Dietary Exposure to Agricultural Pesticides

(are you what you eat?)

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Evaluation of Take-Home Organophosphorus Pesticide Exposure among Agricultural Workers and Their Children

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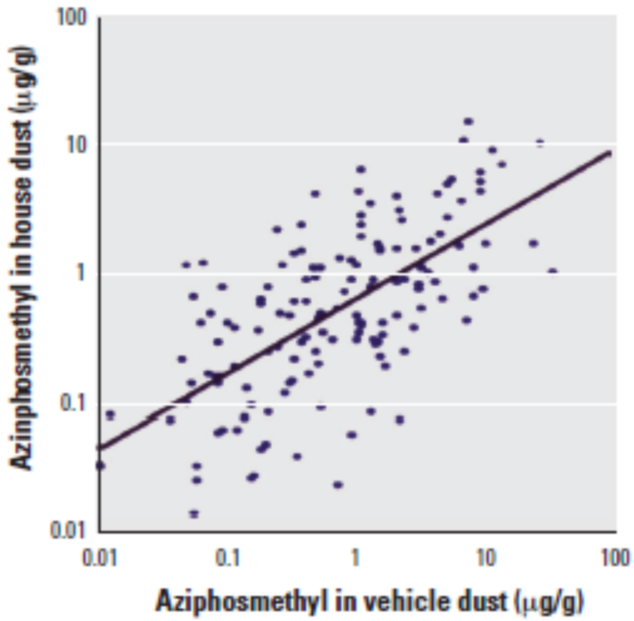

Figure 1. Plot of azinphosmethyl concentrations (n = 145) in vehicle dust (µg/g) versus azinphosmethyl concentrations in house dust (µg/g) by household (r^2 = 0.41; p < 0.0001). This plot includes samples with residue levels below the LOQ.

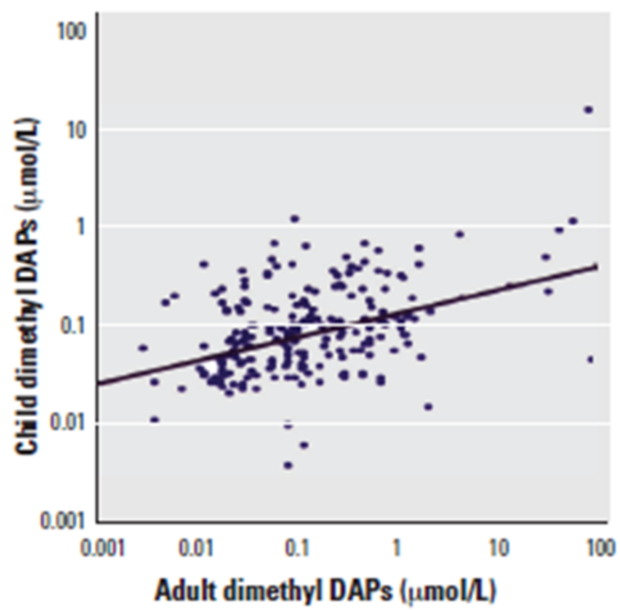

Figure 2. Plot of urinary dimethyl DAP concentrations (n = 206) in adult urine (µmol/L) versus child urine (µmol/L) by household (r^2 = 0.18; p < 0.0001). Creatinine-adjusted results are similar (r^2 = 0.15; p < 0.0001). This plot includes samples with metabolite levels below the LOQ.

Biologic Monitoring to Characterize Organophosphorus Pesticide Exposure among Children and Workers: An Analysis of Recent Studies in Washington State

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Expected

Observed

Adult farmworkers

Kids of pesticide applicators

Kids of farmworkers =

Kids in farming communities

Kids in Seattle

*During "non-spray" seasons

USDA ORGANIC

Prohibits use of:

- **Most synthetic pesticides**, including organophosphates
- Synthetic fertilizers
- Genetic modification
- Irradiation
- Human biosolids ("sewage sludge")
- Antibiotics/synthetic hormones

Organophosphorus Pesticide Exposure of Urban and Suburban Preschool Children with Organic and Conventional Diets

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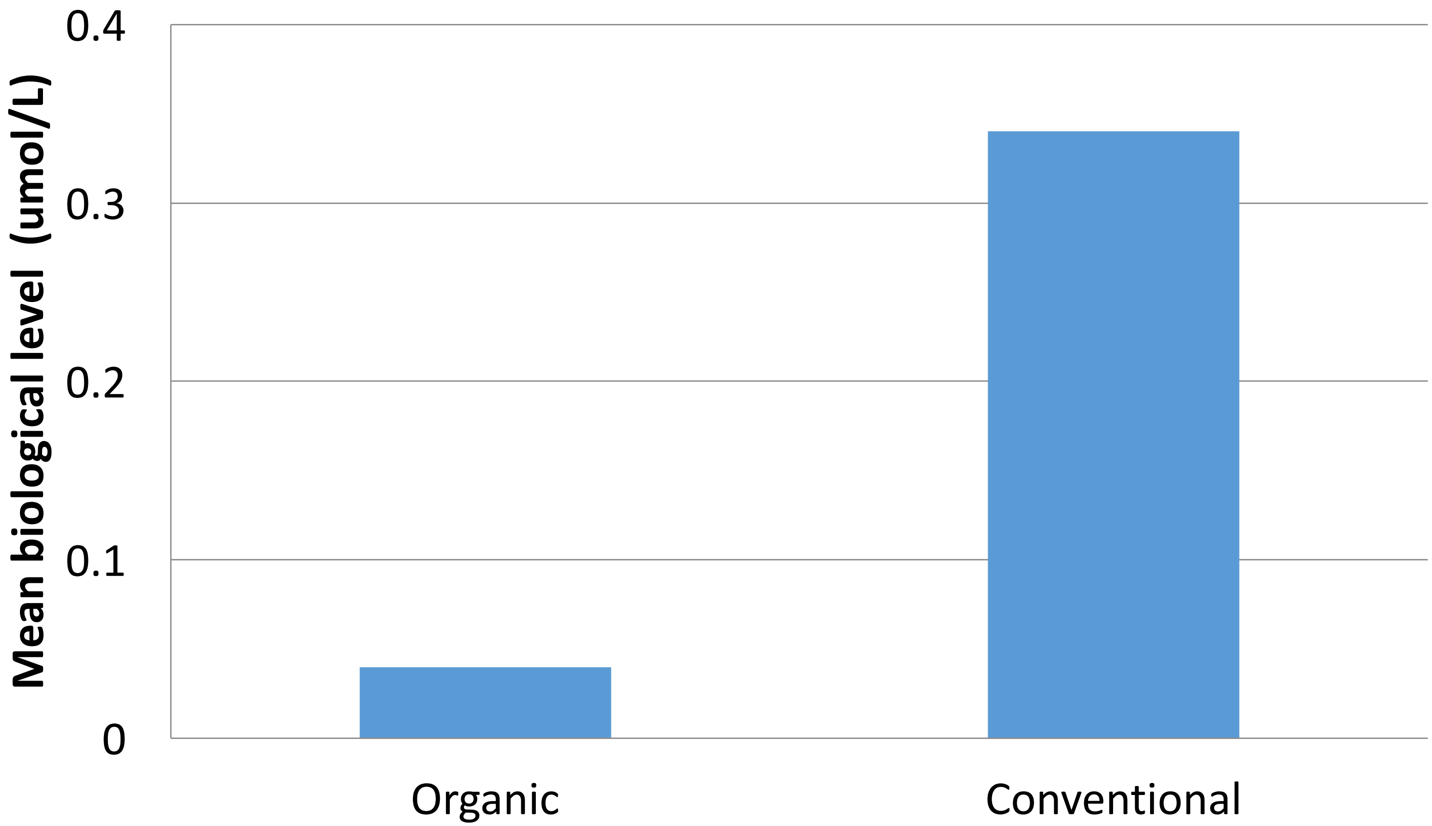

Organic Diets Significantly Lower Children's Dietary Exposure to Organophosphorus Pesticides

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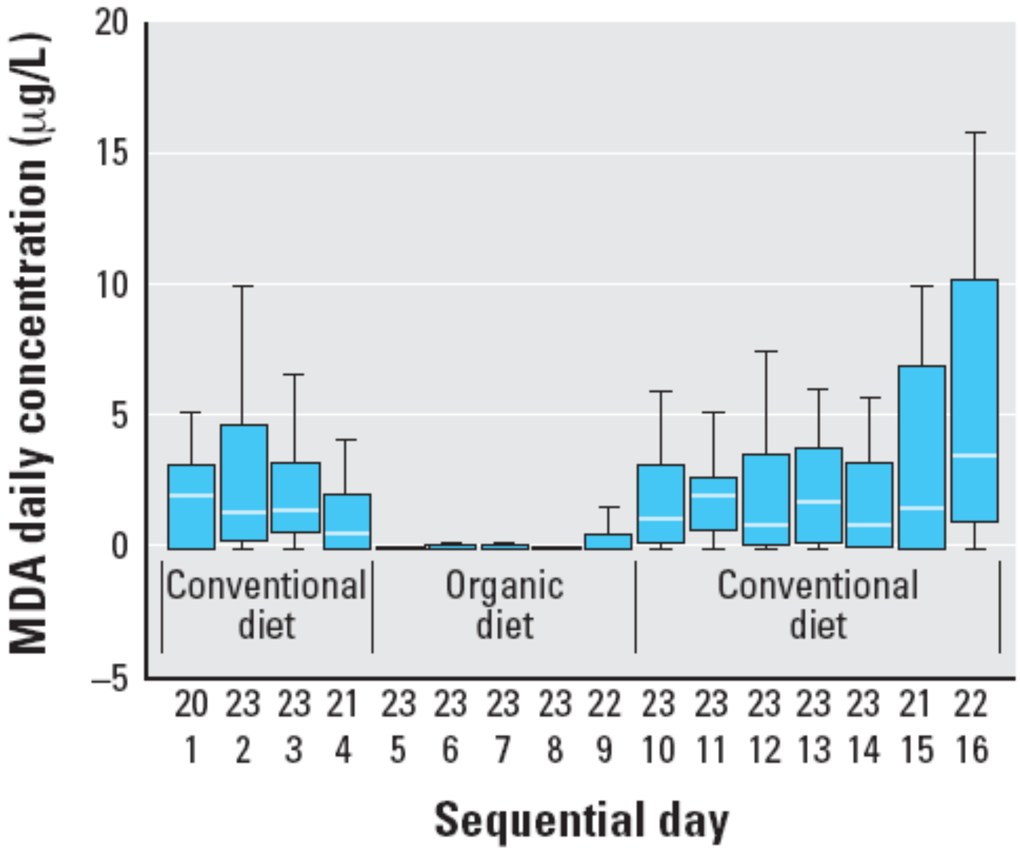

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Reduction in urinary organophosphate pesticide metabolites in adults after a week-long organic diet☆

Liza Oates [a,*], Marc Cohen [a], Lesley Braun [b,1], Adrian Schembri [c], Rilka Taskova [d]

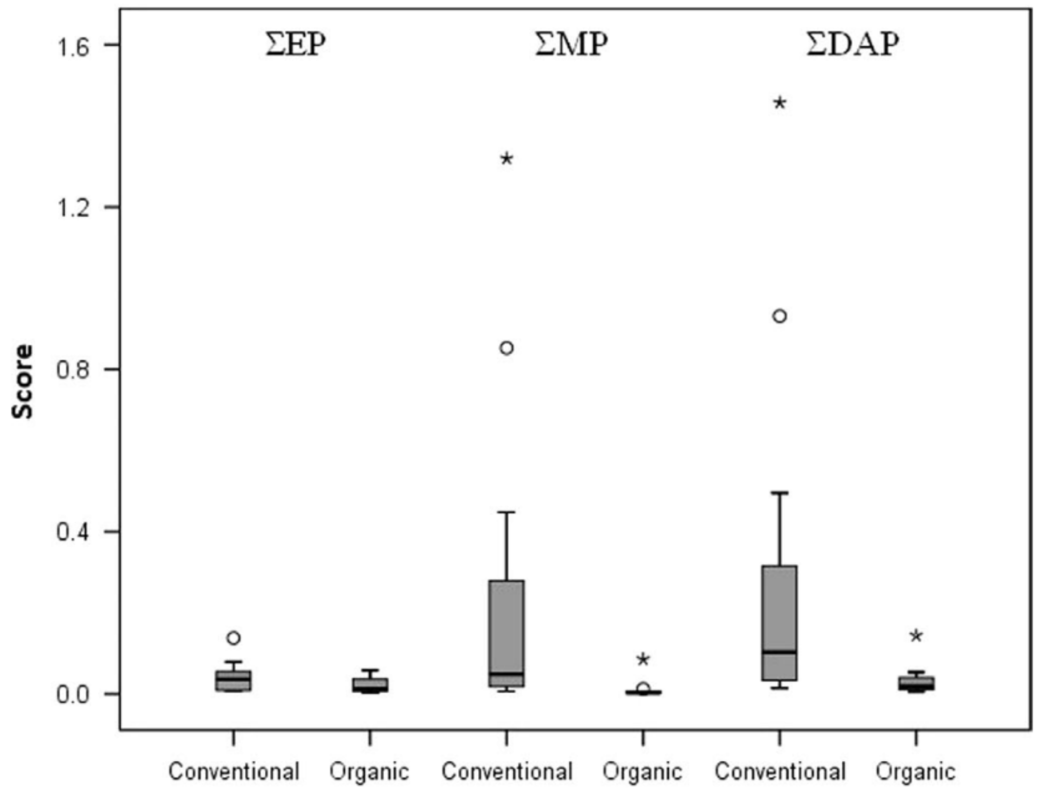

Fig. 3. ΣDAP, ΣMP and ΣEP (creatinine corrected). Mild outliers are marked with a circle (O) and extreme outliers are marked with an asterisk (*) on the boxplot.

Fox News

GREEN YOUR WORLD

New study finds organic foods are healthier than conventionally grown foods

WebMD

Organic Foods Not Necessarily Better

Study Questions Health Benefits of Eating Organic

The New York Times

ENVIRONMENT

Study of Organic Crops Finds Fewer Pesticides and More Antioxidants

Time Magazine

NUTRITION

Is It Worth Buying Organic? Maybe Not

New research questions whether organic produce and meats are really more nutritious or healthier than conventional varieties

(**MORE:** Does Organic Food Turn You into a Jerk?)

Maternal/neonatal exposure

- Mother-child cohort studies suggest that low-level pesticide exposure *in utero* can have neurological and cognitive effects
- Unknown if pesticide exposure due to conventional diet is substantial enough to cause these detriments
- Unknown if organic diet could result in measurable health benefit

Seven-Year Neurodevelopmental Scores and Prenatal Exposure to Chlorpyrifos, a Common Agricultural Pesticide

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Background: In a longitudinal birth cohort study of inner-city mothers and children (Columbia Center for Children's Environmental Health), we have previously reported that prenatal exposure to chlorpyrifos (CPF) was associated with neurodevelopmental problems at 3 years of age.

Objective: The goal of the study was to estimate the relationship between prenatal CPF exposure and neurodevelopment among cohort children at 7 years of age.

Methods: In a sample of 265 children, participants in a prospective study of air pollution, we measured prenatal CPF exposure using umbilical cord blood plasma (picograms/gram plasma) and 7-year neurodevelopment using the Wechsler Intelligence Scale for Children, 4th edition (WISC-IV). Linear regression models were used to estimate associations, with covariate selection based on two alternate approaches.

Results: On average, for each standard deviation increase in CPF exposure (4.61 pg/g), Full-Scale intelligence quotient (IQ) declined by 1.4% and Working Memory declined by 2.8%. Final covariates included maternal educational level, maternal IQ, and quality of the home environment. We found no significant interactions between CPF and any covariates, including the other chemical exposures measured during the prenatal period (environmental tobacco smoke and polycyclic aromatic hydrocarbons).

Conclusions: We report evidence of deficits in Working Memory Index and Full-Scale IQ as a function of prenatal CPF exposure at 7 years of age. These findings are important in light of continued widespread use of CPF in agricultural settings and possible longer-term educational implications of early cognitive deficits.

Key words: chlorpyrifos, neurodevelopment, pesticides. *Environ Health Perspect* 119:1196–1201 (2011). doi:10.1289/ehp.1003160 [Online 21 April 2011]

Each year, thousands of new chemicals are released in the United States, with very little documentation about potential long-term human health risks (Landrigan et al. 2002). First registered in 1965 for agricultural and pest control purposes, chlorpyrifos (CPF; 0,0-diethyl-0-3,5,6-trichloro-2-pyridyl phosphorothioate) is a broad-spectrum, chlorinated organophosphate (OP) insecticide. Before regulatory action by the U.S. Environmental Protection Agency (EPA) to phase out residential use beginning in 2000, CPF applications were particularly heavy in urban areas, where the exposed populations included pregnant women (Berkowitz et al. 2003; Whyatt et al. 2002, 2003). In a sample of pregnant women in New York City (Perera et al. 2002) detectable levels of CPF were found in 99.7% of personal air samples, 100% of indoor air samples, and 64–70% of blood samples collected from umbilical cord plasma at delivery (Whyatt et al. 2002).

Early concerns about the possible neurotoxicity of OP insecticides for humans derived from rodent studies showing that prenatal and early postnatal exposures to CPF were associated with neurodevelopmental deficits, and these effects have been seen at exposure levels well below the threshold for systemic toxicity caused by cholinesterase inhibition in the brain (e.g., Slotkin and Seidler 2005). Evidence has accumulated over the past decade showing that noncholinergic mechanisms may play a role in the neurotoxic effects of CPF exposure in rodents, involving disruption of neural cell development, neurotransmitter systems (Aldridge et al. 2005; Slotkin 2004), and synaptic formation in different brain regions (Qiao et al. 2003). Such developmental disruptions have been associated with later functional impairments in learning, short-term working memory, and long-term reference memory (Levin et al. 2002).

In humans, OPs have been detected in amnionic fluid (Bradman et al. 2003) and are known to cross the placenta (Richardson 1995; Whyatt et al. 2005), posing a threat to the unborn child during a period of rapid brain development. Using urinary metabolites as the biomarker of exposure, several different birth cohort studies have reported that prenatal maternal nonspecific OP exposure was associated with abnormal neonatal reflexes (Engel et al. 2007; Young et al. 2005), mental deficits and pervasive development disorder at 2 years (Eskenazi et al. 2007), and attention problem behaviors and a composite attention-deficit/hyperactivity disorder indicator at 5 years of age (Marks et al. 2010).

Using a different biomarker of exposure (the parent compound of CPF in umbilical cord plasma), we have previously reported (in the same cohort as the present study) significant associations between prenatal exposure to CPF (> 6.17 pg/g) and reduced birth weight and birth length (Whyatt et al. 2004), increased risk of small size for gestational age (Rauh V, Whyatt R, Perera F, unpublished data), increased risk of mental and motor delay (< 80 points) and 3.5- to 6-point adjusted mean decrements on the 3-year Bayley Scales of Infant Development (Rauh et al. 2006), and evidence of increased problems related to attention, attention deficit hyperactivity disorder, and pervasive developmental disorder as measured by the Child Behavior Checklist at 2–3 years (Rauh et al. 2006). Taken together, these prospective cohort studies show a consistent pattern of early cognitive and behavioral deficits related to prenatal OP exposure, across both agricultural and urban populations, using different biomarkers of prenatal exposure.

We undertook the present study to identify the developmental consequences of prenatal exposure to CPF in a sample of New York City children at 7 years of age. Given the mechanisms proposed in the rodent literature, and early findings from prospective human studies involving nonspecific OP exposures, we hypothesized that prenatal exposure to CPF would be associated with

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The authors declare they have no actual or potential competing financial interests.

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Remaining uncertainties regarding long-term exposure in vulnerable populations

- Chronic vs acute exposure measurement
  - Short half-lives
  - Short interventions
- Realistic dietary interventions
  - Most “organic consumers” don’t eat 100% organic
- Vulnerable population
  - No organic intervention studies to date in pregnant women
- Confounding
  - Observational studies are challenged by factors associated with the choice to consume organic

Estimating Pesticide Exposure from Dietary Intake and Organic Food Choices: The Multi-Ethnic Study of Atherosclerosis (MESA)

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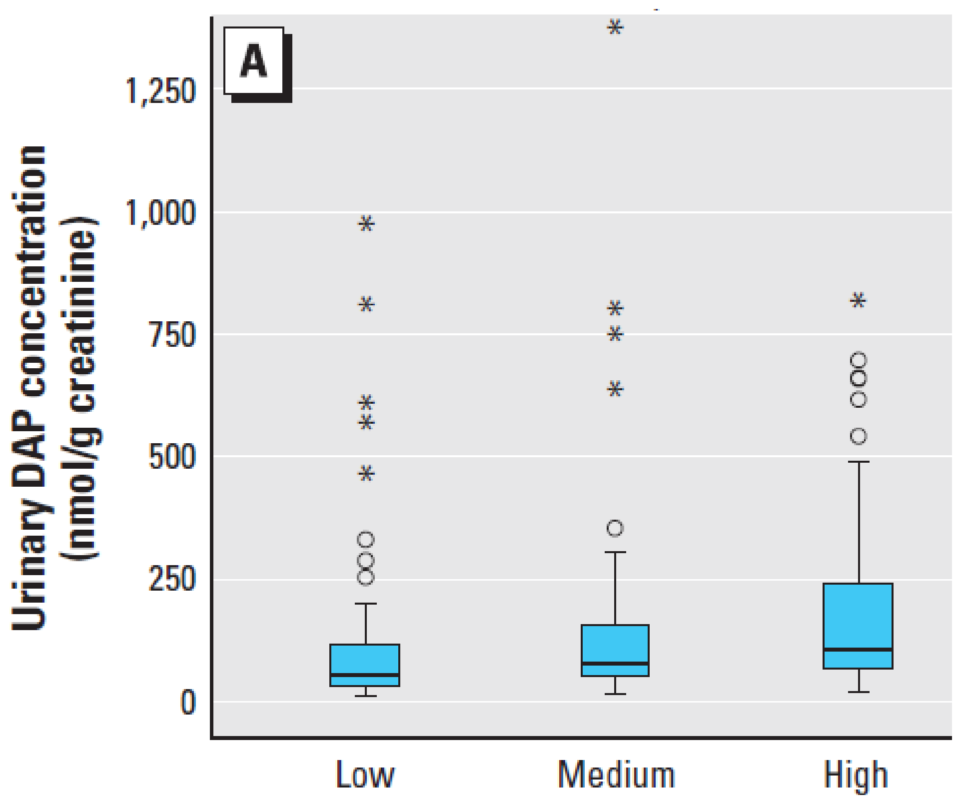
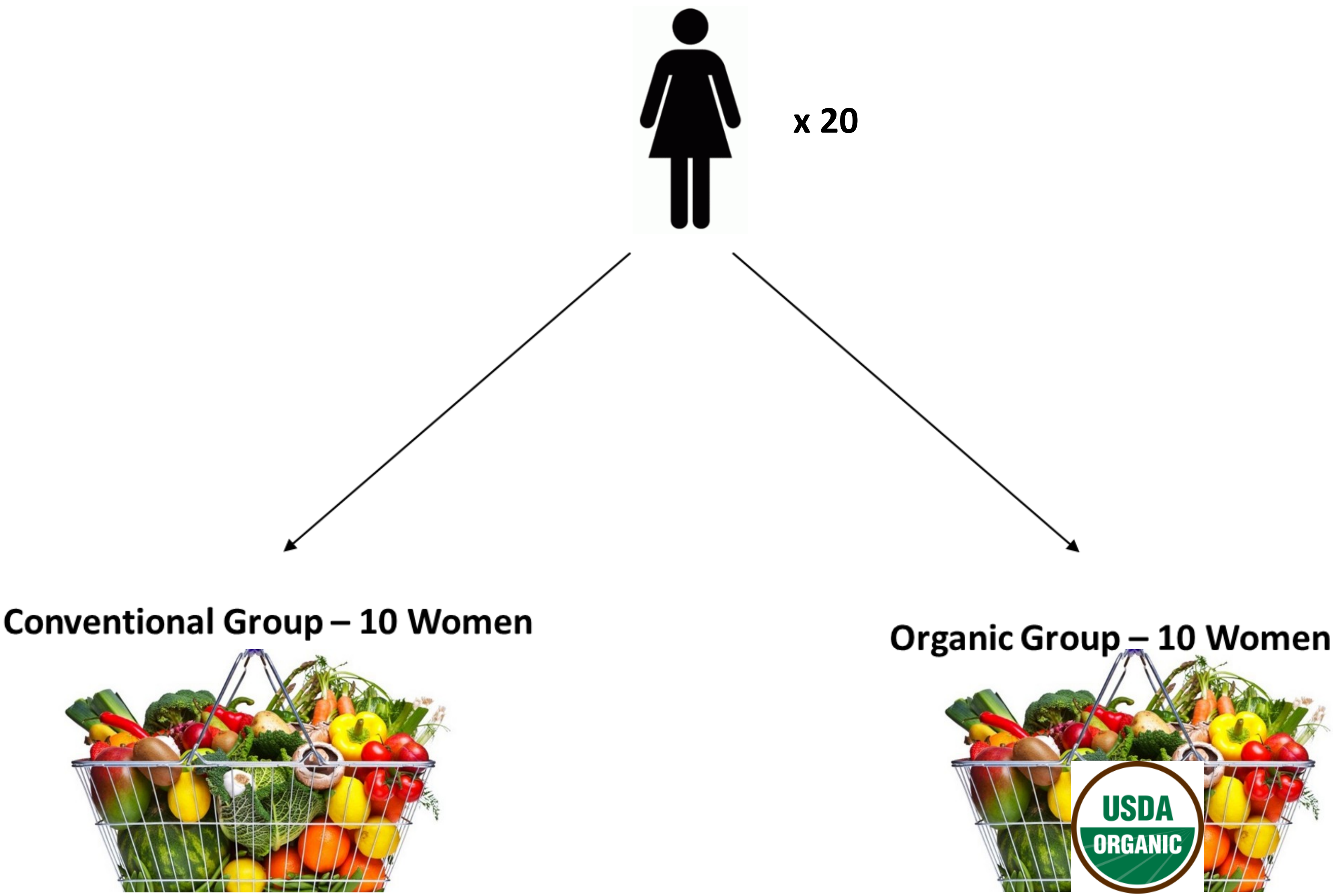
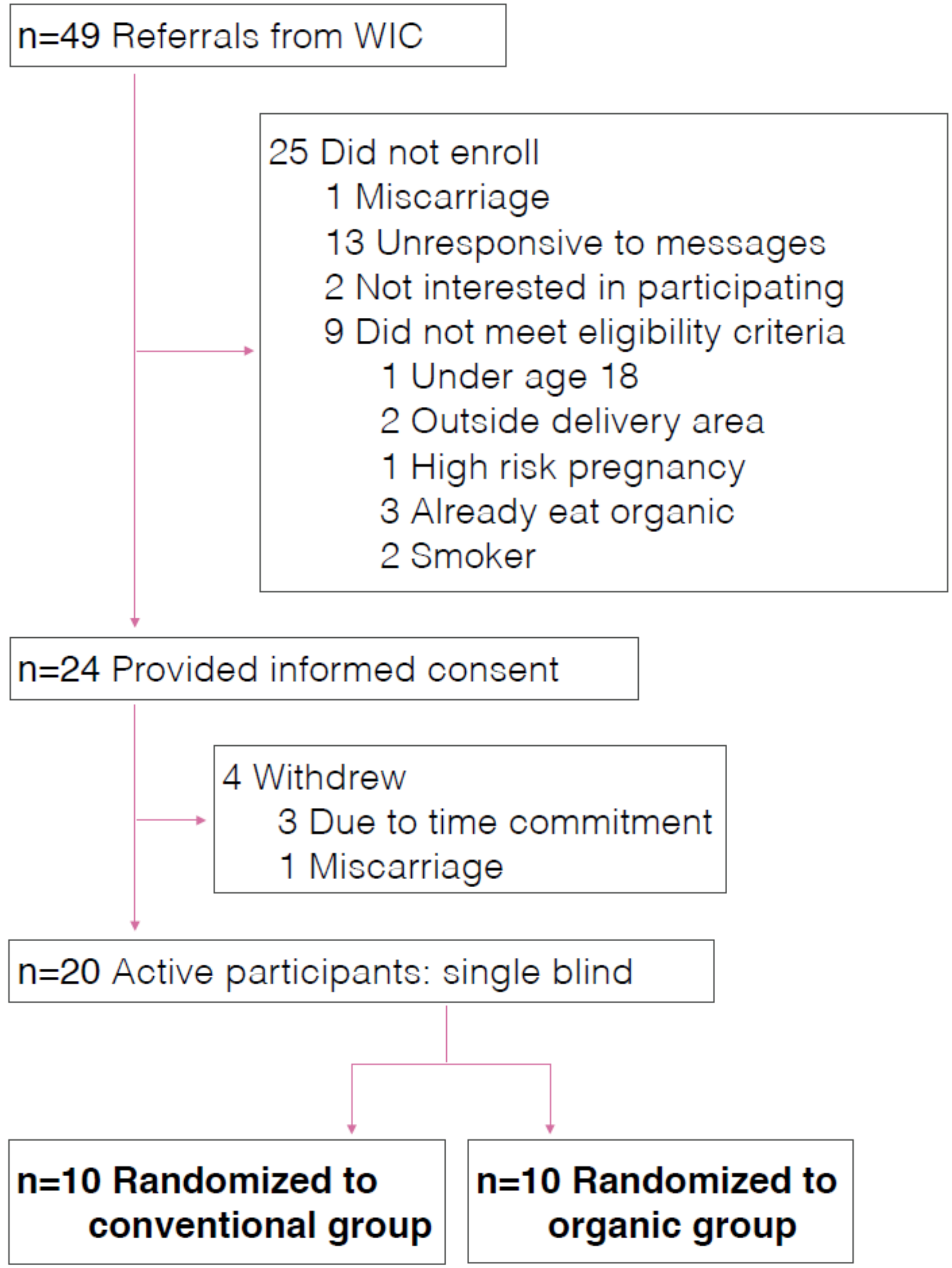
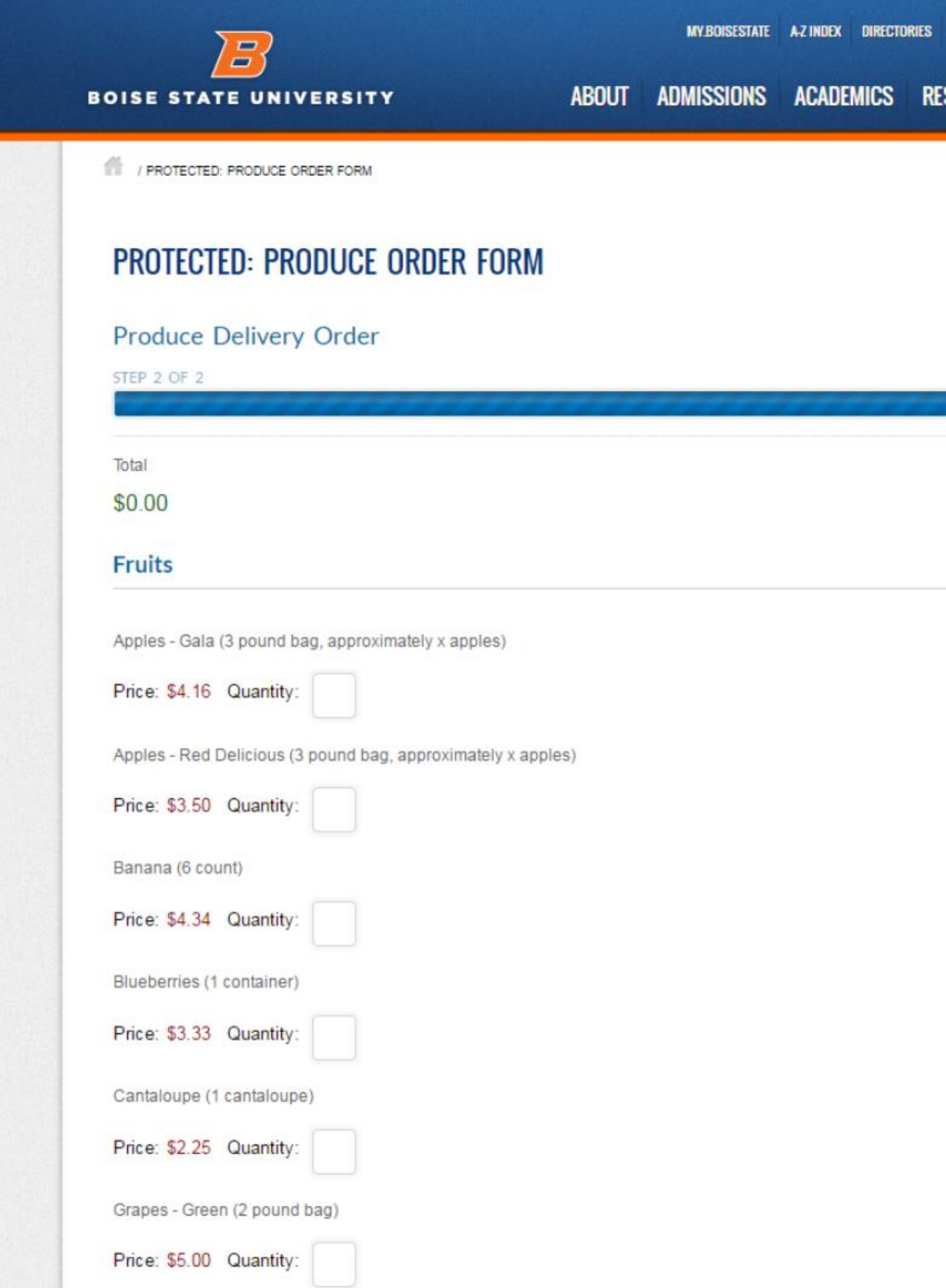



x 20
Conventional Group – 10 Women
Organic Group – 10 Women
USDA
ORGANIC


n=49 Referrals from WIC
25 Did not enroll
1 Miscarriage
13 Unresponsive to messages
2 Not interested in participating
9 Did not meet eligibility criteria
1 Under age 18
2 Outside delivery area
1 High risk pregnancy
3 Already eat organic
2 Smoker
n=24 Provided informed consent
4 Withdrew
3 Due to time commitment
1 Miscarriage
n=20 Active participants: single blind
n=10 Randomized to conventional group
n=10 Randomized to organic group

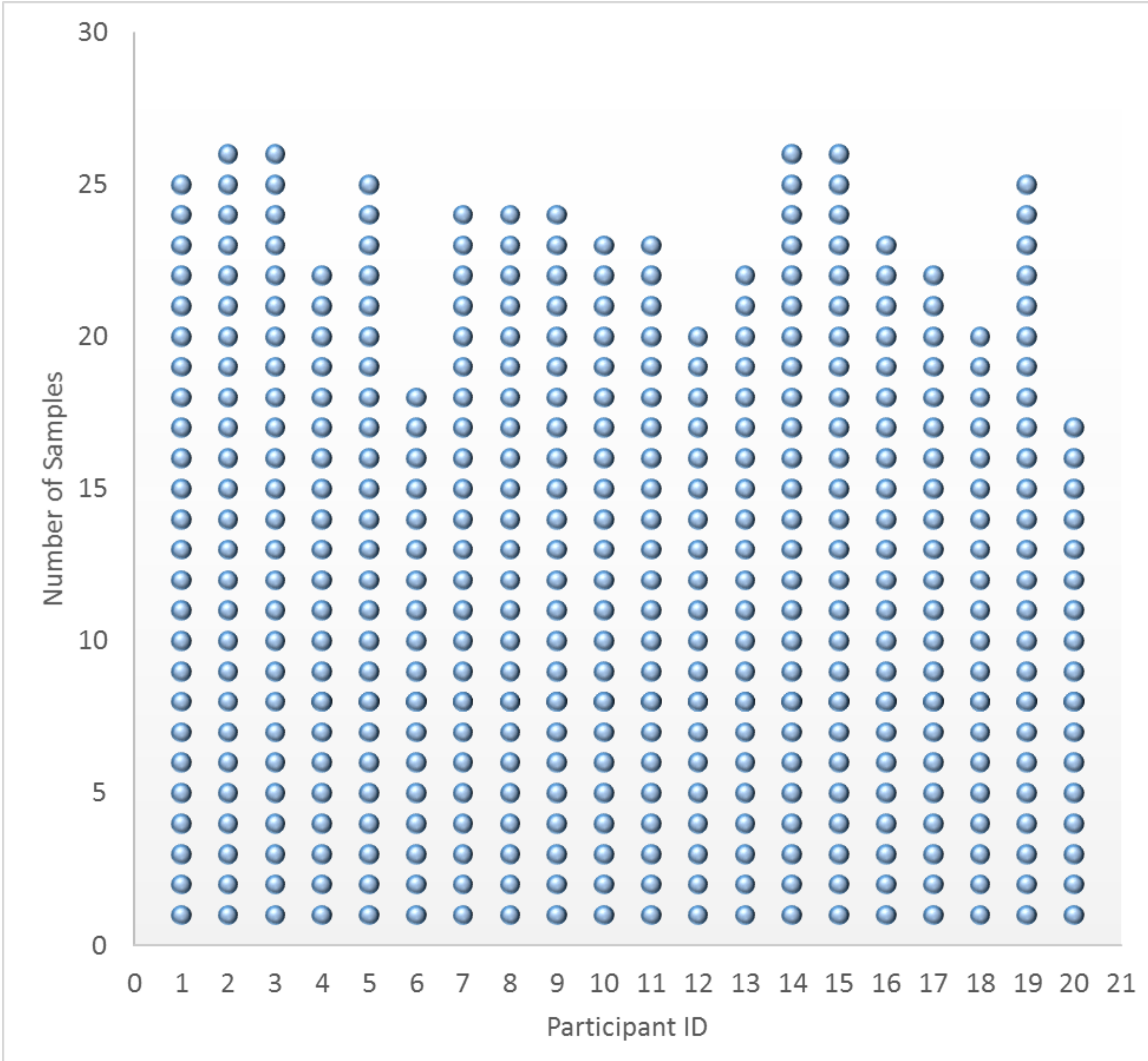


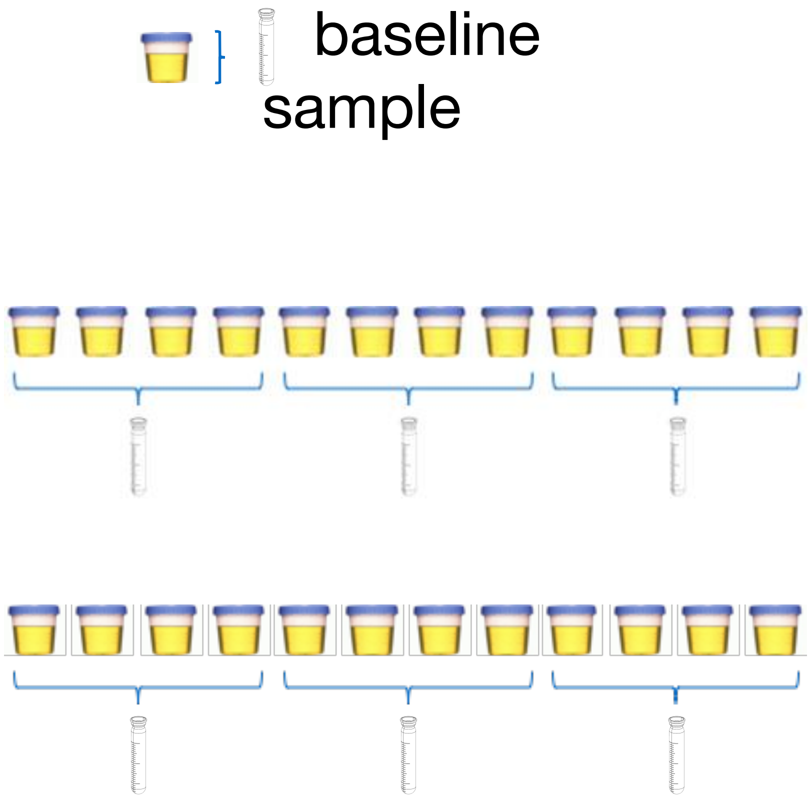
- $20-worth of fresh fruit and vegetables delivered weekly to participants homes
- Deliveries continue throughout second and third trimester (up to $480 total)
- Partnership with local produce distributors and delivery service
- Convenient and easy for participants

Developed a study-specific food diary app

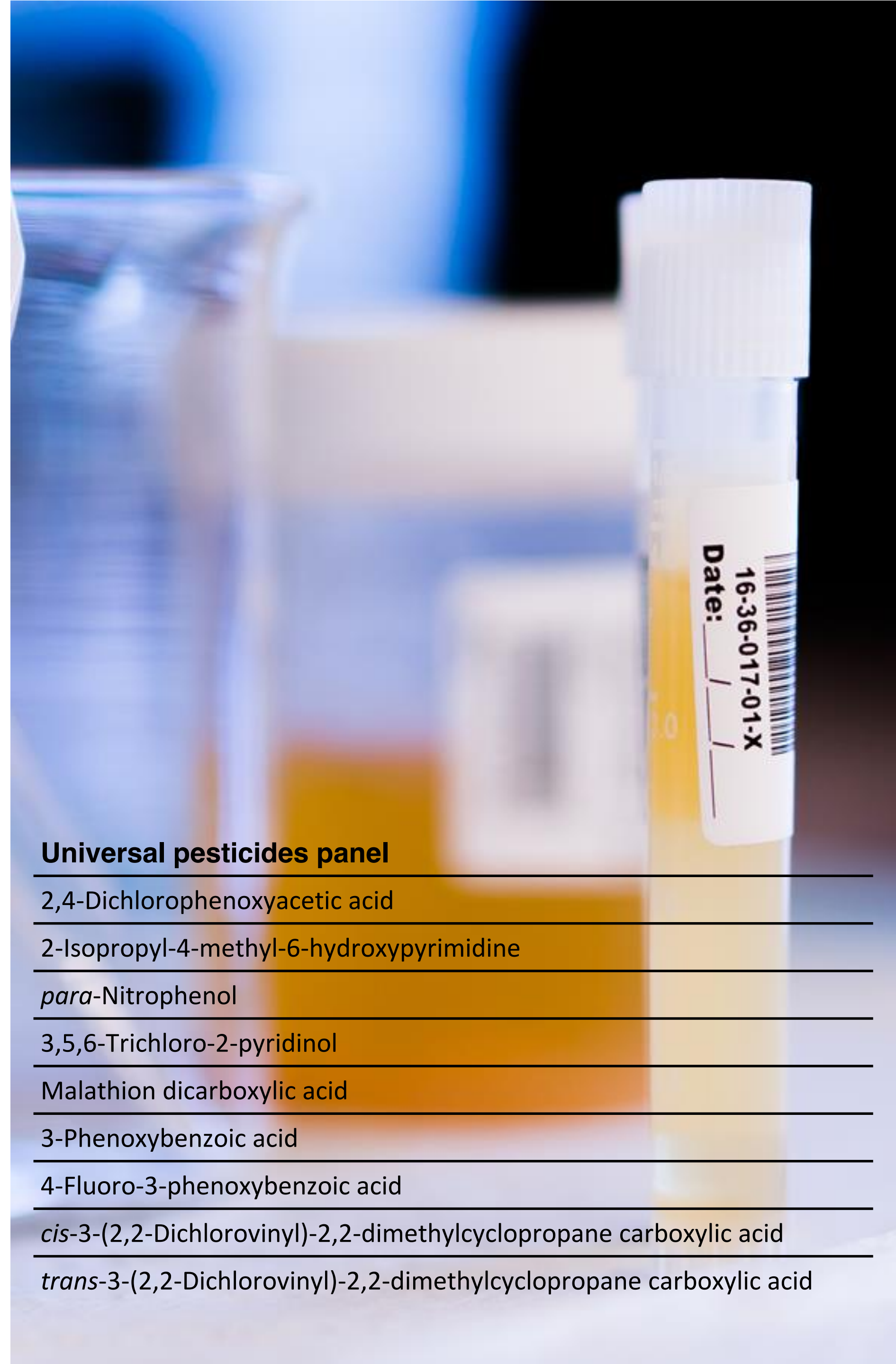
- Participants captured:
  - amount and type of all produce consumed (including photos)
  - whether it was provided by the study or not
  - and if not, whether it was conventional or organic
- Used to calculate number of conventional and organic servings of each type of produce consumed during the study

We collected 461 samples from 20 women over a 1-year period, representing an average of 23 weeks (~6 months) per participant.



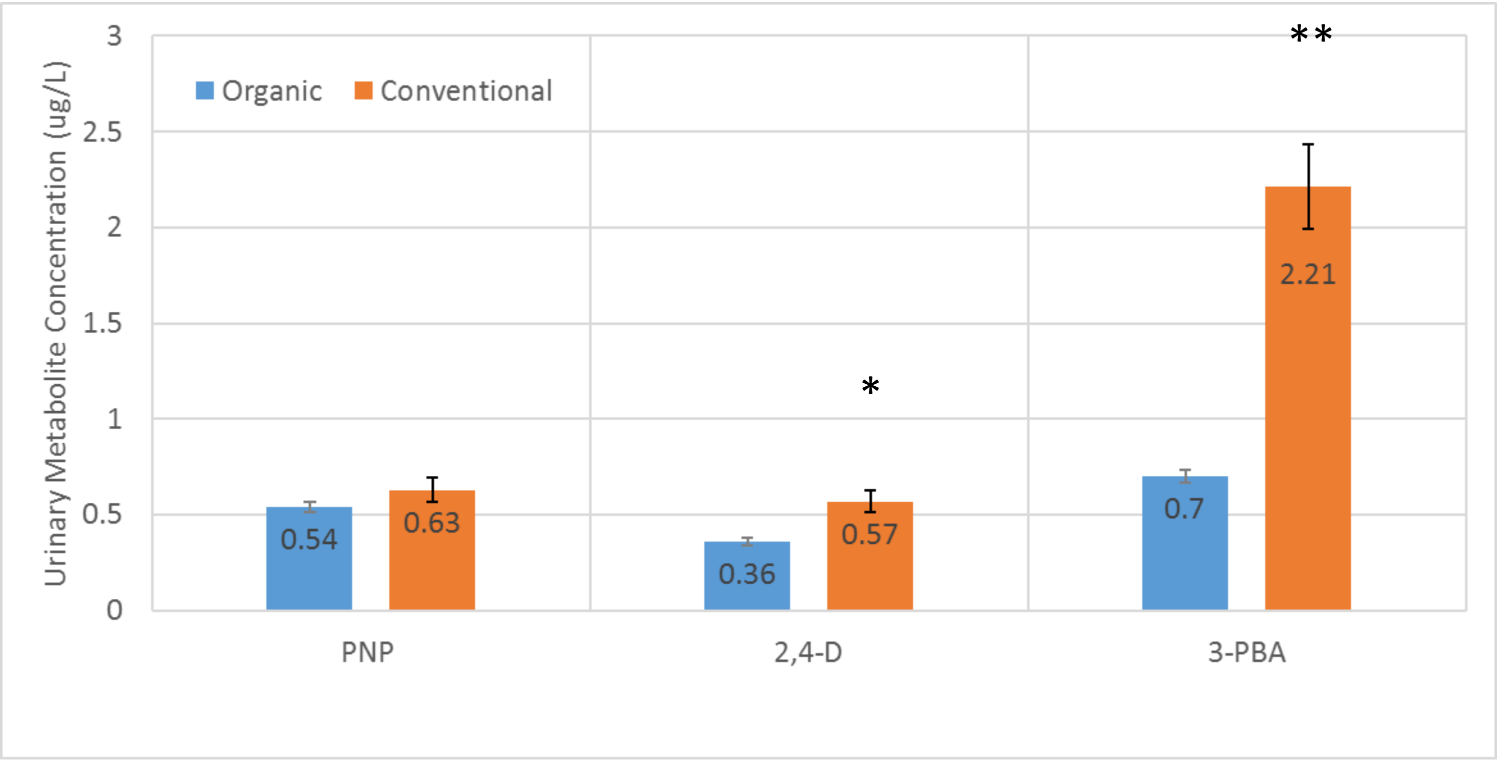


24 weekly samples composited in 1 mL aliquots to create six “monthly” aggregate samples representing the **second and third** trimesters



Universal pesticides panel
2,4-Dichlorophenoxyacetic acid
2-Isopropyl-4-methyl-6-hydroxypyrimidine
para-Nitrophenol
3,5,6-Trichloro-2-pyridinol
Malathion dicarboxylic acid
3-Phenoxybenzoic acid
4-Fluoro-3-phenoxybenzoic acid
cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid
trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid

Provision of organic fruits and vegetables *significantly* decreased exposure to 2,4-D (an herbicide) and 3-PBA (a metabolite of pyrethroid insecticides)



Curl et al. (Work in progress)

Conclusions

- Consumption of an organic diet significantly reduces exposure to synthetic agricultural pesticides, including herbicides and several classes of insecticides
  - This is true even when the diet is only partially organic

- For populations without occupational or residential sources, diet is the dominant route of exposure to several classes of synthetic agricultural pesticides

- This work demonstrates the feasibility of a randomized organic diet intervention study among pregnant women, which may be the best way to evaluate the health effects of dietary exposure to agricultural pesticides in conventionally grown food

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