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Public Health Issues Related to Lead

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This presentation

- Background
- Potential low-level effects
- Drinking water as a source
- How lead is handled by body
- Health management
- Who is potentially most susceptible
- Conclusions

Preview of conclusions

- Drinking water is at most a minor source of lead for children
- Drinking water may contribute a small amount if *sustained* exposure
- Children of greatest concern are those who already have body burden, BPb > 10 μg/dL

Background to the issues

- Lead is a natural element, present in soil
- Insignificant environmentally until 1800's
- Human activity mobilized lead in the environment
- Children and the fetus are potentially most at risk
- Pregnant and nursing mothers
- Potential behavioral, cognitive effects

Terminology

- "Acute" is short-term; "chronic" is long-term
- Overt "lead poisoning" is a classic, specific syndrome, usually acute
- "Lead toxicity" is less obvious, always chronic
- The lower the lead, the better the "group outcome" for behavioral endpoints; individuals vary
- Concentration in water (ppb) does not readily convert to blood levels (µg/dL)
- "Body burden" reflects *sustained* – not transient – exposure

Public health issues with lead: overview

- "Legacy" related to paint, gasoline, printing ink, ceramics
- Because of above, lead remains among most common and serious toxic exposures (esp. in children)
- "Lead poisoning" is now rare in US
- Risk of lead exposure is greatest when lead burden is *already high*
- Control of sources more effective than changing behavior

Lead poisoning in children:

(effects that generally occur at > 60 μg/dL)

Central Nervous System

- Lethargy, wakeful
- Irritability
- Clumsiness, ataxia
- Projectile vomiting
- Visual changes
- Delerium, convulsions, coma

Other

- Anemia
- Abdominal pain
- Growth retardation
- Peripheral nervous disorders
- ↑Blood pressure

Lead toxicity

- Blood lead (BPb) is most useful test
- CDC recommendation for children is BPb > 10 μg/dL
- Early evidence suggests that there may be risk at 5 μg/dL
- Dose-response: behavioral outcomes linear with BPb
- Therefore, the lower the BPb, the better

Why are we concerned about low-level lead toxicity?

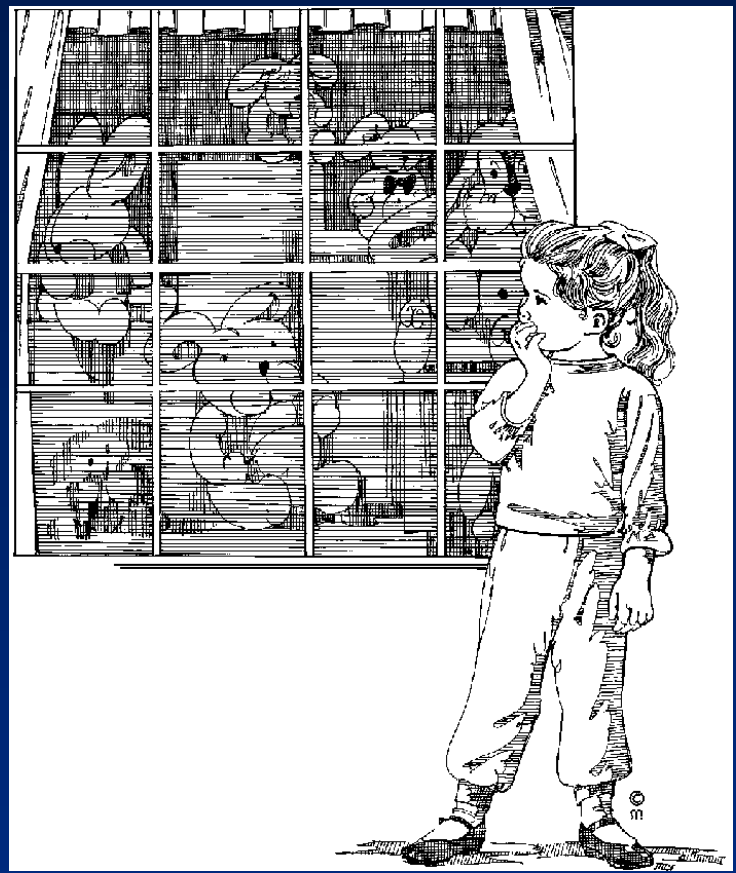
- Assumes sustained exposure
- Potentially affects developing nervous system
- May be associated with:
  - Diminished school performance
  - Reduced scores on standardized IQ tests
  - Aggressive behavior
  - Schizophrenia? (new evidence, unproven)
  - Delayed puberty (recent data)
- These are group risks; individuals vary

Lead as a toxic substance

- Continuous versus intermittent exposure
- Readily absorbed and mobilized in the body
- Cumulative body burden: body retains some
- It is the free lead in blood that causes toxicity
- Tends to affect nerve tissue and blood-forming organs

Lead Exposure in Children

- More susceptible
- Other sources, e.g. pica, house dust
- Consume more tap water
- Lead absorbed much more readily from gastrointestinal tract
- Peak levels about 2 y



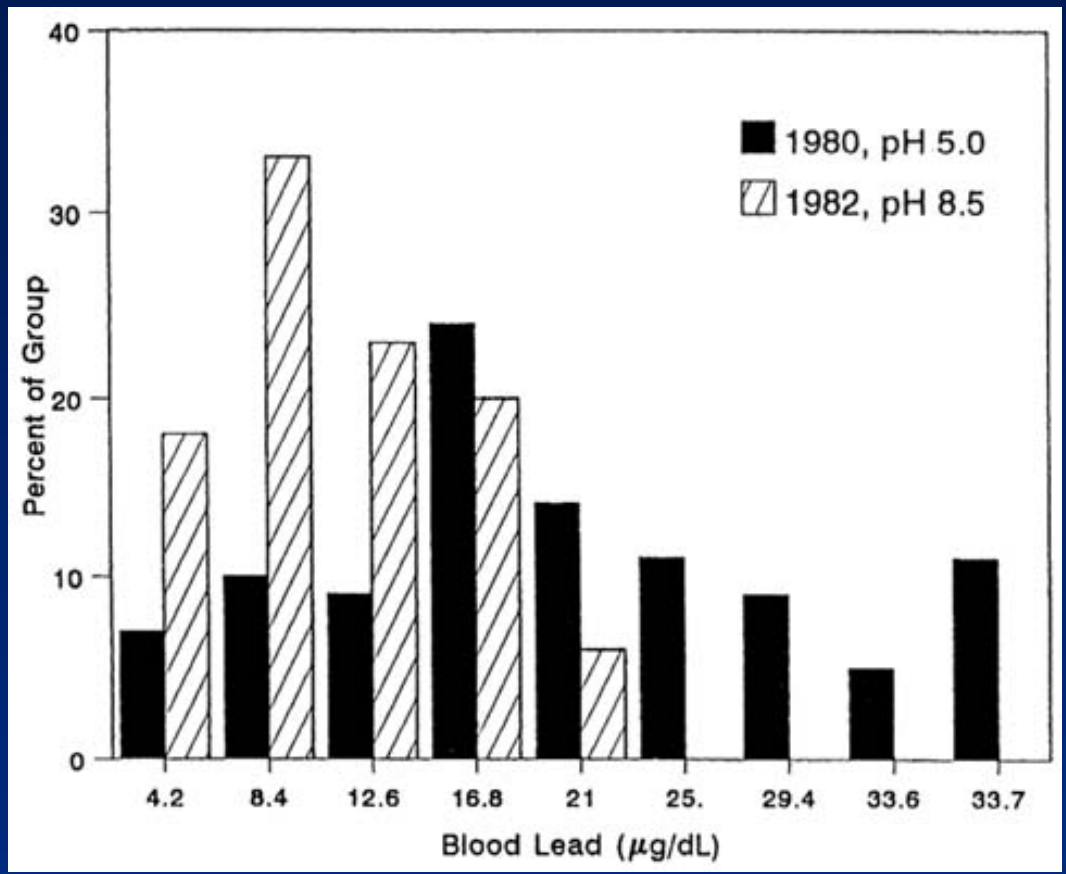
Protecting the fetus and newborn

- Lead is mobilized during pregnancy
- Readily crosses placenta
- Fetus is susceptible
- Postpartum, risk of exposure of child
  - Via breast milk
  - Via formula

Source apportionment for toddlers, children aged 2 y (United States)

Medium	Proportion of total exposure	Estimate of ave. daily intake
Dust (esp. on hands)	75%	~ 20 μg
Food	16%	~ 5 μg
Water	7%	~ 2.5 μg
Soil	1%	~ 0.5 μg
Air	<1%	~ 0.5 μg
Pica	NA	≤ 5 μg

Lead in drinking water and blood lead in Scottish mothers



- Best data
- Mothers were getting pregnancy care
- Near Glasgow, Scotland
- Levels in water exceeded 1000 ppb
- BPb high already

Contribution of drinking water to blood lead in US children

- Concentration in water (μg Pb/liter) does not translate directly into BPb (μg/dL)
- In adults, BPb affected by lead in drinking water at high levels (>1000 ppb)
- EPA's Integrated Exposure Uptake and BioKinetic Model
  - Predicted BPb in infants exceeded 10 μg/dl only when 100% of water consumed contained 100 ppb (μg Pb/liter) on a sustained basis
  - Visible effect on BPb of children requires at least sustained levels of 300 ppb (basis of Dr Paulson's recommendation)
- Conclusion is that contribution in relevant range is at most small

Behavior of Lead in the Body – 1

- Ingestion more efficient route of exposure in children (~ 40%) than adults (~ 10%)
- Increased absorption with
  - Fe deficiency, anemia
  - Fatty meals
  - Fasting
  - Low calcium or phosphate in meal

Behavior of Lead in the Body – 2

- Lead is carried in the red cell
- Most of it goes to bone and stays there (94%)
- What stays in the blood is eliminated over time in urine
- Bone constitutes reservoir in equilibrium with blood; keeps blood level from disappearing
- Lead moves across placenta from mother to fetus; also enters breast milk

Behavior of Lead in the Body – 3

- Inorganic Pb is not metabolized
- Excretion/elimination of lead
  - Unabsorbed lead in gut leaves in feces
  - Most absorbed lead is excreted in urine (75%)
  - Much absorbed lead is excreted (via bile) in feces
- Bottom line:
  - Absorbed lead has $t_{1/2}$ = 2 – 3 weeks in blood
  - some of the absorbed lead never completely leaves body but most of what remains is inactive

Given sufficient exposure, who may be at most risk?

Exposure-response

- Preexisting BPb close to or > 10 μg/dL
- Continuous, sustained exposure so that lead is replaced in body

Personal Characteristics

- Children < 6 y
- Pregnant or lactating women

Unknown, suspected

- ?African Americans
- Calcium deficiency

Medical conditions

- Inborn errors of heme metabolism (porphyrias)
- Hereditary anemias (e.g. the thalassemias)
- Nutritional deficiency, esp. Fe, Ca^{++}, vitamin D
- Preexisting neurological, blood or renal disease
- ?Alcohol abuse

Management of lead exposure to protect children

- Minimize sources of lead exposure
- Optimize nutrition, avoid fasting
- Report through public health dept.
- Home lead abatement: Dust, paint, soil control
- Rule out passive exposure (e.g. parent's workplace)
- Do not boil water for infant formula excessively
- Do not use first-draw water for infant formula
- Education and awareness

Chelation: only appropriate for lead poisoning

- Only mentioned here because questions often arise
- Not a decision to be taken lightly
- Requires close monitoring, experience
- Potentially serious side effects
- Recommended only for BPb > 45 μg/dL
- Inappropriate for this situation!

Conclusions

- Drinking water is at most a minor source of lead for children
- Drinking water may contribute a small amount if *sustained* exposure
- Children of greatest concern are those who already have body burden, BPb > 10 μg/dL