Estimating Risks in Urban Agriculture

- Urban vs rural agriculture- definition
- Agriculture and horticulture in densely populated areas or near industry
- One-half of the world's population is or soon will be urban.
- Agriculture will continue with attendant risk

Magnitude of populations at risk & scale of crop production

- 1/4 of U.S. households “have” a vegetable garden
- ½ million (below 1 %) use community gardens in U.S. May be unequal socioeconomic dependence
- Allotments (established locations) a long tradition in Europe, serve larger fraction of population
- Up to 40% of vegetables in some areas grown in urban conditions (not in U.S.)
- Agriculture continues in rapidly developing urban areas worldwide until forced out by population growth

Contaminants of most concern in urban settings

- Heavy metals- lead, (cadmium, copper, zinc, mercury)
- Arsenic- also a rural water problem
- PCBs, DDT, Chlordane
- Dioxins, PAHs

Lead may be the #1 risk because:

- Neurotoxin at <10 ug/dL in children & there is no known safe threshold
- High soil levels remain from leaded gasoline use, some places still use it
- Secondary smelters and reprocessing of batteries, which are in increasing demand
- High-lead paint in older urban areas
- Continued use of lead-containing paints in Asia (e.g. on export toys)

Typical lead levels in central city soils upper layers

- Total to 1000 mg/kg, median ~500 mg/kg
- Available levels up to 500 mg/kg, median ~200 mg/kg in upper few cm
- This estimate is based on near current values for many cities worldwide
- Surface concentrations <u>may</u> decrease with removal of leaded gasoline source

Samples of a continuing problem

- Gump et al, Env Health Persp 116 (2008) on altered cortisol stress response effects at <10 ug/dL blood lead
- Clark et al, Env Res 102 (2005) find 2/3 paints in China, India, Malaysia > 5000 ppm, see also Aug 14, 2009 report by www.cseindia.org/lead_paints.pdf (still true)
- M.A.S.Laidlaw, Association between soil lead and blood lead- Evidence 2009, >~100 abstracts www.urbanleadpoisoning.com
- Carrizalesa et al, Env Res 101 (2006) 90 % 3-6 yr olds near copper smelter in Mexico exceed 10 ug/dL blood lead
- Edwards et al, Env Sci Technol (2009) elevated blood lead from water in Washington DC
- Mitra et al, Int J Env Res Public Health 6 (2009) blood lead 25 +/-10 ug/dL in an industrial Bangladeshi city area

Wang et al, Env Health Persp 116 (2008) on ADHD in China, controls have 5.8 ug/dL, affected 8.8 ug/dL (both high for today)

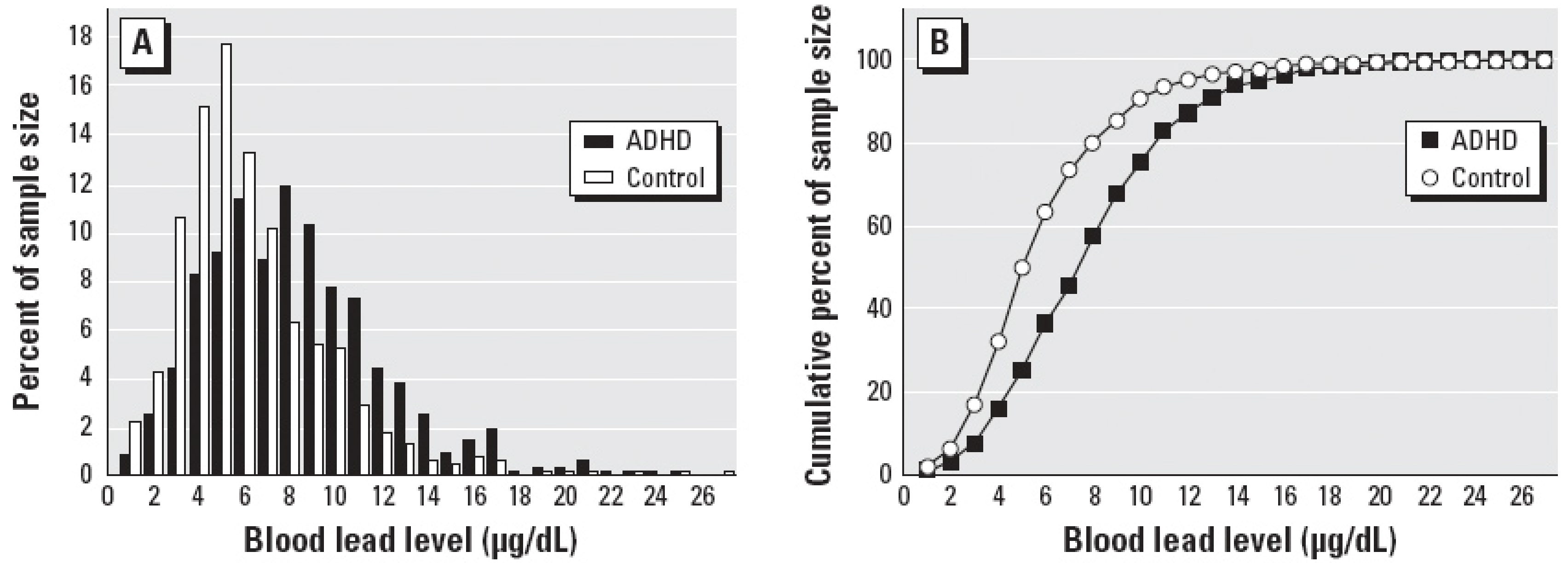


Figure 1. (*A*) Blood lead distribution (%) of ADHD cases and controls. (*B*) Cumulative distribution (%) of blood lead for ADHD cases and controls.

The U.S. target for children's total lead intake is <10 ug/d, EU is 25 ug/kg/wk

- Direct soil or house dust ingestion is major contributor (e.g. 20 mg @ 500 mg/kg = 10 ug)
- Drinking water contributes < 2 ug/d, on average, can exceed 100 ug/d (e.g. Washington DC from 2001-2004, chloramine T effect)
- Air inhalation contributes little directly when no leaded gasoline in use (few PM2.5s)
- U.S. commercial foods (other than vegetables) contribute < 3 ug/d to adult diet

Weighing the relative risks

Lead transfer to food crops and other vegetation occurs by two routes

1. Uptake via roots yielding leaf dry wt levels ~ 1% of soil total concentration; range 0.001 to 0.03, depending on soil type, lead availability
2. Contact sorption- highly variable by site, reaches up to ~10 % of soil levels (per dry wt) including:

A. Ultrafine (PM2.5) particles from lead sources

B. Wind-blown dust, rain splashed surface soil

Diet is a major route of potential lead ingestion for all ages

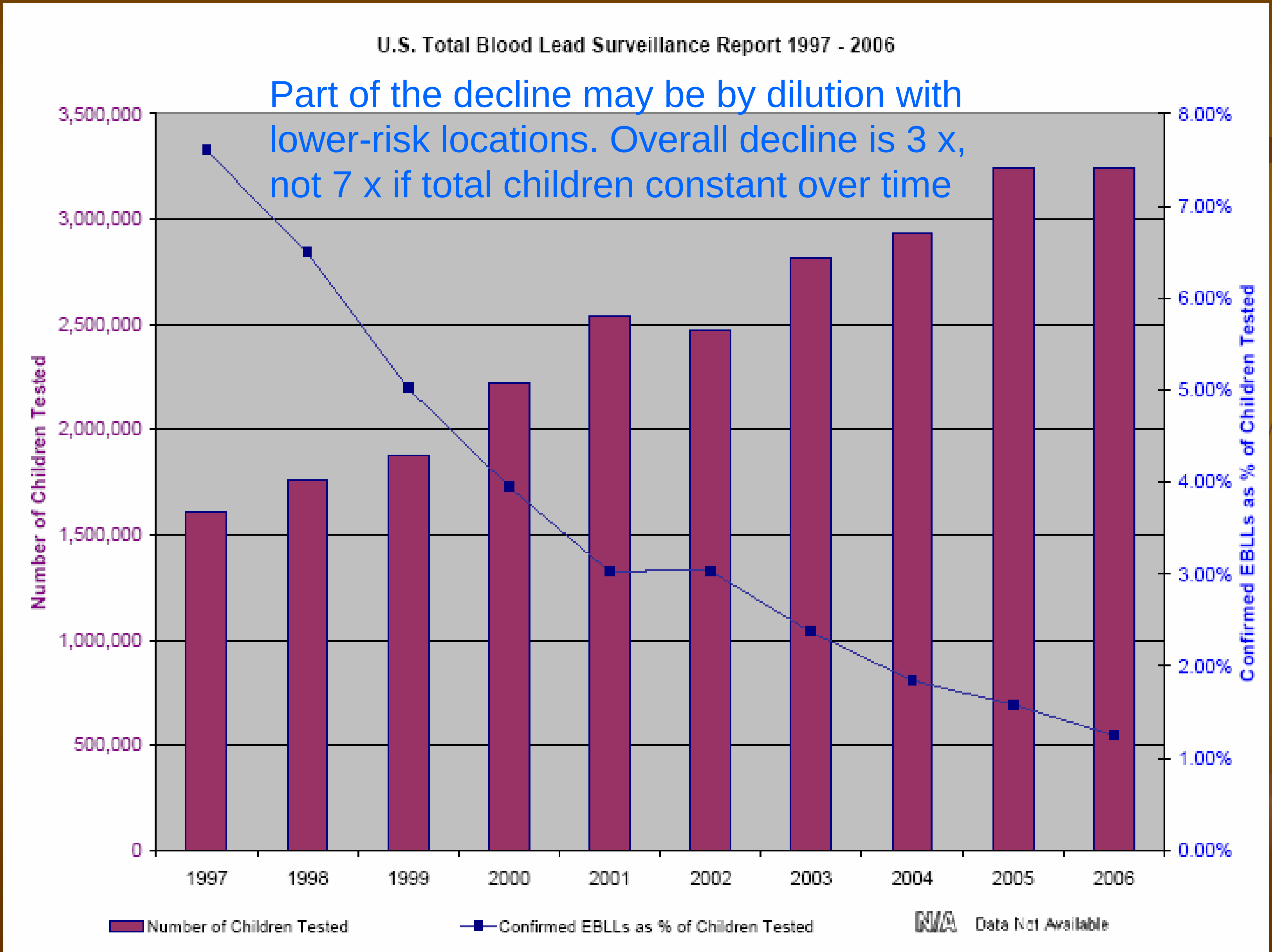
Adult food intake is <0.5 - 1 kg/d dry wt. Beverages and drinking water another source.

For young children up to 1 kg (fr wt)/d food and beverages, especially formula for infants

Lead may be contained in food or sorbed to it from dust and dirt, in production & distribution

Homegrown vegetables may contain 10 to 40 mg/kg dry wt from a soil with 1000 mg/kg lead. Proportionality at low lead is hard to show

Heading in the right direction



Target for total lead intake in children is <10 ug/d, a very low value

- Direct soil or house dust ingestion is major contributor (e.g. 20 mg @ 500 mg/kg = 10 ug)
- Drinking water contributes < 2 ug/d, on average, can exceed 100 ug/d (e.g. Washington DC from 2001-2004, chloramine T effect)
- Air inhalation contributes little directly when no leaded gasoline in use (few PM2.5s)
- U.S. commercial foods (other than vegetables) contribute < 3 ug/d

Estimating lead contribution of fresh vegetables from likely consumption

- A 2-year-old consumes ~6 g/d (fresh wt) root or leafy vegetables & <12 g/d other vegetables likely to be home grown
- Lead accumulation in edible root or leaf (fresh wt basis) is 1/300 to 1/2000 of soil level; assume 1/1000 typical (fresh wt)
- With soil level 500 mg/kg, plant material gives 0.5 ug/g, or 9 ug/d with 18 g all vegetables in diet
- Seasonality restricts most home produce items to consumption 1/6 of year, so annual average is 1.5 ug/d
- A higher-risk scenario would be an accumulation ratio of 1/400 yielding ~4 ug/d.
- A 5x greater consumption of vegetables on soil with 1000 mg/kg lead would give a further 10x increase in intake.
- High available lead plus high vegetable consumption could give undesirably high intake. This is very unlikely in U.S. but not unreasonable in dense urbanizing areas of rapid development regions (e.g. Egypt, Pakistan, Bangladesh)

EPA's IEUBK model estimates blood lead related to multiple inputs.

- For vegetables, an intake of 17 ug/d may give a 3-4 ug/dL increase in blood lead. (Current blood lead levels in U.S. children are near, <2 ug/dL, except in central cities.)
- Ingestion of dirt or dust will easily provide 10-20 ug/d, potentially much more (primarily dependent on area soil lead levels).
- For children eating large amounts of homegrown produce from highly contaminated soils, there is a definite risk of significant elevation of blood lead levels

Cadmium is a potential cumulative risk

- Cadmium may come from biosolids, industrial wastes
- In the U.K., there is no evidence for cadmium levels elevated in urban (industrial) vs rural areas
- Biosolids (historically with industrial waste) may be applied to urban allotments or agricultural areas.

  1.In Berlin one area of long term biosolids disposal gave crops with high cadmium.

  2.In U.S. there is no evidence for increased cadmium in crops where biosolids are disposed
- Rice may be an effective cadmium accumulator

Arsenate comes from several sources, natural and agricultural

- Arsenate reported accumulation in plants varies widely with soil type. Soils with ~40 mg/kg As showed plant levels ranging below 1, up to 40 mg/kg in similar U.S. studies
- Compost decreases and phosphate may increase accumulation in plants
- Acceptable As in food is generally <1 mg/kg
- High soil As happens near CCA treated wood, or when irrigation water or soil contains high As (e.g. Bangladesh, a few U.S. regions)