Vitamins, minerals, and metals: Do healthy diets counteract health effects of toxicants?

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Pathways of Exposure

Ingestion

- Foods of all kinds

- Dietary supplements

- Breast milk for infants

- Water as a beverage or in juices, soda, coffee, tea, soup

Uptake

- **Absorption of Contaminants**: Residues, heavy metals, unintentional additives

- **Absorption of Nutrients**

  - Bioavailability from different foods

  - Interaction of nutrients in foods to aid or block absorption

Study Population and Measures

Early Life Exposures to Metals and ENvironmental Toxicants (ELEMENT)

- **Sample:** 250 pregnant mothers and children ages 8-15 years
- **Exposures:**
  - Cd (urine): 3rd trimester of pregnancy and adolescence
  - Pb (bone): 1 month postpartum; (blood) 8-15 yr
- **FFQs** (mother, child): Estimate dietary Cd and nutrient intakes
- **Metabolic syndrome components** measured in adolescents:
  - Adiposity (WC, BMI, skinfolds)
  - Blood pressure; fasting glucose and lipid levels

Background: Cadmium

- Ubiquitous metal with modifiable exposure sources: tobacco and diet where take up Cd from soil

- Toxic effects include renal and bone disease, cardio-metabolic dysfunction, and cancer

- Pregnant women and children are vulnerable groups in countries undergoing the nutrition transition, but little is known about their exposure

Figure 1. *Exposure to cadmium from food.*

aadnc-aadnc.gc.ca
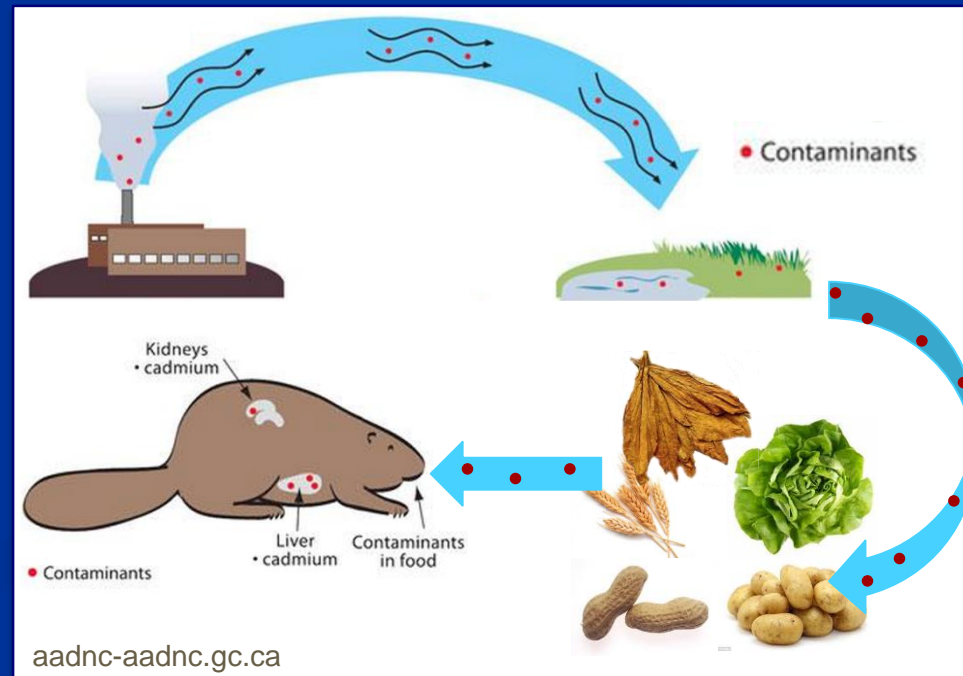
Study Goal and Analysis

- Is dietary cadmium (DCd) associated with urinary cadmium (UCd) of mothers during 3rd trimester and children aged 8-15 years, stratified by smoking status?

- **Statistical Analysis**
  - DCd estimated from FFQ and US FDA Total Diet Study, energy-adjusted
  - UCd, log-transformed; specific gravity adjusted
  - Linear regression models estimated association of DCd and UCd for mothers and children, stratified by maternal smoking history
  - Covariates: cohort, sex, age, SES level, BMI

**Moynihan , et .al. CEHC-PEHSU Annual Meeting, October 2015.**

Characteristics of mothers and children by maternal smoking history

Mothers		+ Smoke	− Smoke
N	192	94	98
Sex Female	192 (100)	94 (100)	98 (100)
Age (years)	27.4±5.9	26.4±5.2	28.5±6.3
SES level	8±3.2	8±3.3	8±3.2
BMI^2	29.6±4.0	30.2±4.2	29.0±3.8
DCd (μg/day)	9.2±3.9	8.6±3.4	9.9±4.2
UCd (μg/L)	0.268±0.6	0.206±0.2	0.326±0.8

Children		+ Smoke	− Smoke
N	223	112	111
Sex Female	118 (52.9)	57 (50.9)	61 (55.0)
Sex Male	105 (47.1)	55 (49.1)	50 (45.0)
Age (years)	10.3±1.6	10.2±1.5	10.4±1.7
SES level	8±3.3	9±3.3	8±3.3
BMI^2	0.85±1.2	0.95±1.3	0.74±1.2
DCd (μg/day)	12.1±6.4	12.3±6.8	11.8±5.9
UCd (μg/L)	0.150±0.1	0.139±0.1	0.161±0.2

- DCd were within average intake ranges (8-25 g/day): Mothers (9.2 μg/day) and children (12.1 μg/day)
- UCd levels were higher in mothers (0.268 μg/L) than children (0.150 μg/L)

Estimated daily percentage of DCd
by food group for mothers and children
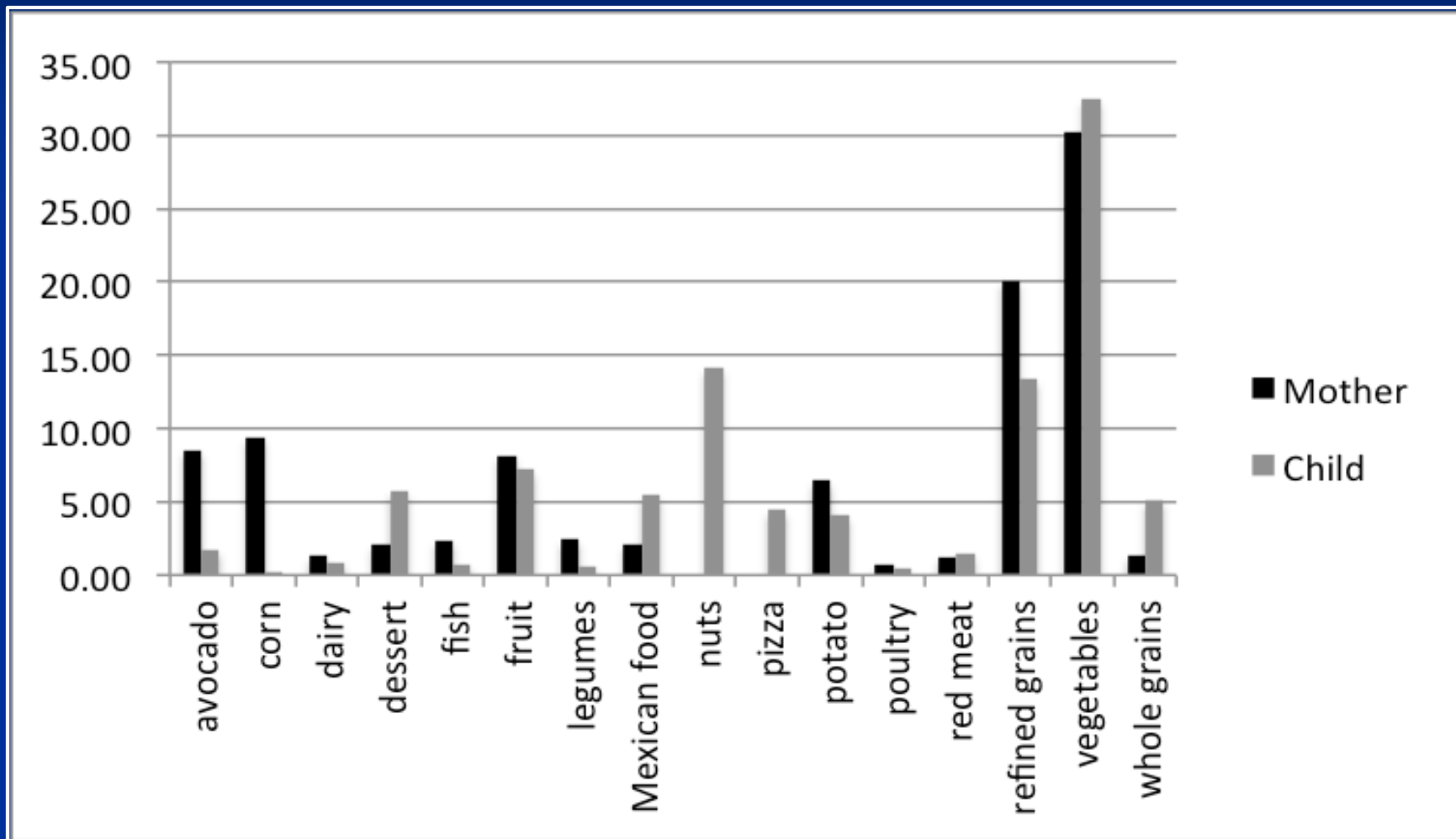
Dietary Predictors of UCd

Associations with log UCd for mothers and their children by maternal smoking history[1]

|	Mothers				Children			
	+ Smoke		**− Smoke**		**+ Smoke**		**− Smoke**	
	Beta	p-value	Beta	p-value	Beta	p-value	Beta	p-value
Unadjusted								
Dietary cadmium	-18.01	0.431	**63.73**	**0.005**	-3.75	0.6989	**20.76**	**0.080**
Adjusted[1]								
Dietary cadmium	-34.49	0.139	**49.76**	**0.025**	-4.02	0.690	**26.12**	**0.033**

[1]Multivariable models for mothers and children adjusted for cohort, sex, age, SES level, and BMI.

Associations of intake of selected food groups with log UCd resulting from stepwise regression[2]

Food groups (g/day)	Beta	p-value
Mother[2]		
Poultry	0.007	0.111
Fruit	0.001	0.001
Vegetable	0.002	0.037
Children[2]		
Avocado	0.004	0.068
Potato	0.014	0.03
Pizza	-0.007	0.018

[2]Analyses limited to mothers and children without a maternal history of smoking.

Lead exposures: Mexico City
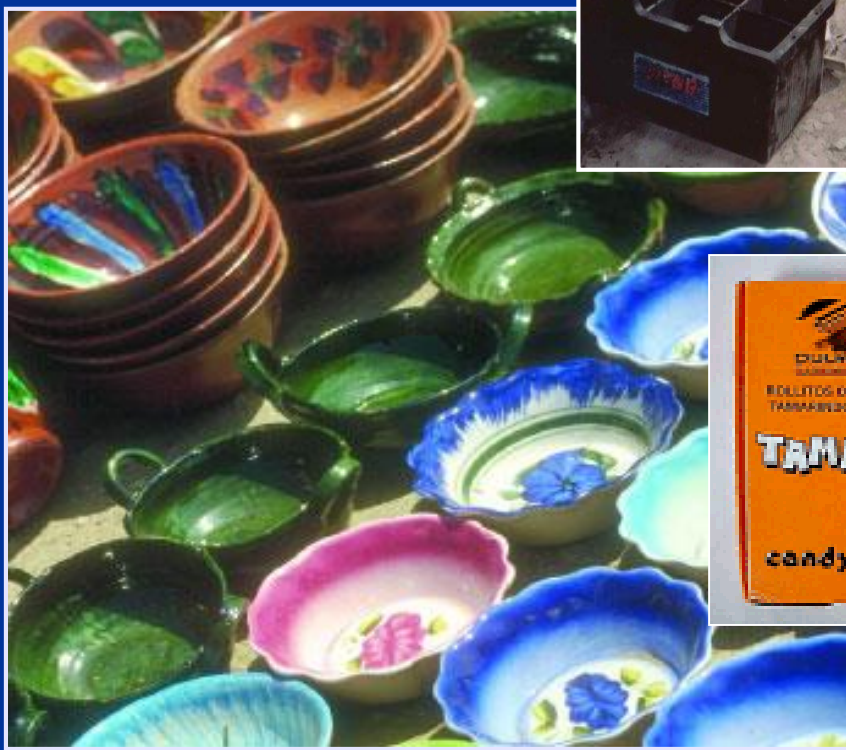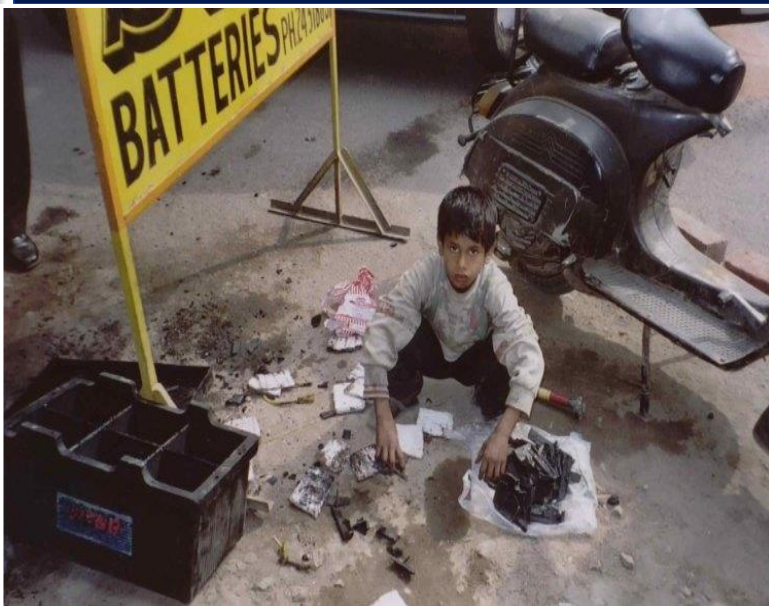
Leaded gasoline phased out in Mexico between 1991 and 1997.

Lead exposure and cardiometabolic risk

- Metabolic syndrome affects 30 % of obese adolescents
- Life stage Pb exposures in ELEMENT related to:[1]
  - **Lower** **BMI and leptin**, only in <u>girls</u>
  - **Increases** in **BP and serum lipids** in <u>girls</u>
  - **Increases** in fasting **glucose** in <u>boys</u>
- Findings suggest relationships that reflect oxidative stress but vary in boys and girls.
- **Antioxidant nutrients** may have potential to modify effects of Pb on children's cardiometabolic risk[2]

[1]**Peterson ISEE 2013; Zhang, et al., in preparation;** [2]**Moynihan, CEHN Conference Feb 2015**
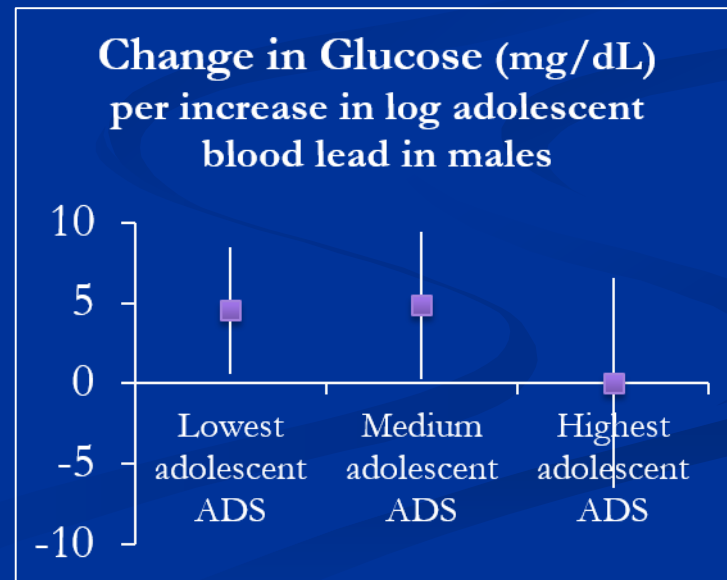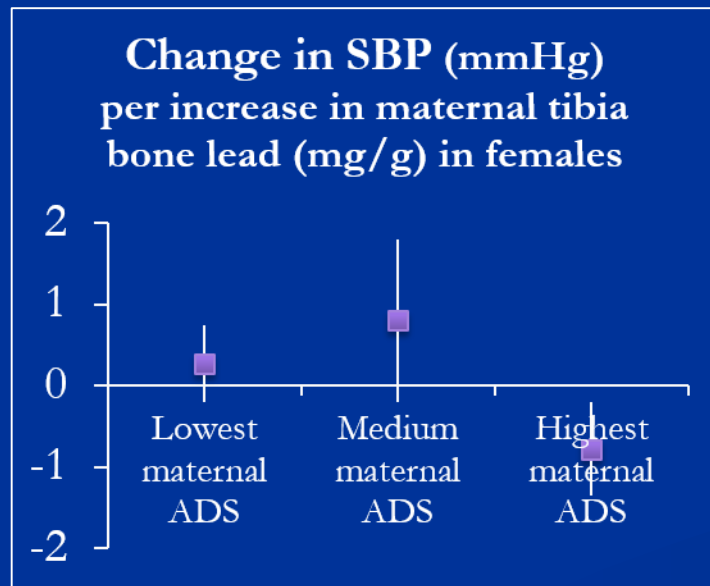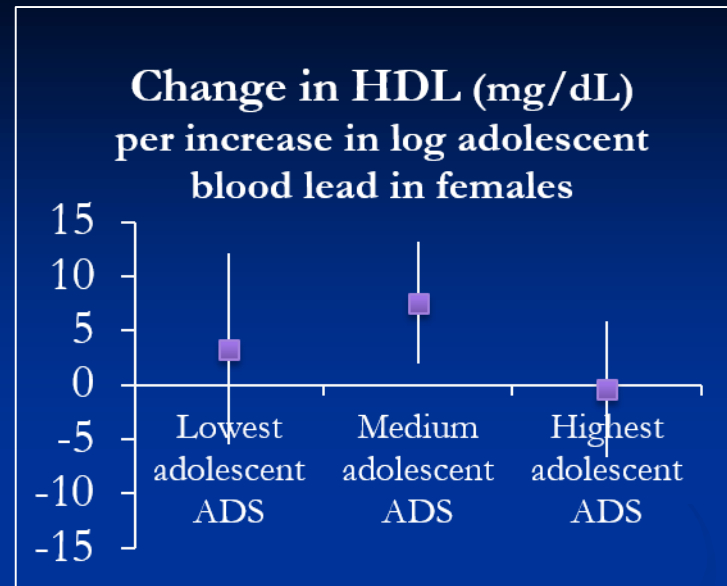
Objectives

- Estimate antioxidant intake of pregnant mothers and their children at 8-15 years
  - **Antioxidant diet score (ADS)**
  - Based on quintile of intake of 14 nutrients calculated by FFQ
  - Sum of nutrient scores
  - Pro-oxidants (saturated fat & cholesterol) inversely scored
- Determine if antioxidant intake modifies the association of *in utero* and concurrent Pb exposure with cardiometabolic outcomes in adolescence

Maternal Antioxidant Diet Score (ADS)

Nutrient	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Vitamin A, RAE (µg)	504.1	745.8	910.0	1076.8	1627.9
Vitamin C (mg)	85.0	128.0	160.4	200.6	319.5
Vitamin E, α-tocopherol (mg)	6.7	8.0	7.2	8.9	10.1
Selenium (µg)	31.6	41.0	45.8	51.7	63.1
Vitamin B6 (mg)	1.4	1.7	1.9	2.1	2.5
Magnesium (mg)	254.0	292.1	316.0	340.5	385.6
Zinc (mg)	7.7	8.8	9.6	10.5	12.6
Copper (mg)	1.0	1.2	1.3	1.4	1.6
Iron (mg)	8.8	12.0	14.3	17.8	31.6
Monounsaturated fat (g)	12.5	17.2	19.5	22.1	27.7
Polyunsaturated fat (g)	4.5	6.4	7.6	9.0	12.2
Fiber (g)	15.4	19.2	21.6	25.1	30.9
Saturated fat (mg)	83.9	73.9	68.0	61.7	51.8
Cholesterol (mg)	341.1	256.7	219.3	183.8	123.2

- Mean ADS for mother (27.9 ± 8.4) and child (28.0 ± 9.4).

Change in metabolic outcomes at 8-15 years per unit increase in Pb exposure by Antioxidant Diet Score tertile

Change in HDL (mg/dL) per increase in log adolescent blood lead in females

Change in SBP (mmHg) per increase in maternal tibia bone lead (mg/g) in females

Change in Glucose (mg/dL) per increase in log adolescent blood lead in males

Moynihan, CEHN Conference Feb 2015

Summary

- **Foods** are potential sources of **both toxicants and nutrients**; impact on children's health may depend on lifestyle behaviors

- Dietary Cd was positively associated with Urinary Cd only in **non-smoking pregnant mothers** and their children at 8-15 yr. **Sources** = fruit, vegetables, nuts, refined grains

- **Antioxidant nutrients** across developmental periods may modify association of Pb with cardiometabolic risk factors

- **Limitations:** sample size, estimated Cd content of foods

- **Next steps:** Repeated measures (n=400) across puberty; relate metals exposure to metabolomics and lipidomics; explore mediation by DNA methylation

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