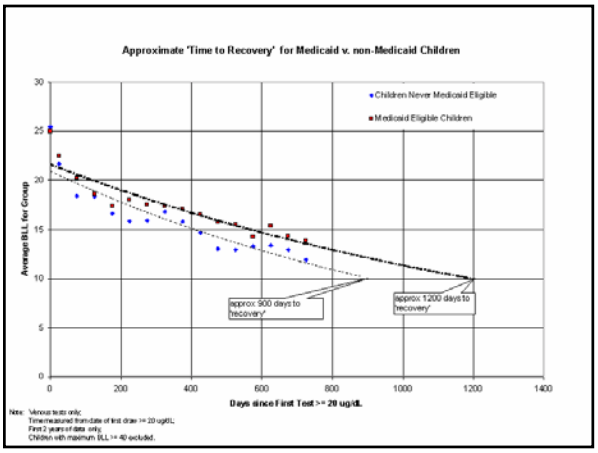
***HOME = Home Observation for Measurement of the Environment**

Lead Toxicokinetics

- Absorption
  - Inhaled lead ~40% (not sig. for children)
  - Ingested lead ~10-40% (children) ~32%% adults
- Distribution
  - Blood & soft tissue, ½ life=30-40 days
  - Tooth & bone, ½ life=25 years (>90% body burden)
  - Equilibrium exists between the compartments

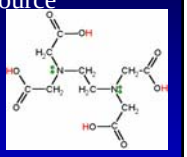


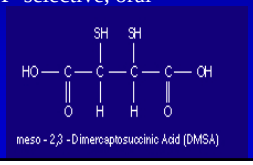
- Excretion primarily via bile/feces & urine, ~2:1



Treatment

- Identify & eliminate exposure source
- Chelating agents
  - BAL--selective, IM injection
  - EDTA--IV, broad chelater
  - DMSA--selective, oral

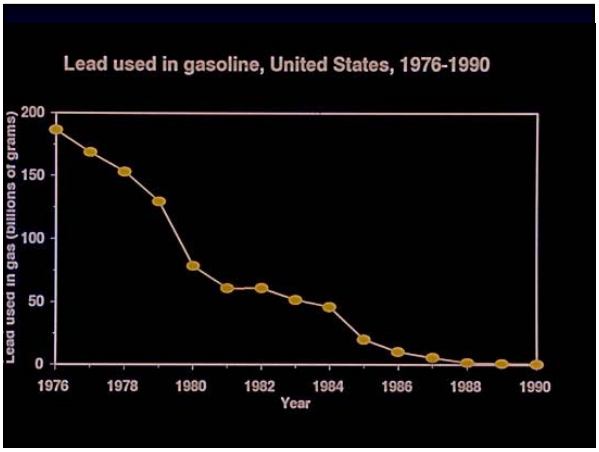


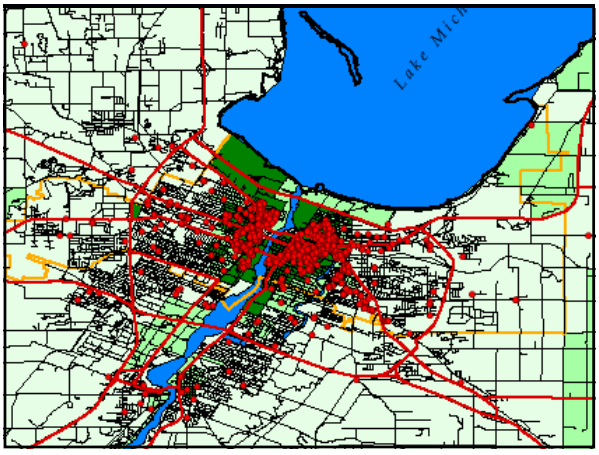


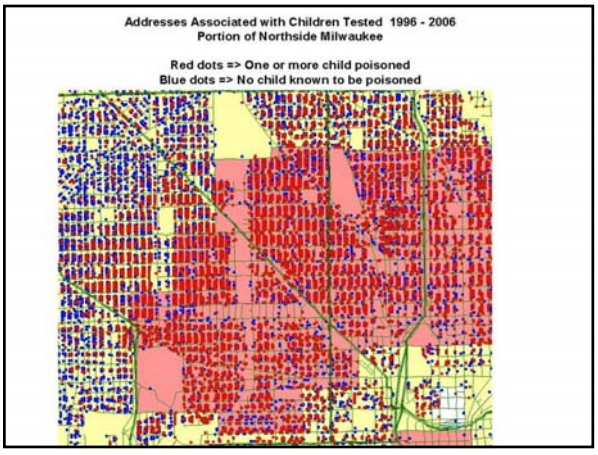
Major Pb Exposure Sources

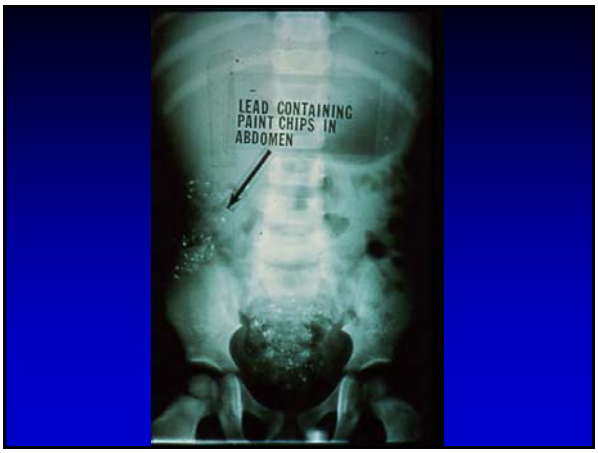
- Lead-based paint
  - 38 million homes have LBP
  - 24 million have lead hazards
  - 1.2 of the 24 million w/young kids

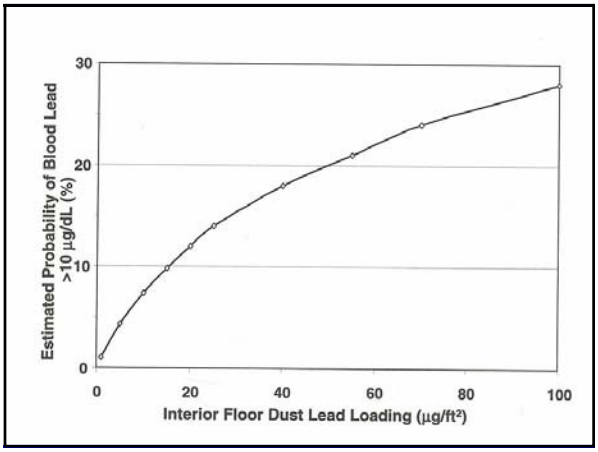
  Jacobs et al., Env Hlth Persp 2002:110 #10
- Soil, from paint and gasoline
- Industrial sources--restricted











Other Exposure Sources

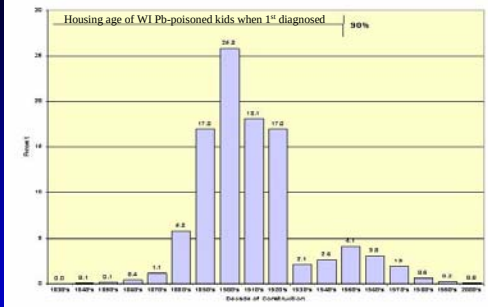
- Ceramic glazes
- Traditional medicines & cosmetics

Recent Hazards

- Consumer products
  - TOYS
  - Jewelry
    - CSPC moves to ban
    - Death in MN 2006
  - Sidewalk chalk 2003

Risk Factors/Predictors

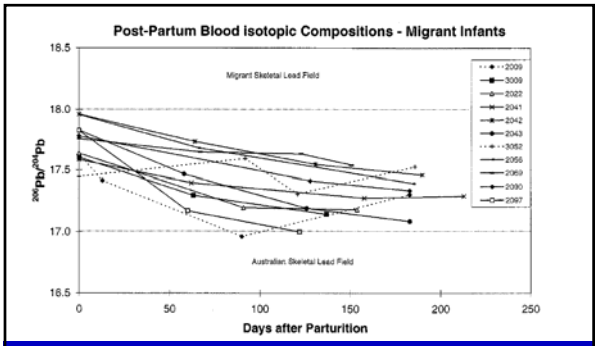
- Housing age & condition
  - 92% of WI poisoned kids live in pre-1950 housing
- Poverty
  - 88% of poisoned kids in Medicaid/WIC
- Housing renovation
- Residency Status
- Pica and developmental deficits
- Fe and other dietary deficiences



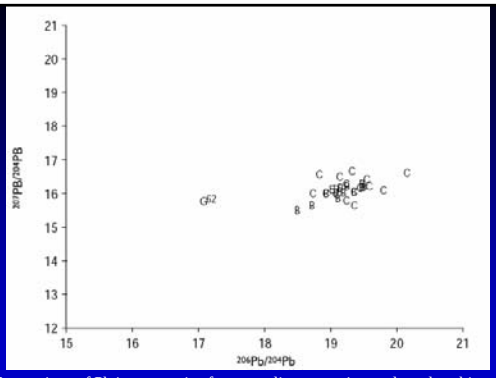
Age of housing associated with initial diagnosis of Pb-poisoning, 1996-2006 (WI DHFS)

Pb Isotope Ratios

- Pb has four isotopes:
  - Pb 204 "native," relative abundance (ra)=1.4%
  - Pb 206 product of uranium decay, ra=24.1%
  - Pb 207 product of actinium decay, ra=22.1%
  - Pb 208 product of thorium decay, ra=52.4%
- RAs differ slightly in different source Pb
- Isotope ratios can be examined to
  - Demonstrate aspects of Pb pharmacokinetics
  - Characterize exposure sources
    - Value decreasing as Pb recycling homogenizes ratios



Changes in blood Pb isotope ratio over time for migrant infants.
Gulsen et al., Env Res 2001:85



Comparison of Pb isotope ratios from gasoline, ceramics, and study subjects.
B=blood, C=ceramics, G=gasoline
Chaudhary-Webb et al., Salud publica de Mexico 2003:45 #2

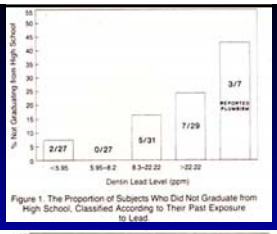


Figure 1. The Proportion of Subjects Who Did Not Graduate from High School, Classified According to Their Past Exposure to Lead.

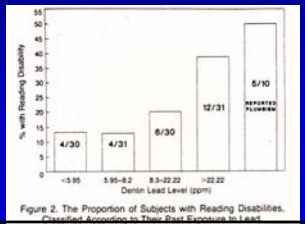
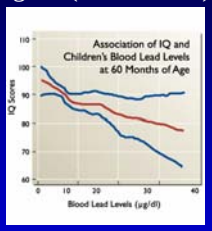
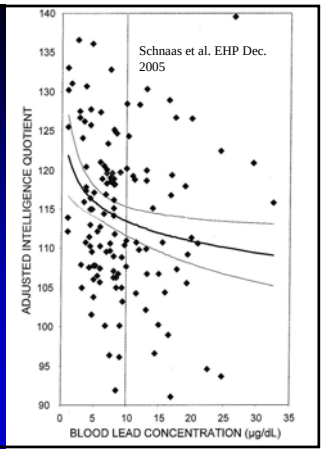


Figure 2. The Proportion of Subjects with Reading Disabilities, Classified According to Their Past Exposure to Lead.

- IQ decline appears steeper from 0-10 ug/dL (~17 cohorts)

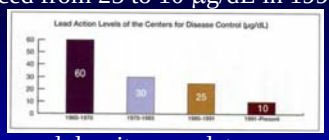


Canfield R, et al. NEJM 2003;348:1517-1526



CDC's Blood Lead Threshold

- Reduced from 25 to 10 µg/dL in 1991



- Unchanged despite new data
  - Examined in 2005 publication
  - Reasons cited for not reducing
    - Lack of effective interventions
    - Lack of demonstrated threshold-artificial to set
    - Measurement uncertainty, resulting false pos/neg
    - Lack of resources
    - Politics???

Jusko et al. study

- Study designed to examine impact of [Pb] <10 ug/dL on cognitive function
- Cohort followed 6 mo.-6 yr, n=174
- IQ measured using Weschsler Scale
- Confounding variables controlled:
  - Child's birthweight, gender, transferrin saturation
  - Mother's race, IQ, and education level
  - HOME-SF total score (home observation for measurement of the Environment Inventory-short form)
  - Family income
  - Maternal prenatal smoking

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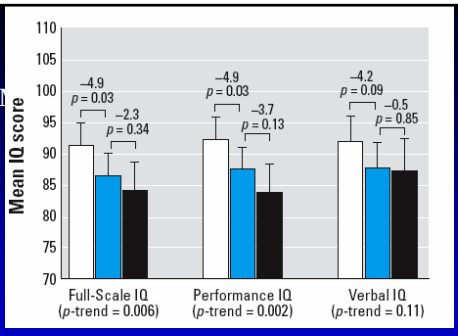
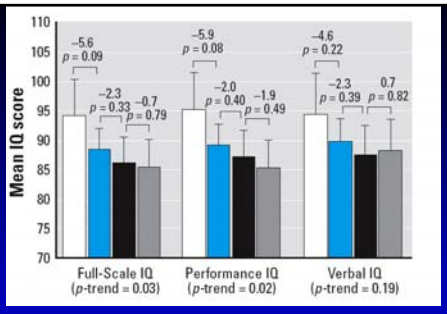


Differences in IQ associated with increasing lifetime blood Pb concentration.
Jusko et al., Env Hlth Persp 2007, doi: 10.1289/ehp10414
White bars = 0-5 µg/dL, Blue bars = 5-9.9 µg/dL, Black bars = ≥10 µg/dL



Differences in IQ associated with increasing peak blood Pb concentration.
Jusko et al., Env Hlth Persp 2007, doi: 10.1289/ehp10414

White bars = 0-5 µg/dL, Blue bars = 5-9.9 µg/dL, Black bars = 10-14.9 µg/dL
Grey bars = ≥15 µg/dL

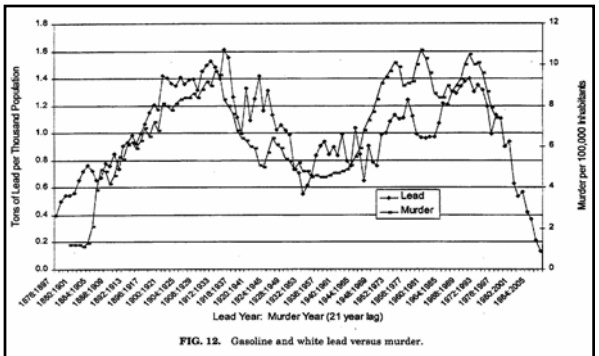
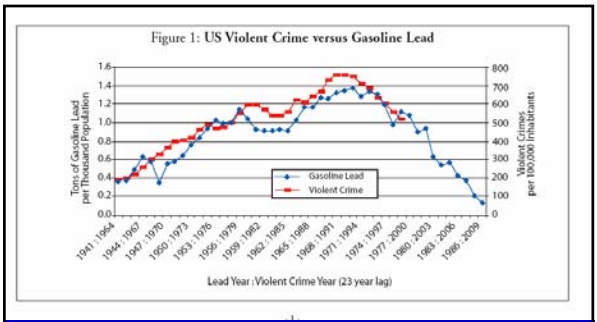
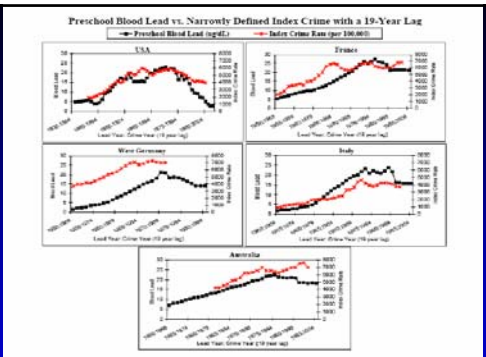


FIG. 12. Gasoline and white lead versus murder.

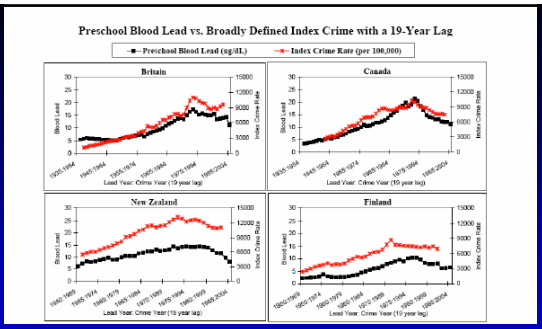
Differences in IQ associated with increasing peak blood Pb concentration.
Nevin, Env Res 2000:83



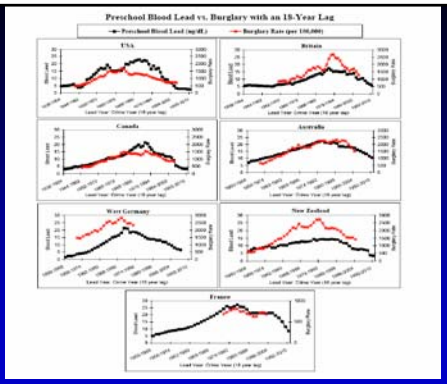
Trends in violent crimes (murder, rape, robbery, aggravated assault) and gasoline Pb, 23 year offset.
Nevin, Env Res 2007:104 #3



Trends in index crimes (violent crimes +burglary & theft) and blood Pb, 19 year offset.
Nevin, Env Res 2007:104 #3



Trends in index crimes that include threats, simple assaults, and petty theft and blood Pb, 19 year offset.
Nevin, Env Res 2007:104 #3



Trends in burglary and blood Pb, 18 year offset.
Nevin, Env Res 2007:104 #3

So, Pb exposure has gone down

In turn, IQ has gone up

Consequently, you might be smarter than your parents

and more law-abiding too!