Understanding Blood Lead Levels Less than 10 μg/dL and Reducing Childhood Exposures to Lead

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BLL<10 μg/dL Workgroup: 2002-2004 (published 2005)

- No "safe" level of lead has been identified
- Evidence favors causal association between lead acquisition and impaired cognitive functioning

- Concern for residual confounding (e.g., social factors)
- Strength and shape of relationship between lead and cognitive outcomes uncertain

- Children with BLL <10 μg/dL not "lead poisoned" as term is used in clinical setting
  - All children have measurable BLL
  - Use of cross-sectional studies not predictive of effects on individual children

  - Other influences on child development are strong

Clinical Group Charge -- 2003

- Management strategy options for blood lead <10 μg/dL
- Recommendations for clinicians

Process

- Review literature
- Draft Document

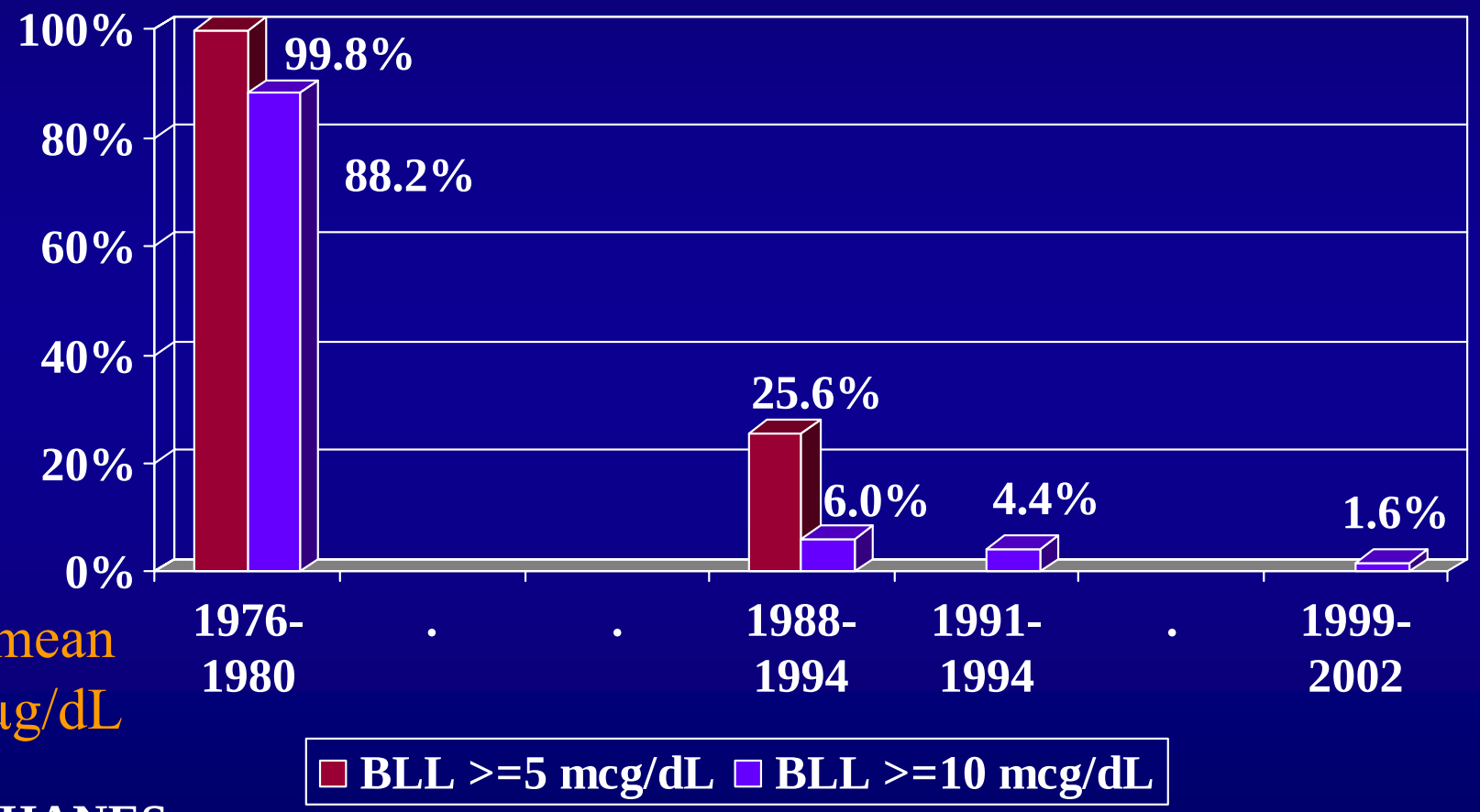
- Review by ACCLPP and approval

- Review by *Pediatrics*
- Revisions and additional review/approval by ACCLPP

- Submit to MMWR
- MMWR Editor review – extensive revisions

- MMWR Editorial team review – revisions
- MMWR (new) Editor review --- ???

Historical Perspective: Blood Lead Levels for U.S. Children Aged 1-5 Years



Geo. mean 15.0 µg/dL

Geo. mean 1.9 µg/dL

NHANES

Pirkel et al, *JAMA* 1994;272:284-91

Bernard et al, *Pediatrics* 2003;112:1308-13

Blood Lead Measurements: Laboratory Uncertainty

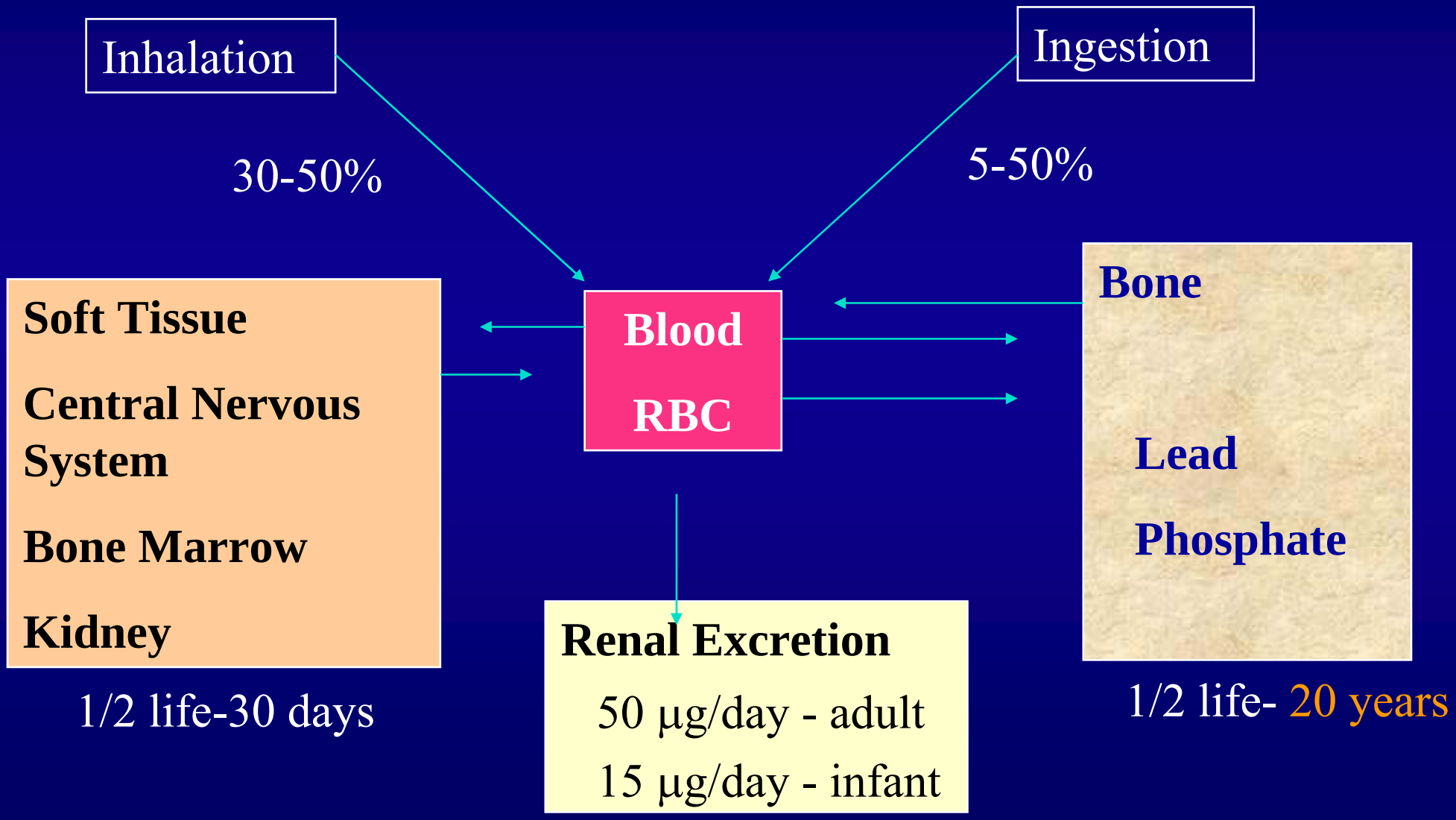
- Random error and systematic error (method & staff)
  - Error of ±4 μg/dL allowed
  - Most labs can operate within ±2 μg/dL
- Variability between laboratories (Johanputra et al)
  - 8 laboratories; blood samples <10 μg/dL
  - All results reported as <10 μg/dL
  - All results within 3 μg/dL of overall mean for that sample

Johanputra et al, *Arch Pediatr Adolesc Med* 1998;152:548-53

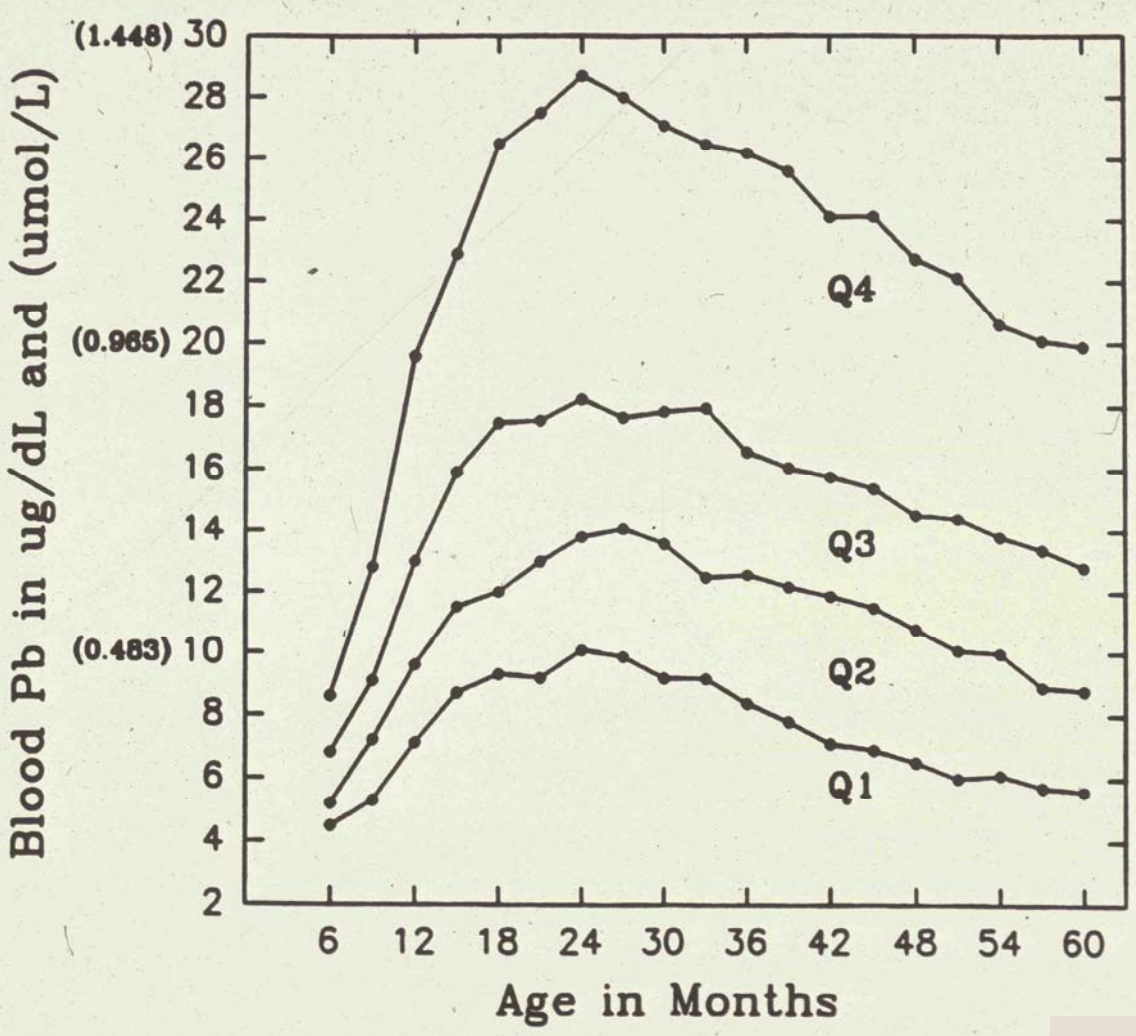
Blood Lead Measurements: Laboratory Uncertainty

- Blood collection processes
  - Capillary sampling for screening
  - Venous for confirmation

Blood Lead Patterns

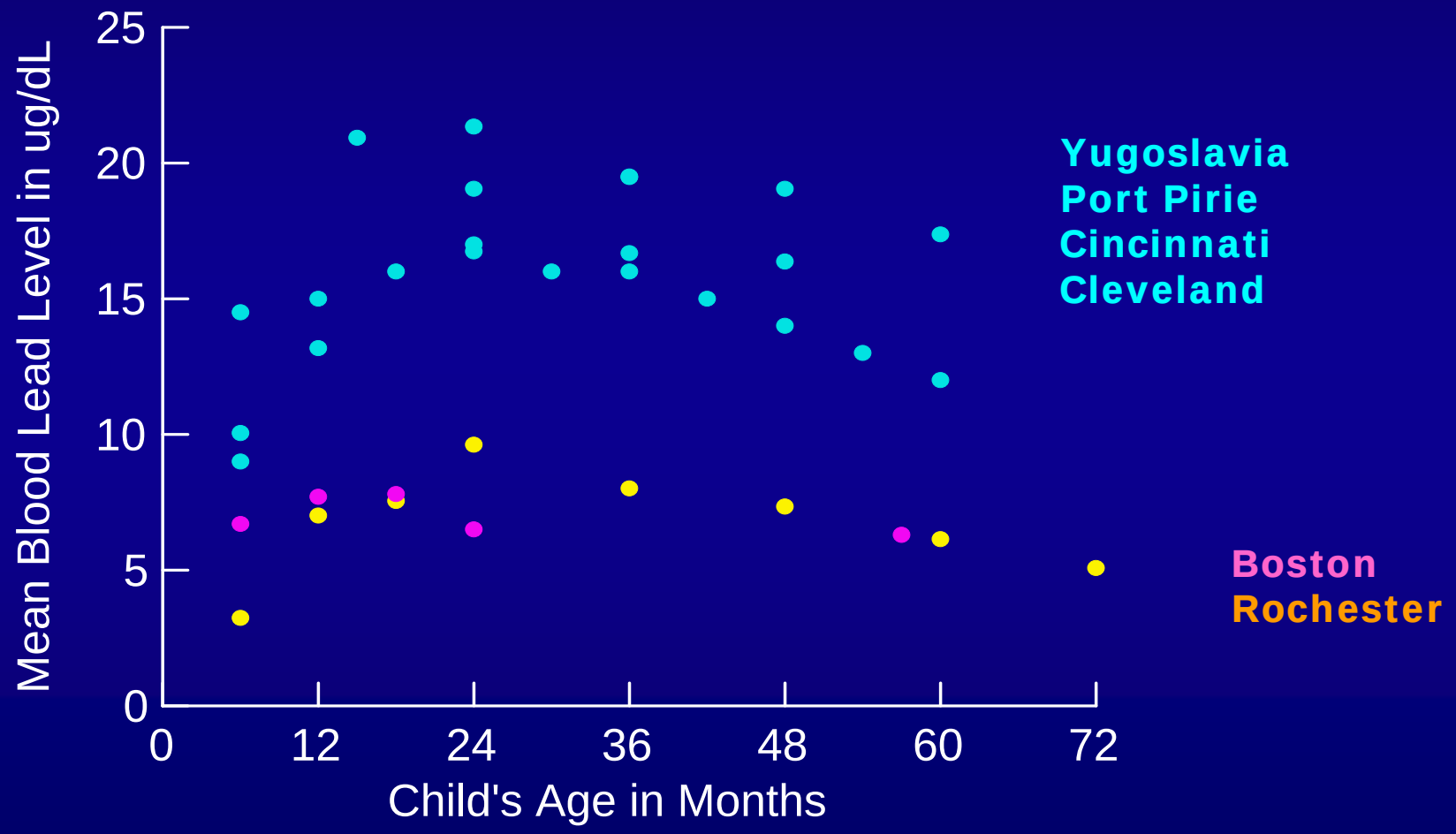


Blood Lead Patterns by Age

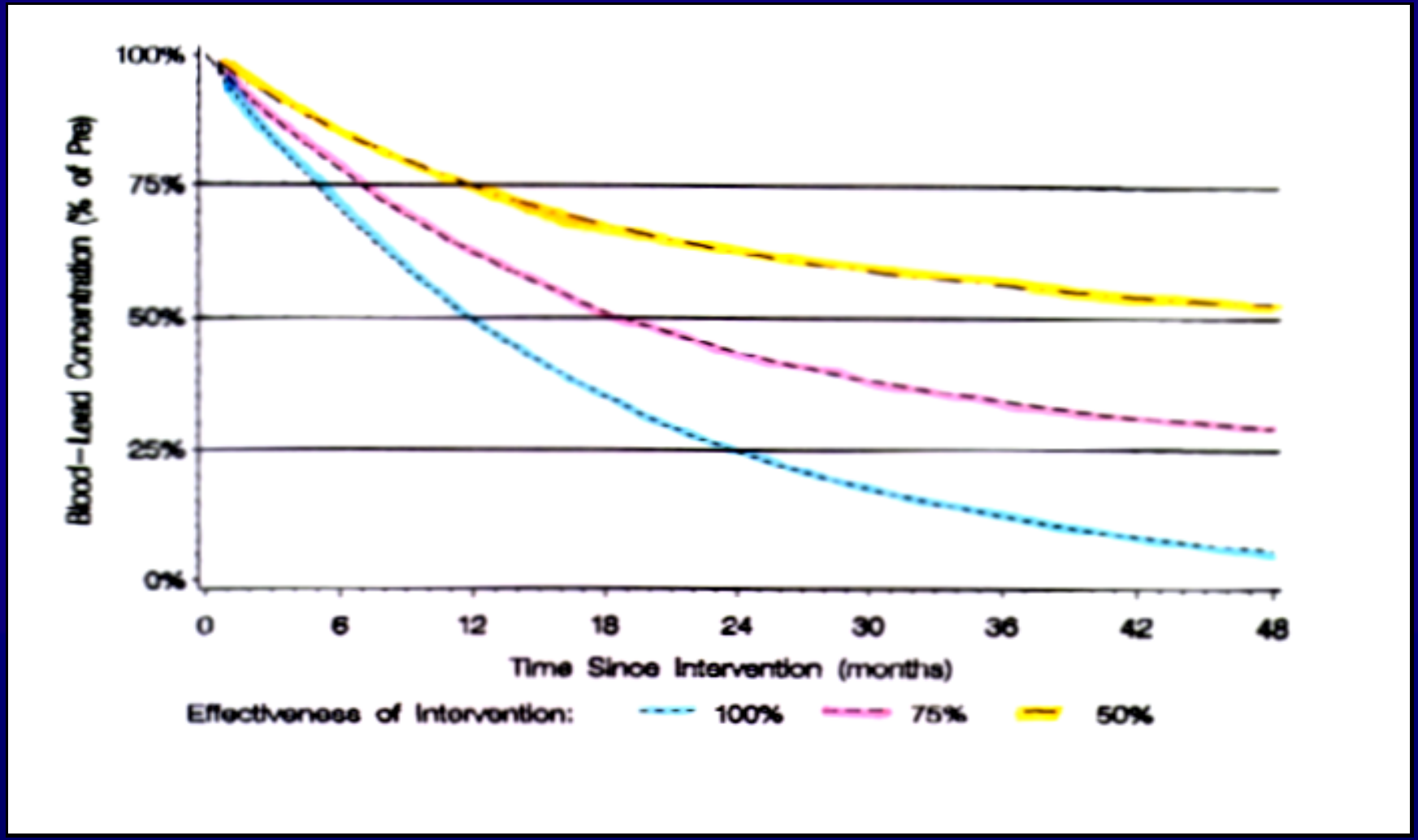


Dietrich (Cincinnati); Pediatrics; 91:301-307 1993

Blood Lead Patterns by Age



Blood Lead Reduction Following Intervention



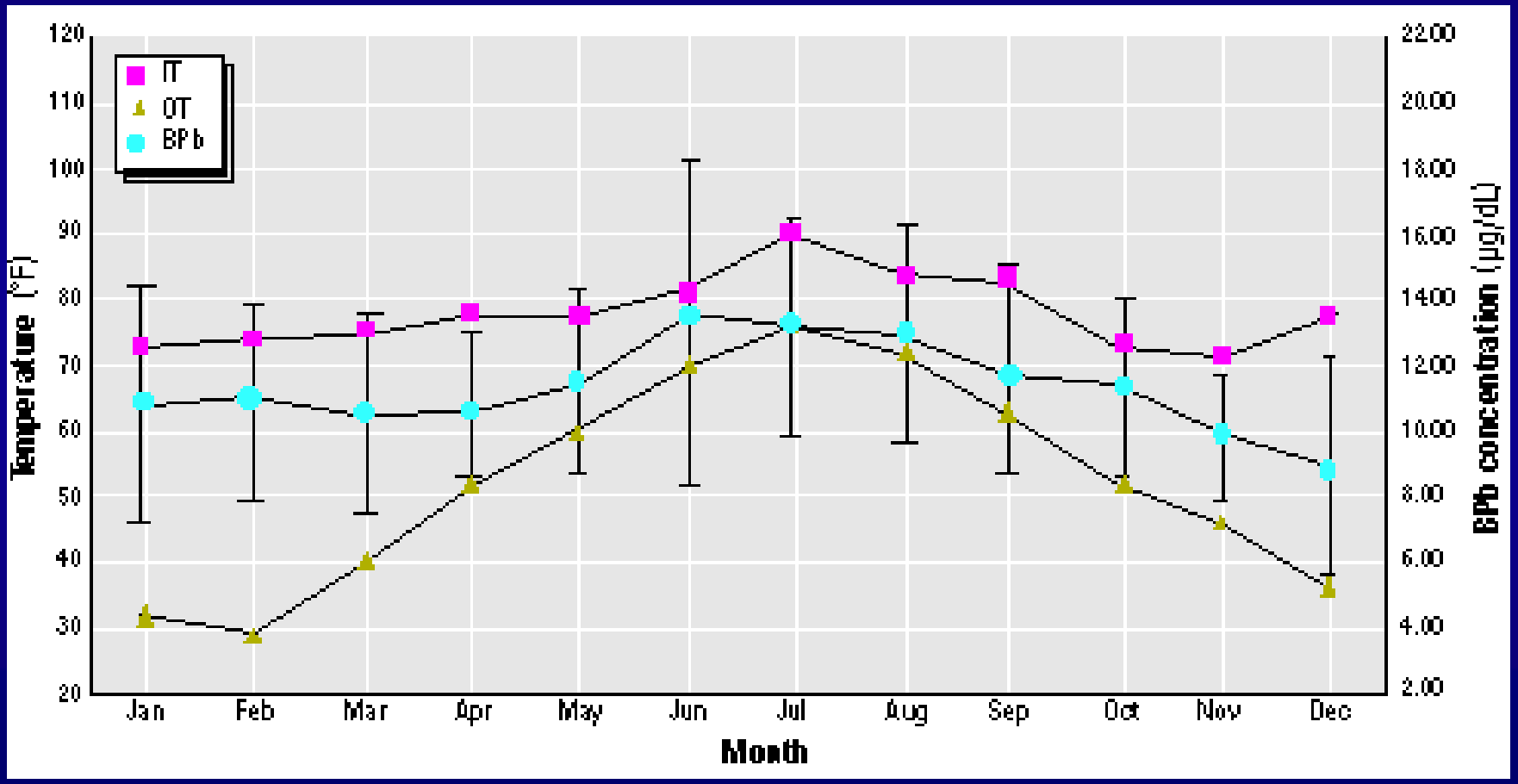
EPA 747-R-95-006, 1995

Expected Time for Children in Case Management to Achieve BLL <10 μg/dL

Baseline Lead	Time for 50% to achieve <10 μg/dL
10-14 μg/dL	9 months
15-19 μg/dL	14 months
20-24 μg/dL	21 months
25-29 μg/dL	24 months

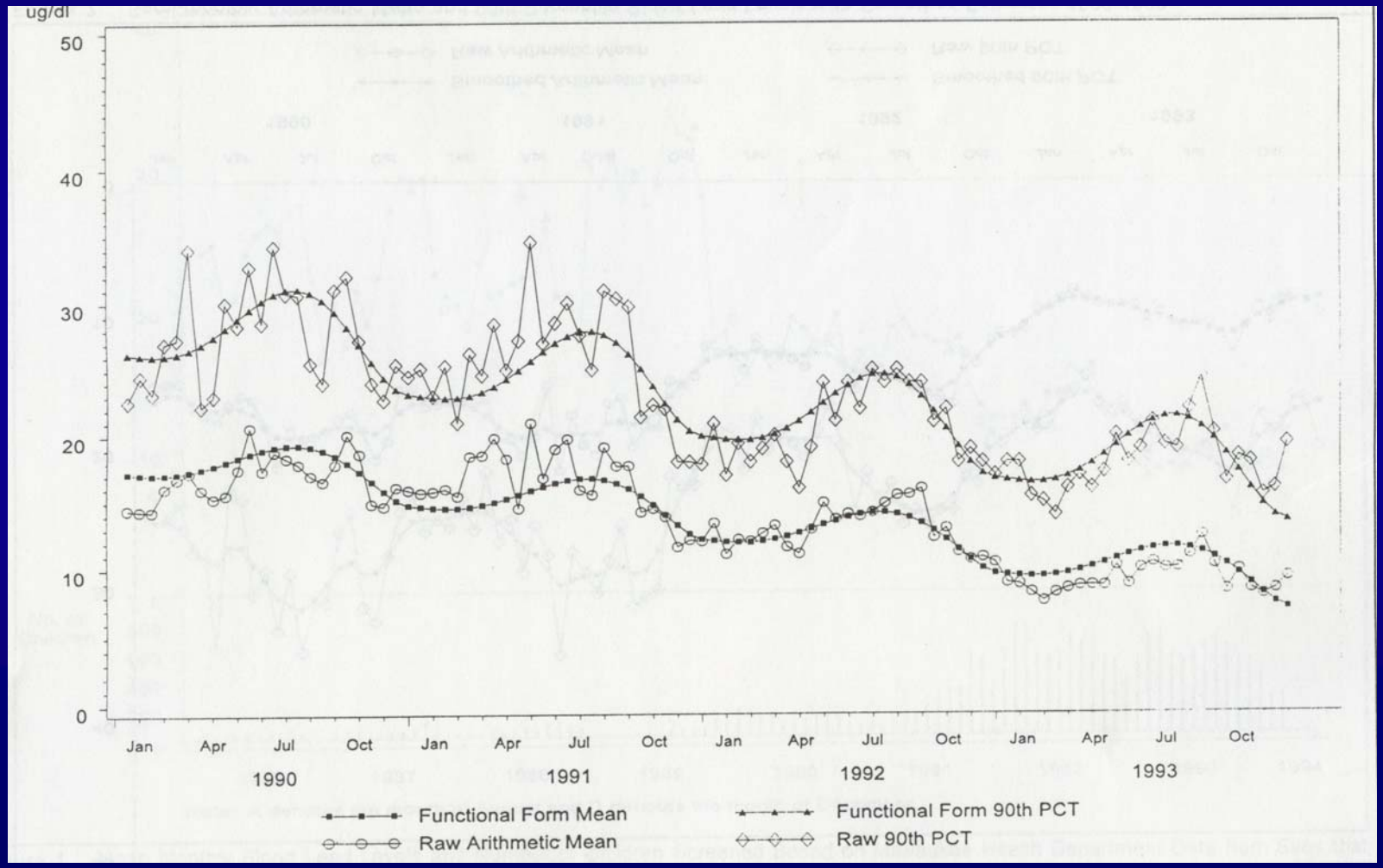
Roberts et al. J Tox-Clin Tox 2001;39:153-60

Blood Lead Patterns: Seasonal Variability



Yiin et al. *Environ Health Perspect* 2000; 108:177-82

Blood Lead Patterns: Seasonal Variability

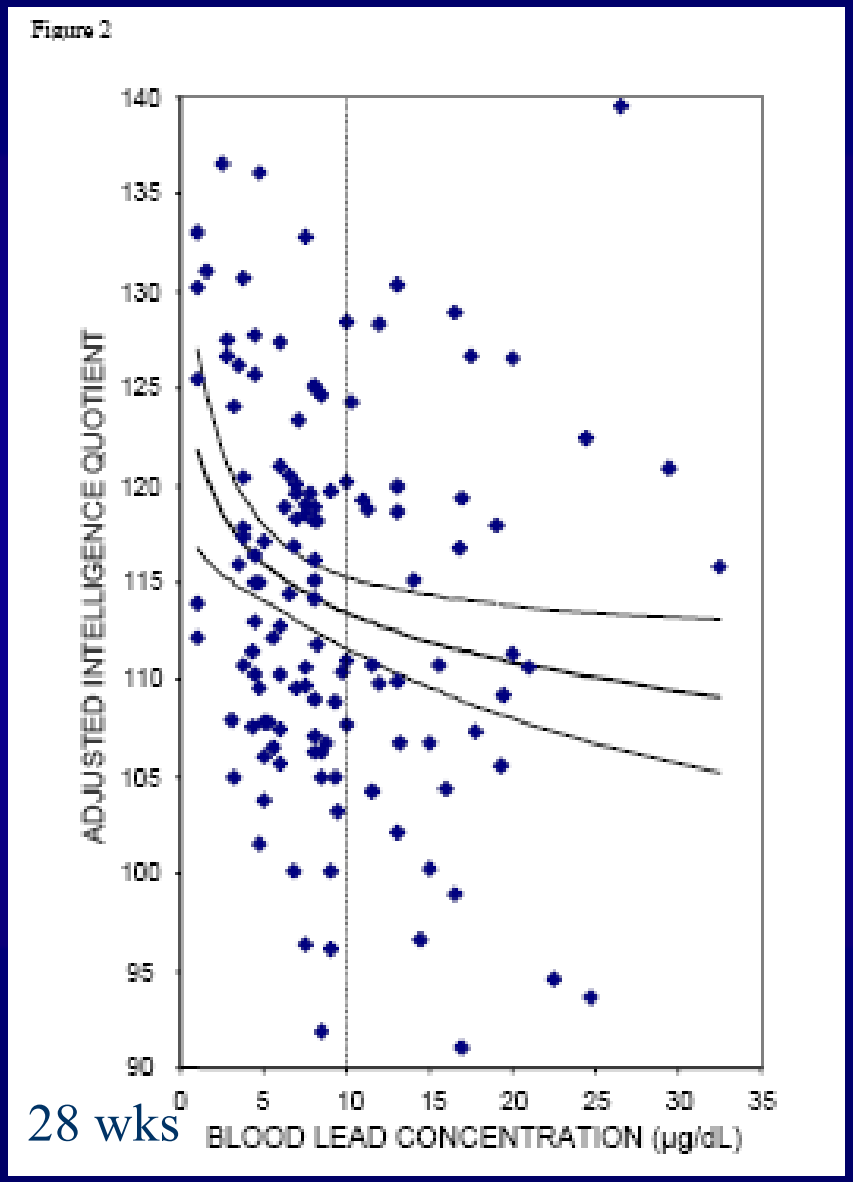


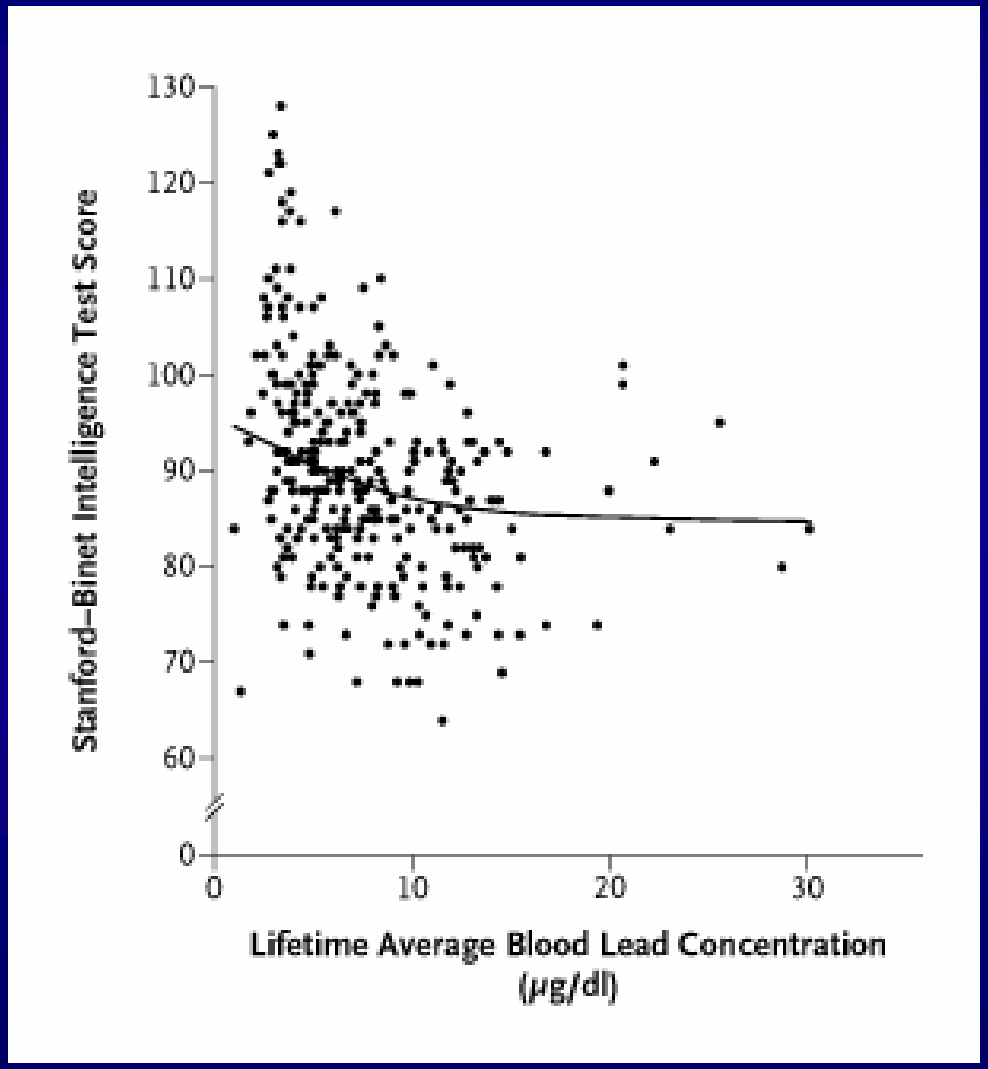
EPA 747-R-95-010

Blood Lead and Outcomes

- Times of measurements
  - Prenatal
  - Peak
  - Average lifetime
  - **Concurrent**
- Outcomes
  - Cognitive
  - Educational achievements
  - Behavior measures
  - Delinquency

Effects of Blood Lead <10 µg/dL



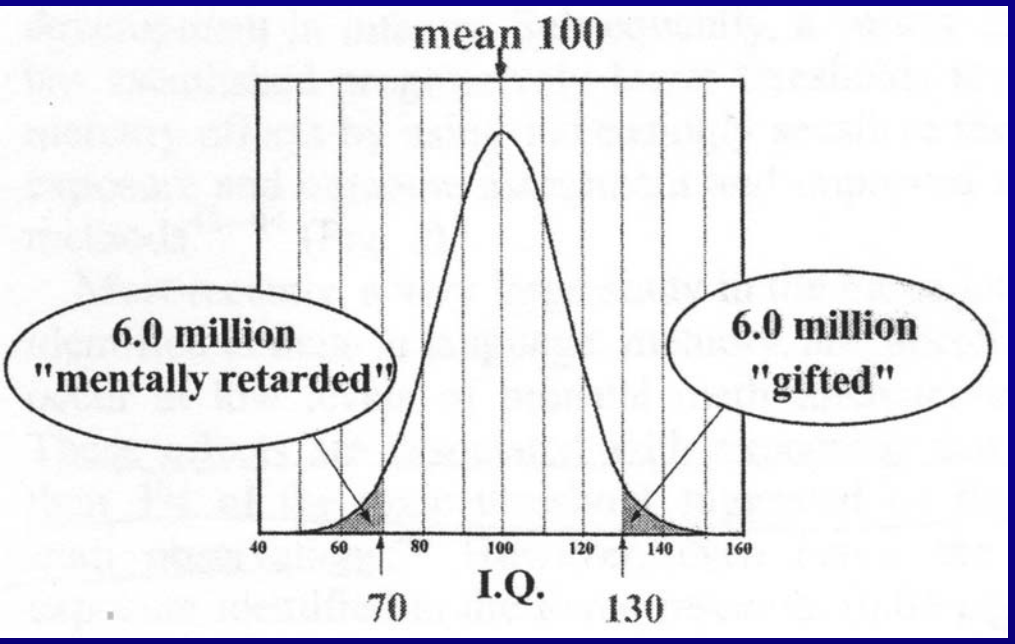


Schnaas: *Env Health Perspect* 2006 Canfield, et al., N Engl J Med

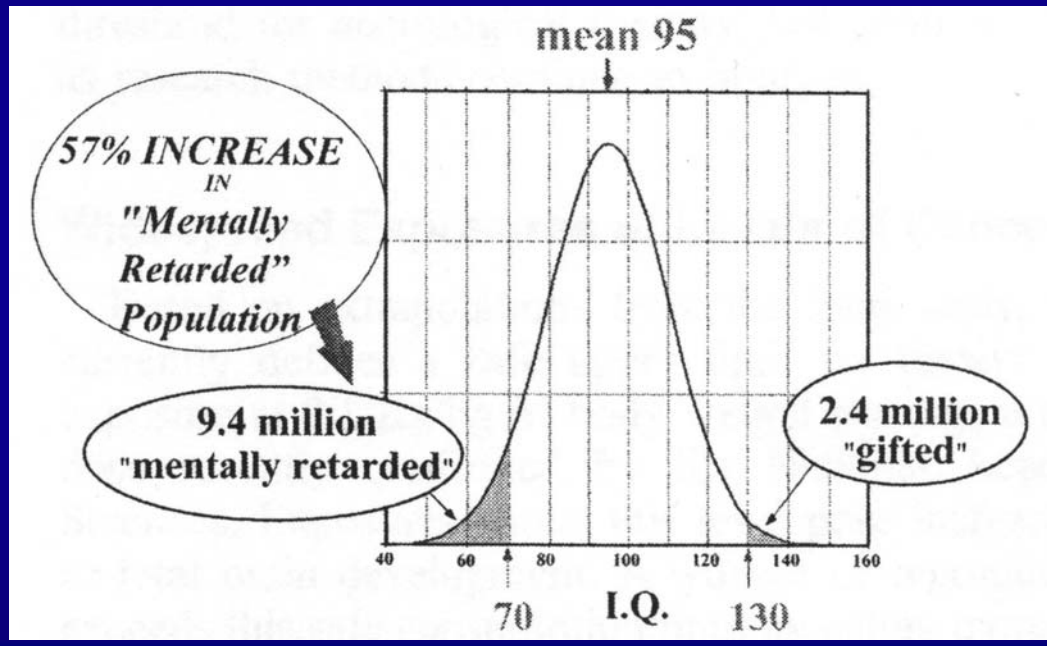
What problems will MY child have?

The effects of lead on cognitive or behavioral development of an <u>individual</u> child is not predictable.

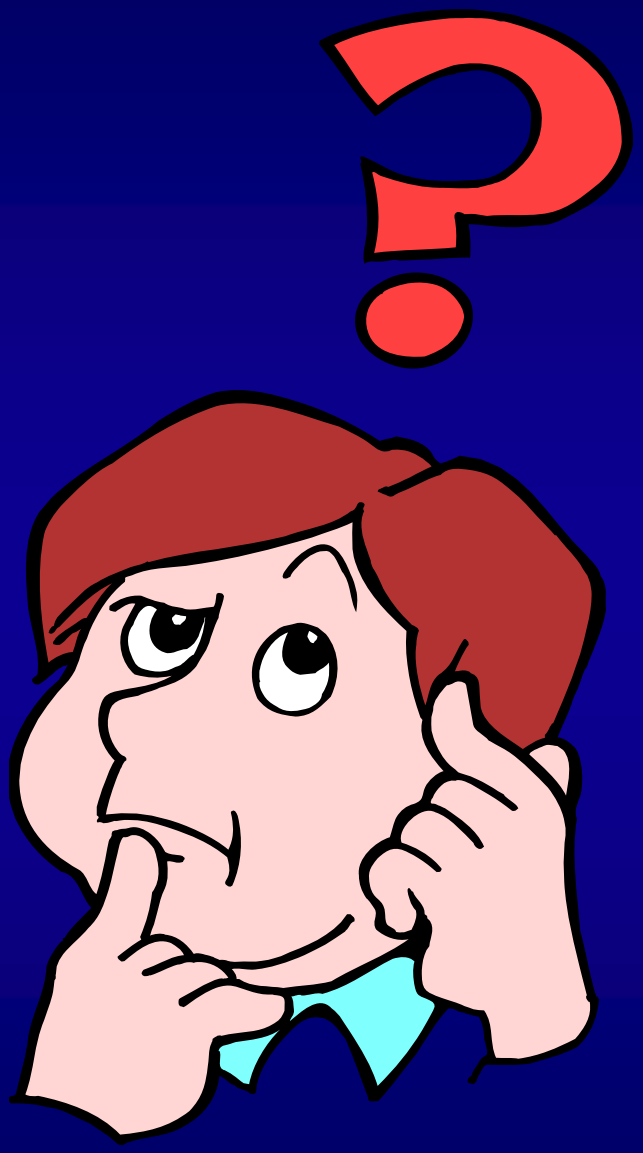
Effect of Shift in Mean IQ of Population



Expected



Shifted by 5 IQ points



So… what about MY child?

Confounding Variables on IQ at Age 7 Years

Baghurst et al. *N Engl J Med* 1992;327:1279-84

Variable	Comparison	Full Scale IQ Advantage
Mother's IQ	>95 vs <85	+15 pts
HOME environment score	High vs Low	+10
Feeding style	Breast vs Bottle	+6
Months of breast-feeding	>6 vs 0	+8
Mother's education	>3 vs ≤3 yrs H.S.	+6
Father's education	>3 vs ≤3 yrs H.S.	+5
Mother's age at birth	>28 vs <23 yrs	+4
Parents who smoke	None vs Any	+5
Birth weight	>3.5 vs <2.5 kg	+6
Parents living together	Yes vs No	+4

Neuron Growth

Genes direct growth of axons and dendrites

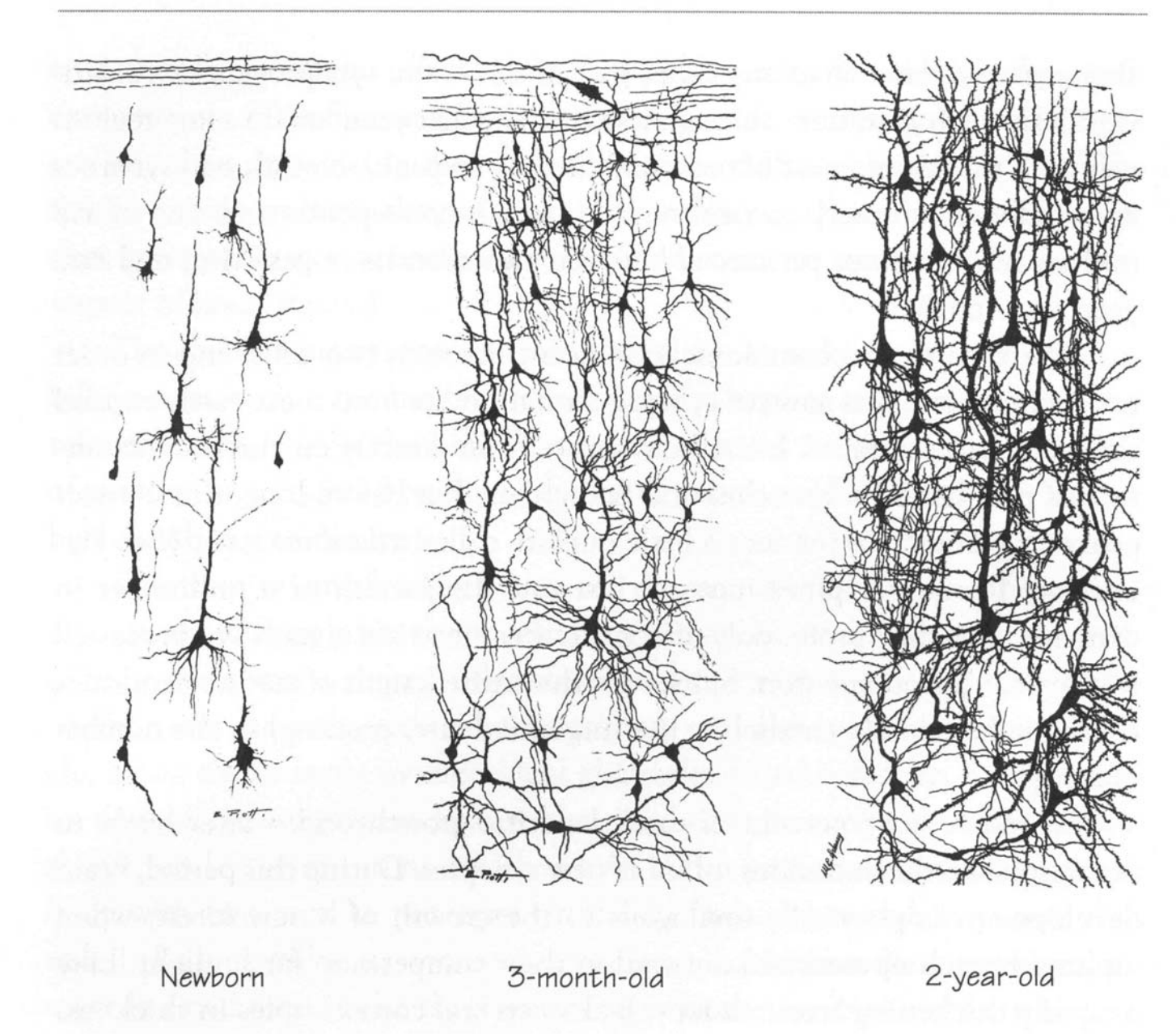


Image from "What's Going on in There?" by L Eliot, pg 28

Pruning to Achieve Adult Patterns

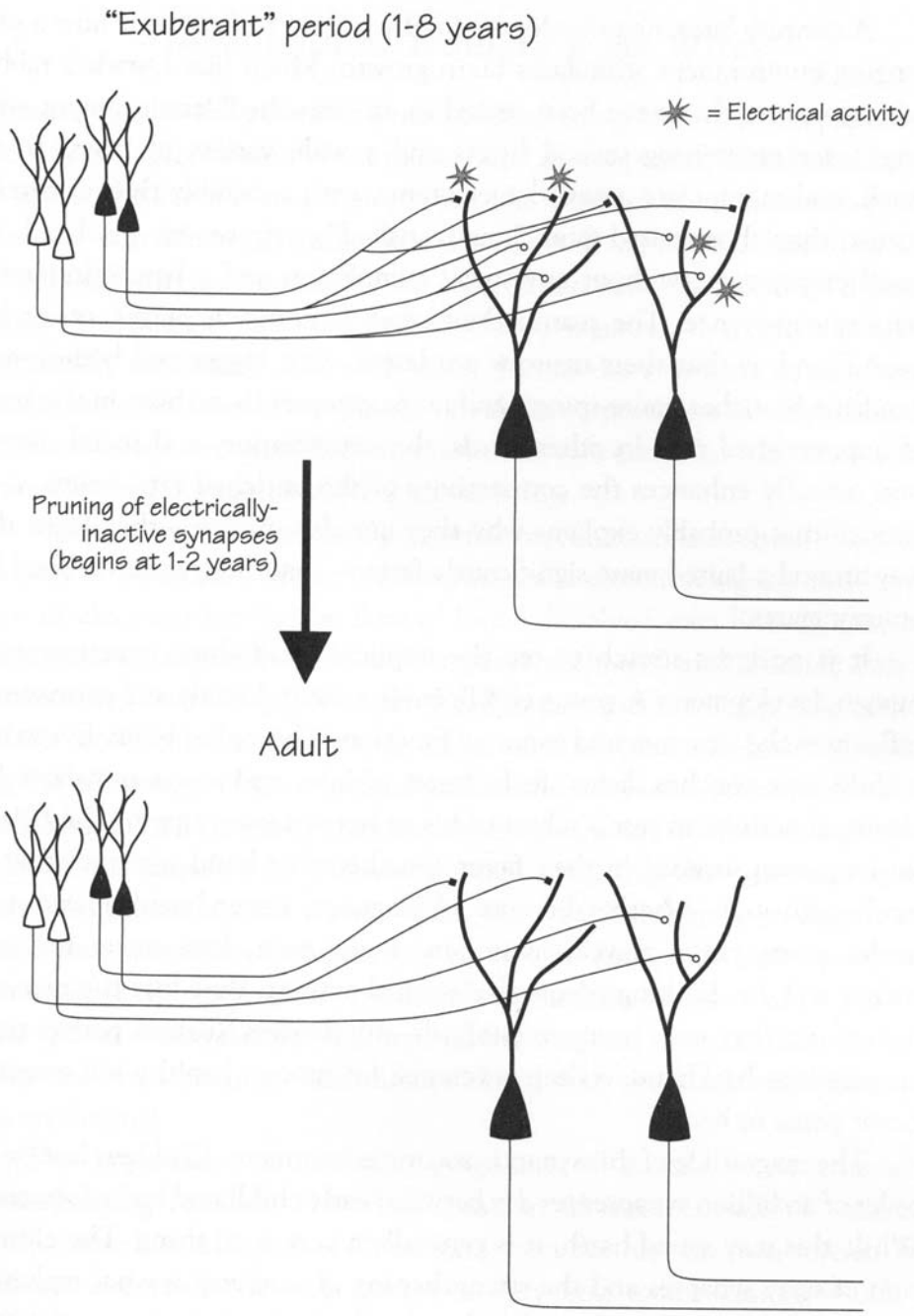
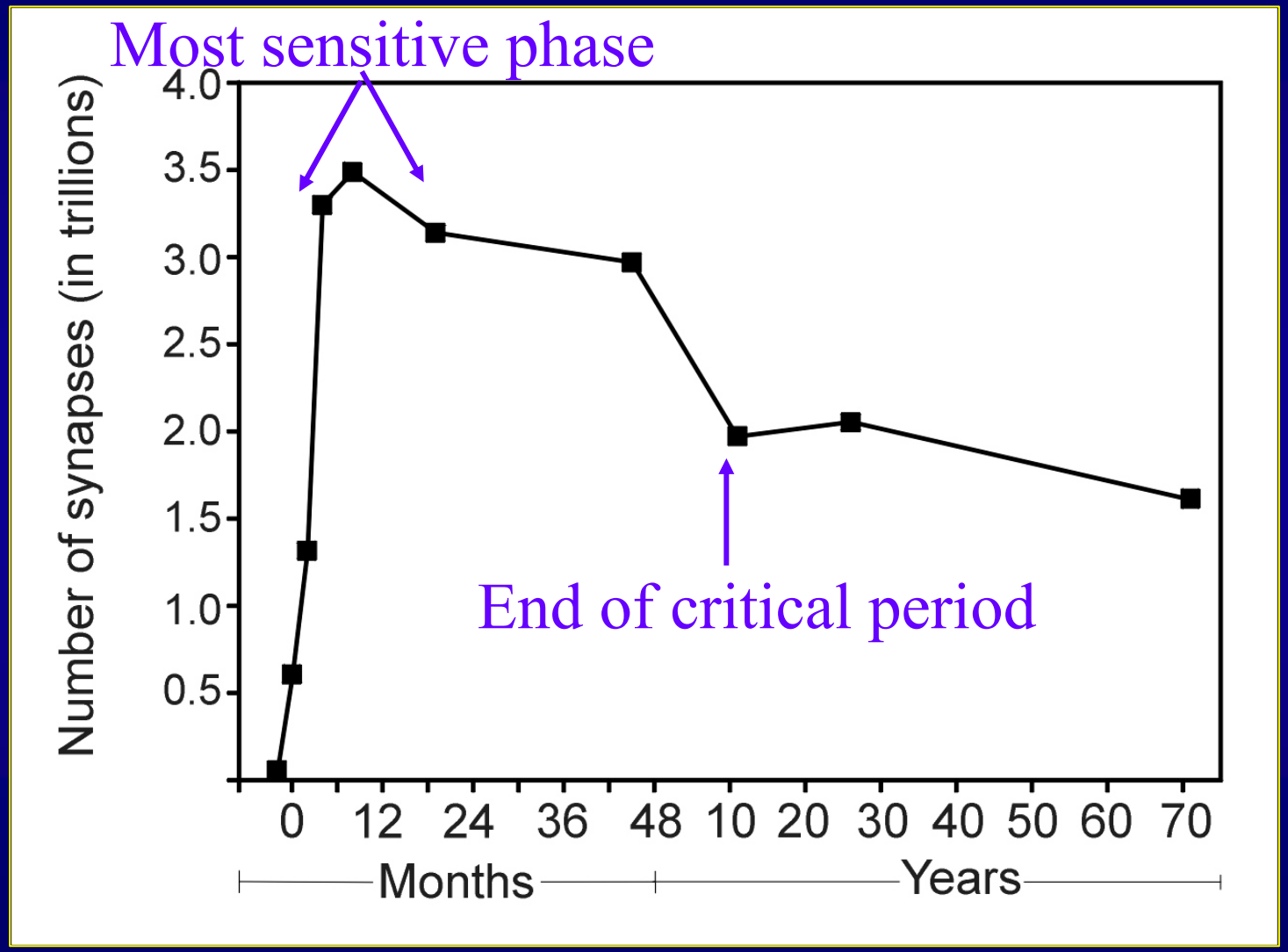


Image from "What's Going on in There?" by L Eliot, pg 31

Overproduction of Synapses

Visual Cortex



Huttenlocher, *Neuropsycologia* 1990;28(6):517-27

Protective Effects of Enriched Environment

- Animal studies (rats)
- 4 groups
- Animals raised in enriched environment were protected from effects of lead

	No lead	+ lead
Enriched	1	2
Isolated	3	4

Schneider et al. *Brain Research* 2001;896:48-55
Guilarte TR et al. *Annals Neurology* 2003;53:50-56

Development of Intelligence

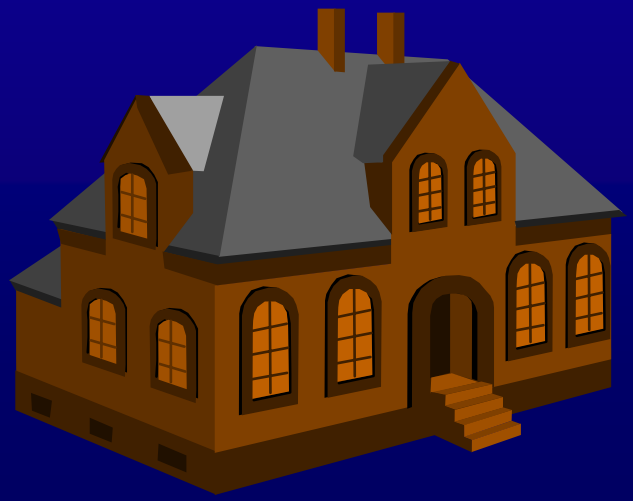
- By 5-6 years correlation between IQ test results and adult IQ is strong (about 0.7)
- Influence of home environment is stronger in early years (less so by older grade school years)
- Grade school performance largely influenced by quality of family life (less so by genes)
- 2-4% of variance (4-5% of explained variance) in neurodevelopment measures accounted for by child's blood lead

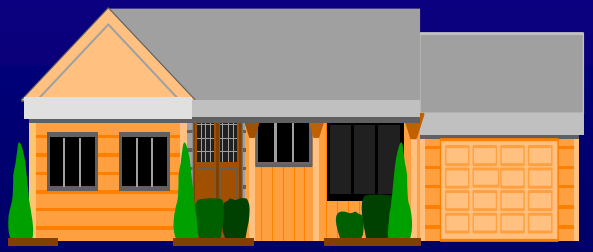
Strategies to Enhance Positive Development Outcomes

- Foster parental nurturing
  - Reading to your child
  - Language
  - Positive self-concept
- Clinical monitoring
- Early Intervention programs
  - Associations with lead outcomes not specifically examined

Extent of the Problem: Lead Hazards at Homes

Year built	% w/ Pb paint	if child <6 y % w/ Pb hazards
before 1940	68%	81%
1940-1959	43%	57%
1960-1977	8%	9%
1978-1998	3%	1%





HUD. National Survey of Lead and Allergens in Housing. 2001
Jacobs et al. Env Health Perspect 2002;110:A599-606

Attending to Lead Hazards

- Multiple federal, state, local funding strategies insufficient to address magnitude of the problem
- Case management (& BLL that triggers home inspection) varies by state/location

Steps to Address: Educational Programs for Prevention/Intervention

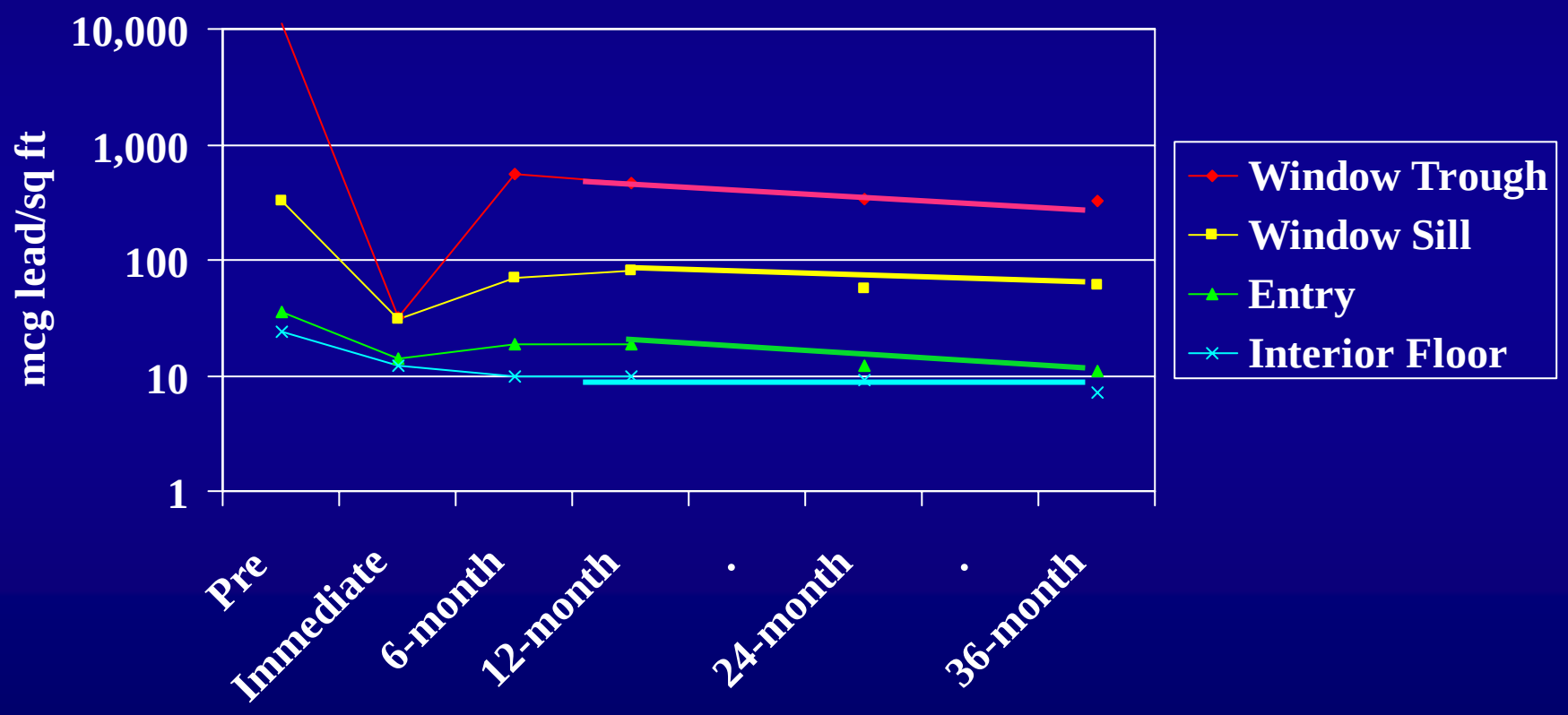
- In-home education (up to 8 sessions) no effect on prevention of blood lead ≥10 μg/dL (Lanphear et al)
- Peer education (28 sessions over 3 years) reduced risk of blood lead ≥10 μg/dL by 34% (Jordan et al)
- No studies on effectiveness of office-based education

Lanphear et al, Pediatrics 2000;106(4)/e48
Jordan et al, *Environ Health Perspect* 2003;111:1947-51

Steps to Address: Understand Your Home

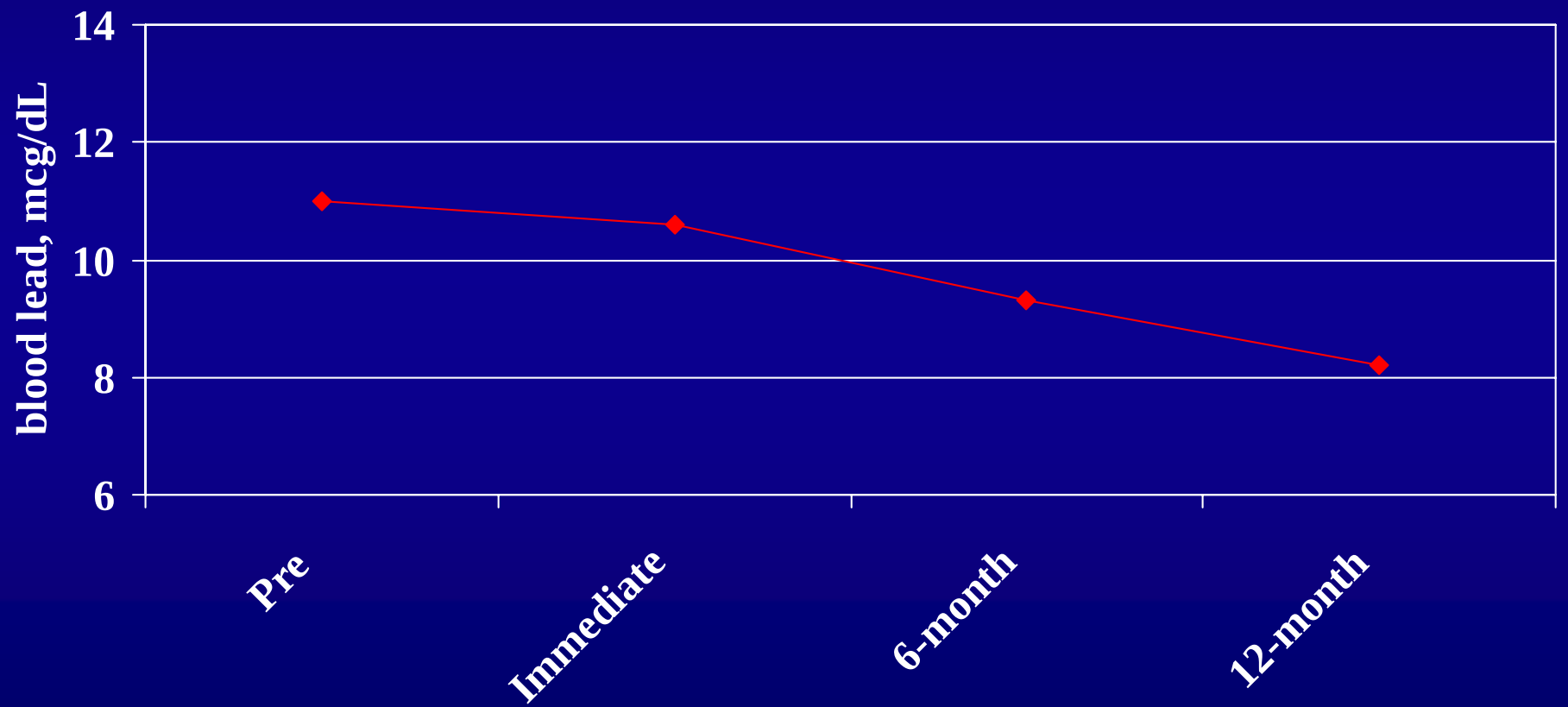
- Identification of lead hazards in homes
  - Tenant – request copy of past lead testing reports
  - Disclosure of known lead at sale
  - Arrange for lead inspection (at buyer/renter expense)
  - Pamphlet "Protect Your Family…"
- Dust wipe testing
- Assume lead in home if "don't know"
- Cautions regarding renovation
  - Skills and training required

Prevention/Intervention: Hazard Control Reduces Lead Dust Levels



Galke et al *Environ Research* 2001;86:149-56

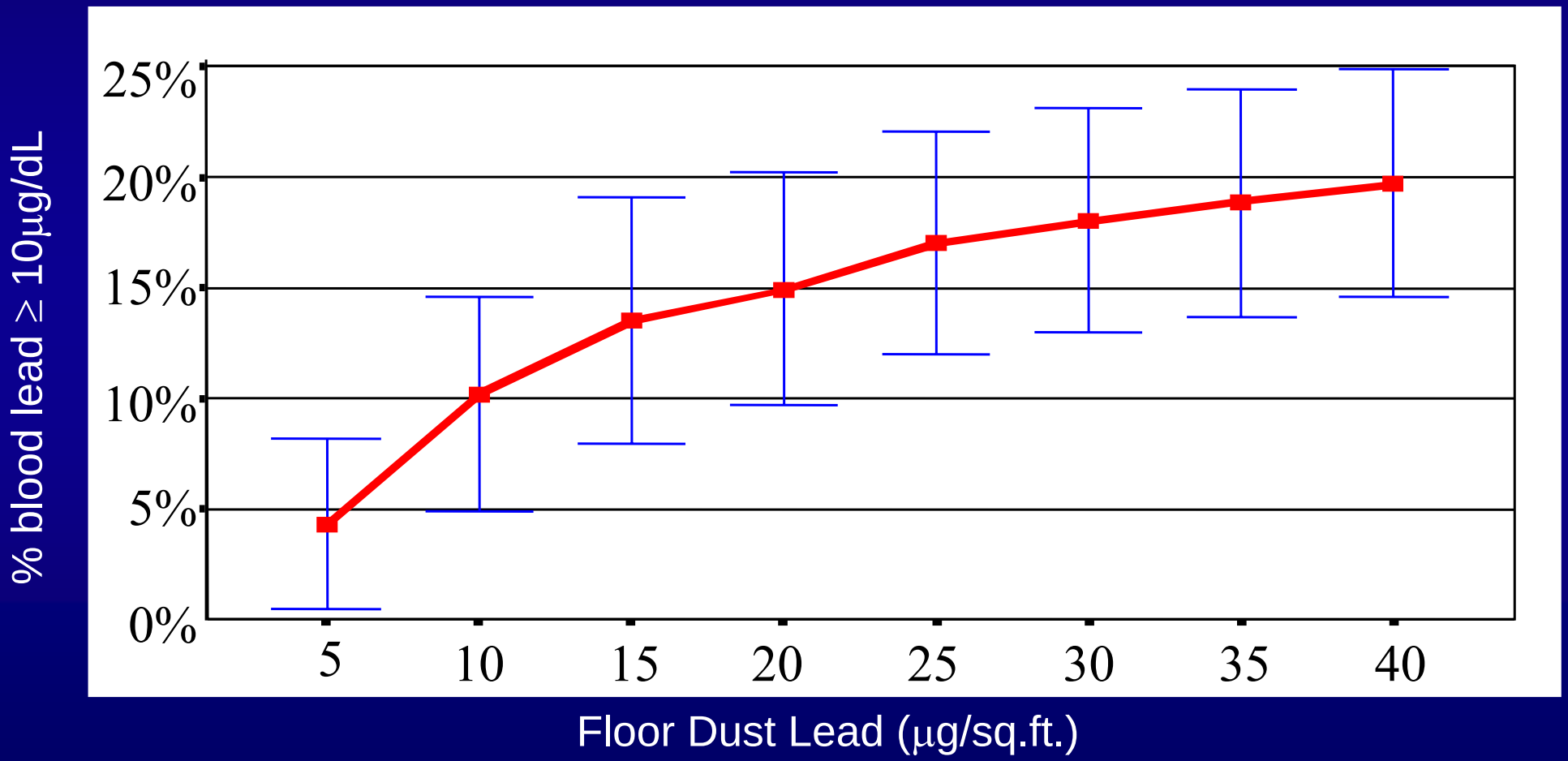
Prevention/Intervention Hazard Control is Associated with Lowering Blood Lead



9% had rising BLL – (<2 yr old child of less educated mother)

Galke et al, *Environ Research* 2001;86:149-56 Clark et al, *Environ Research* 2004;96:196-205

Percent of Children With Blood Lead Levels ≥10 μg/dL for Range of Dust Standards

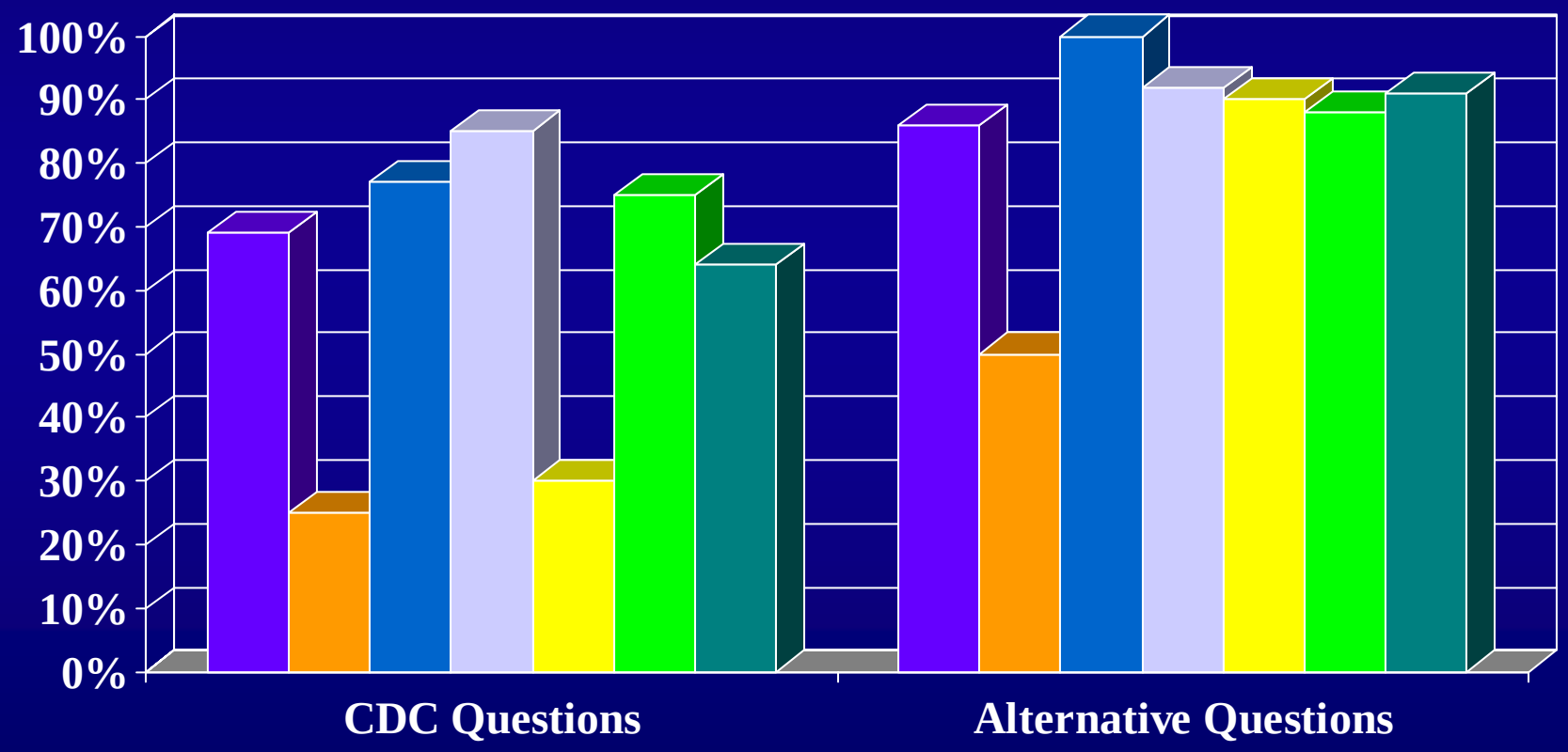


Lanphear et al *AJPH* 1996;86:1416-1421

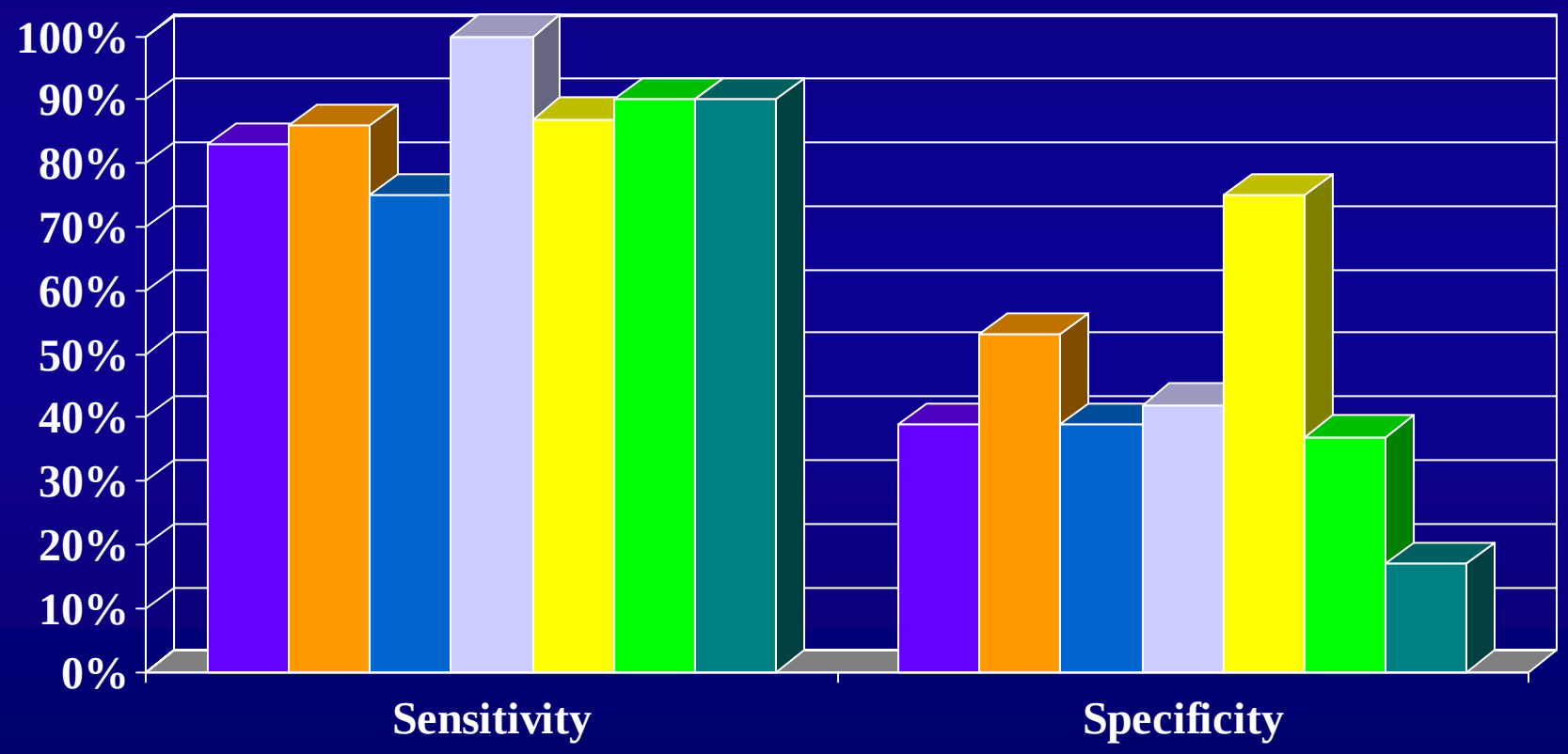
Blood Lead Screening

- Follow local guidelines
- In absence of guidelines, get tests

Sensitivity of Risk Assessment Questionnaires at ≥10 µg/dL



Sensitivity and Specificity of Risk Assessment Questionnaires at ≥10 μg/dL



Recommendations for Clinicians

- Anticipatory guidance to parents
  - Environmental and family history
  - Provide education
  - Encourage parents to examine their homes
  - Encourage parents to make their homes safe
  - Warn parents about unsafe renovation
  - Refer to local, state, federal partners to information

Recommendations for Clinicians

- Use laboratories that routinely achieve performance of ±2 μg/dL for blood lead analysis
- Conduct blood lead screening in accordance with state/local policies
  - If blood lead level nearing 10 μg/dL, consider child age, season, exposure history to in determining follow-up strategy
- Diagnostic blood lead testing for suspected exposures
- Partner with public health, community groups and parents

Recommendations for Government Agencies

- Expand services that promote primary prevention
- Develop systems for clinicians/parents to learn about services

- Establish jurisdictional policies that mandate lead safety in housing – & develop enforcement strategies
- Develop and apply systematic approaches to prevent exposures to even small amounts of lead in food or consumer products, particularly with safer alternatives are available.

Recommendations for Government Agencies

- Promote implementation of primary prevention plans at state and local levels
- Expand availability of and promote early intervention programs
- Research on effects of lead at levels <10 μg/dL and strategies to identify and reduce exposures to lead

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