

# Dietary exposures to lead and cadmium

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SOT Webinar: Metals on the menu and other food for thought

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# Introduction

- The U.S. Food and Drug Administration (FDA), Center for Food Safety and Applied Nutrition (CFSAN) uses a systematic, evidence-based approach to evaluate and reduce potential risks to public health from the presence of contaminants, including the toxic elements lead and cadmium, in the products FDA regulates.
- CFSAN's *Closer to Zero* action plan focuses on reducing exposures to toxic elements from foods consumed by infants and young children.
- As part of CFSAN's effort to reduce dietary exposures to toxic elements, CFSAN used FDA Total Diet Study data to estimate dietary exposures to lead for young children (1 – 6 y), older children (7 – 17 y), females of childbearing age (16 – 49 y), and adults (18 + y). CFSAN also estimated dietary exposures to cadmium for young children.



# U.S. FDA - Total Diet Study (TDS)



- Initiated in 1961; conducted continuously since.
- Modernized in a multi-year effort beginning in 2013.
- Monitors concentrations of pesticide residues, elements (toxic and nutrient), and radionuclides in commonly consumed foods.
- Samples are prepared as for consumption (i.e. table-ready) prior to analysis.
- Analyte concentration data are used (along with NHANES/WWEIA consumption data) for estimating total dietary analyte intakes/exposures.



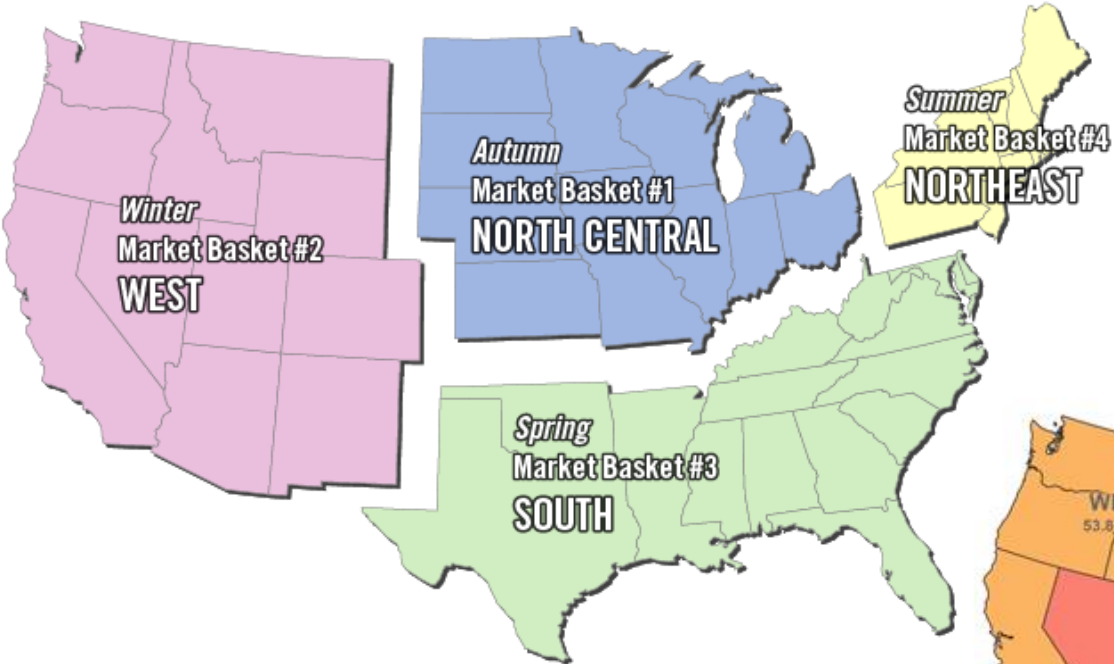
# Foods Collected for Analysis in the FDA TDS



- Pre-2018: Approximately 280 foods, collected in the contiguous 48 states
- 2018+
  - Regional Foods
    - Approximately 90 foods: produce, meat, dairy, bread
    - Samples from 3 cities collected within each sample region
  - National Foods
    - Approximately 170 foods: processed foods, shelf-stable, brand recognized
    - Collected in a single location

# Total Diet Study Sampling Regions

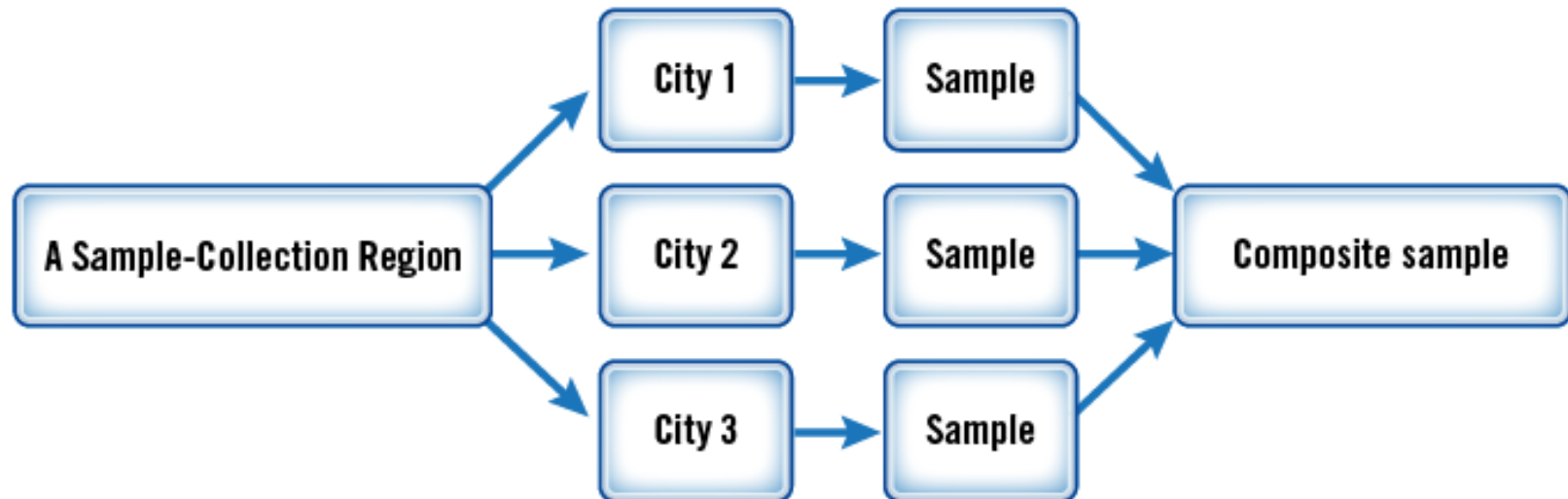
1991-2017



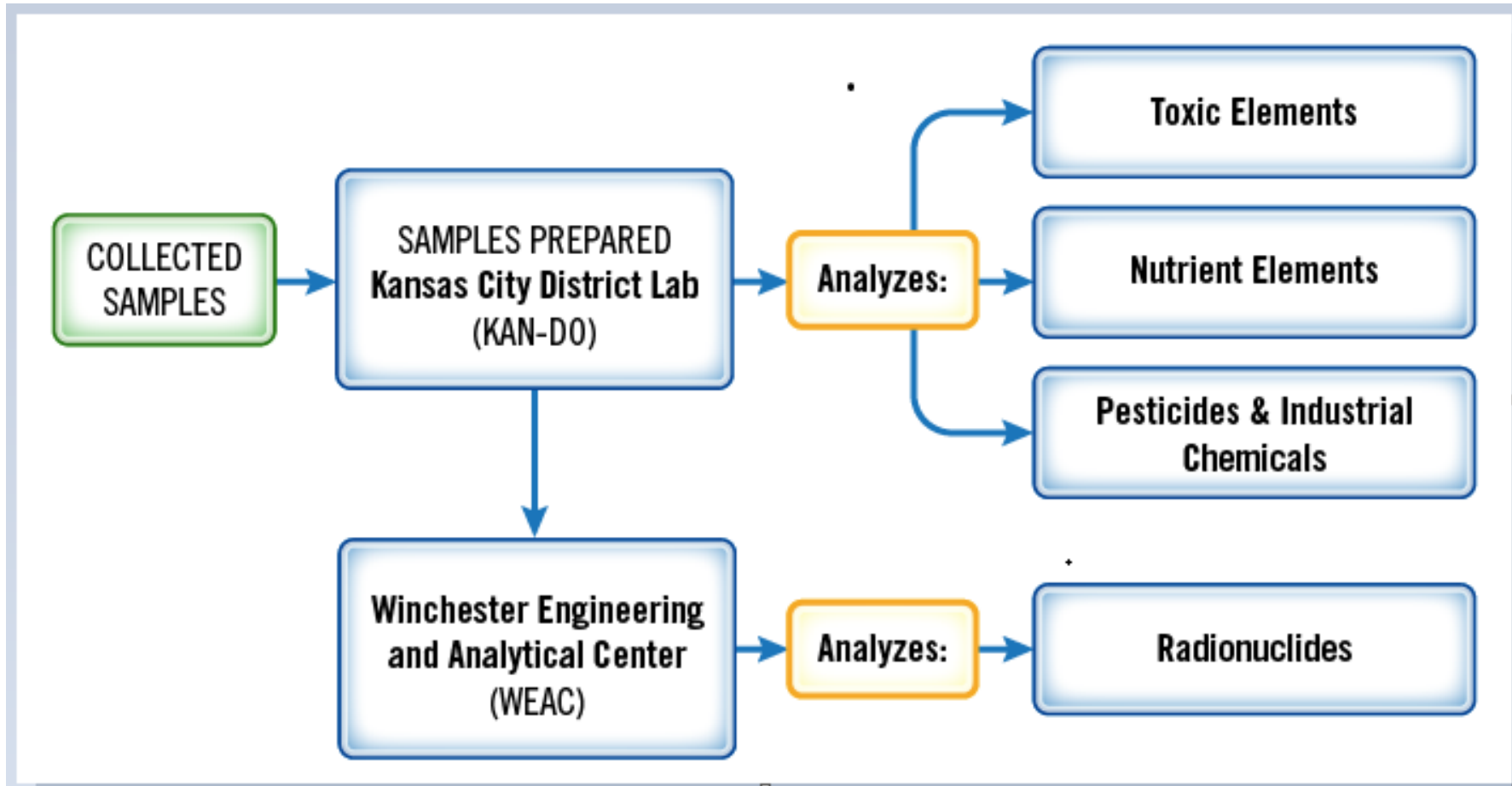
2018+



# Compositing of TDS Regional Foods



# TDS Sample Analysis



## Approach for estimating TDS-based nutrient/contaminant concentrations in NHANES/WWEIA foods

- Each of the ~260-280 TDS foods has been “mapped” to one or more NHANES/WWEIA foods.
- Mapping is based on major ingredient(s), not packaging or other attributes.
- Values for each TDS index food are assumed to apply to all NHANES/WWEIA foods to which the TDS food is mapped.





# Current Mapping of TDS Concentration Data to NHANES/WWEIA Consumption Data: Examples

NHANES/WWEIA code	NHANES/WWEIA description	TDScode_thru14	TDSdesc_thru14
63105010	AVOCADO, RAW	97	Avocado, raw
63408010	GUACAMOLE W/ TOMATOES	97	Avocado, raw
63408200	GUACAMOLE W/ TOMATOES & CHILI PEPPERS	97	Avocado, raw
63409010	GUACAMOLE, NFS	97	Avocado, raw

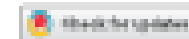


# TDS-Based Lead and Cadmium Dietary Exposure Assessments

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## Children's exposures to lead and cadmium: FDA total diet study 2014-16

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### ABSTRACT

Children are at potential risk effects of these elements of cadmium were estimated by Diet Study (TDS) and on food survey portion of the Estimated mean exposures w scenarios for values below detection; hybrid approach) with major contributions from soups). Estimated mean cadm contributions from grains, declined slightly since 2004 been identified for lead expo 0.1 to 0.83 µg/kg bw/day. Th exposures, will inform resea

## Lead exposures in older children (males and females 7–17 years), women of childbearing age (females 16–49 years) and adults (males and females 18+ years): FDA total diet study 2014–16

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To link to this article: <https://doi.org/10.1080/19440049.2019.1681595>



**Table 1. FDA total diet study food groups and samples.**

Food group	Description	Number of Foods	Number of Composite Samples 2014–2016 <sup>a</sup>
Baby food	All baby foods and infant formula (excluding adult food consumed by children). Infant formulas are ready-to-eat products.	40	417
Beverages	Beverages, includes bottled water, but excludes fruit/vegetable juices	14	154
Dairy	All dairy products (e.g., butter, cheese, milk, and ice cream)	21	231
Eggs	Boiled and scrambled eggs	2	22
Fats/oils	Vegetable fats and oils, and salad dressings	7	77
Fruits	Fruits and fruit juices	27	295
Grains	Items that are primarily grains including starches and baked goods	43	473
Legumes	Legumes, nuts, and seeds	7	77
Meat, poultry, fish	Items that are primarily meat, poultry, or fish (e.g., roasts, fried chicken, fish fillets, and luncheon meats).	26	286
Mixtures	Primarily entrées containing mixtures of meat/poultry/fish, grains, and vegetables (no predominant ingredient)	26	286
Sweets	Includes candy, gelatin, jelly, sugar, and syrup	10	110
Vegetables	Vegetables and vegetable juices	45	495
All		268	2923

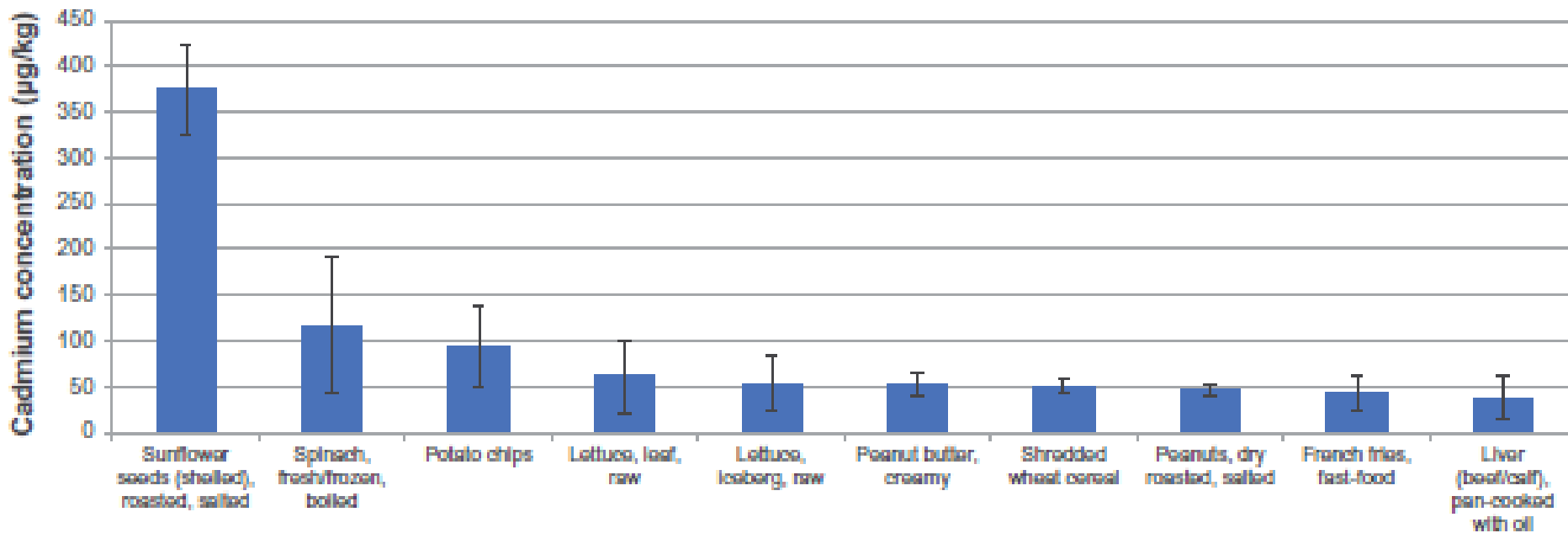
<sup>a</sup>TDS samples were generally collected four times a year, once in each region of the US (west, north central, south, and northeast). However, the fall 2014 collection (“market basket”) was cancelled due to a U.S. government shutdown. For each market basket, and for each of the 268 foods, the products purchased in each of the three cities within a collection region were composited to form single analytical samples.



# TDS 2014-2016 Cd Data

- The limit of detection (LOD) and limit of quantification (LOQ) for cadmium in TDS foods ranged from 0.04 to 1.2  $\mu\text{g}/\text{kg}$  and 0.3–11  $\mu\text{g}/\text{kg}$ , respectively.
- Among the 2923 samples analyzed in 2014–16, 1032 (35%) had cadmium levels below the LOD.
- Cadmium was not detected at all in samples of 56 (19%) of the 268 foods.
- For 140 foods (47%), cadmium concentrations were at or above the LOD in every sample.

# Ten TDS foods with highest mean Cd concentrations



# Toxicological Reference Values for Cd

TRV	
$\mu\text{g}/\text{kg bw}/\text{day}$	Source
0.83	Joint FAO/WHO Expert Committee on Food Additives (JECFA) Provisional Tolerable Monthly Intake (PTMI) of 25 $\mu\text{g}/\text{kg}$ body weight/month (JECFA, 2011)
0.36	European Food Safety Authority (EFSA) Provisional Tolerable Weekly Intake (PTWI) of 2.5 $\mu\text{g}/\text{kg}$ body weight/week (EFSA, 2011)
0.1	U.S. Agency for Toxic Substances and Disease Registry (ATSDR) chronic oral Minimal Risk Level (MRL) of 0.1 $\mu\text{g Cd}/\text{kg}$ body weight/day (ATSDR, 2012)

# Estimated Cd exposures: MF 1-6 y ( $\mu\text{g}/\text{kg bw}/\text{day}$ )

Age group	Mean			90th %ile		
	Lower Bound	Upper Bound	Hybrid	Lower Bound	Upper Bound	Hybrid
	ND = 0	ND = LOD	ND = 0.5 * LOD if history of contamin ation	ND = 0	ND = LOD	ND = 0.5 * LOD if history of contamin ation
1 through 6 y	0.40	0.42	0.41	0.65	0.67	0.66
1 through 3 y	0.42	0.45	0.43	0.69	0.71	0.70
4 through 6 y	0.38	0.39	0.38	0.58	0.60	0.59

# Estimated food group intakes and contributions to Cd exposures, MF 1-6 y

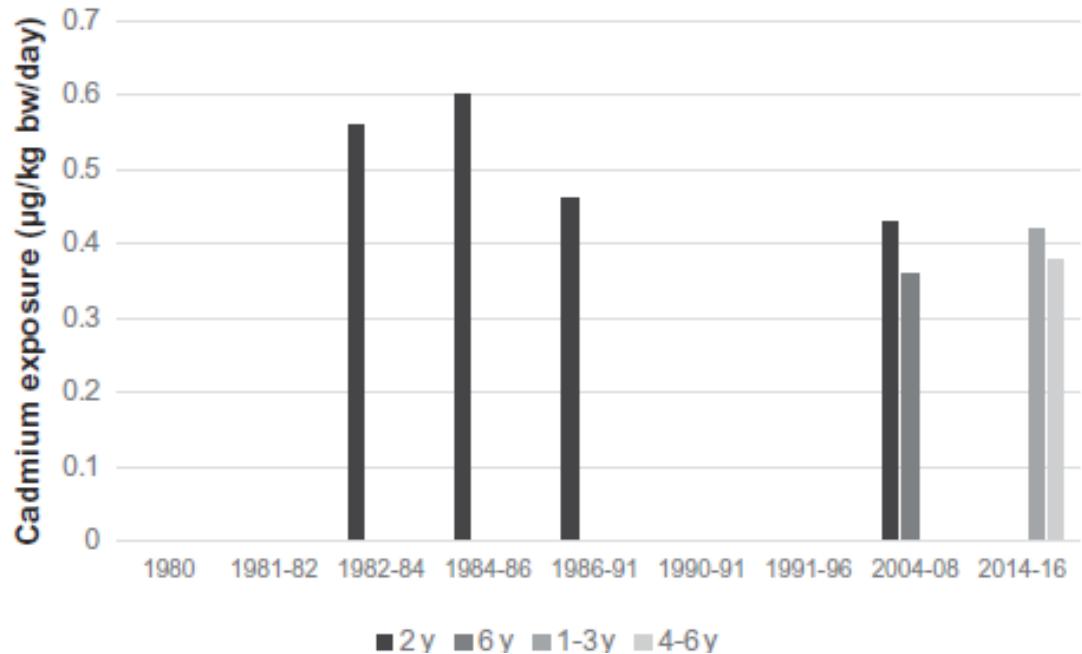
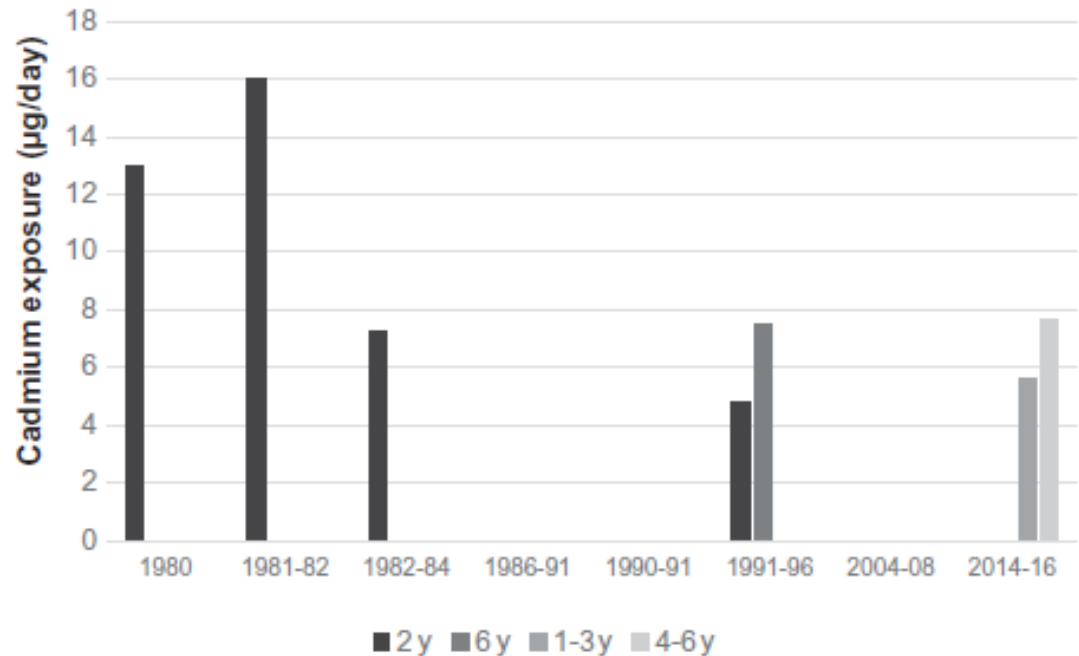


Food Group	Food Intakes	Dietary Cd exposures	
	g/day	µg/day	% total
Baby Food	18	0.03	0.5
Beverages	299	0.00	0.0
Dairy	428	0.16	2.4
Eggs	16	0.00	0.0
Fats/oils	2	0.00	0.1
Fruits	243	0.20	3.0
Grains	131	2.10	31.8
Legumes, nuts, seeds	11	0.42	6.4
Meat, poultry, fish	66	0.25	3.8
Mixtures	147	1.92	29.1
Sweets	17	0.08	1.2
Vegetables	66	1.44	21.8
Total	1444	6.6	100





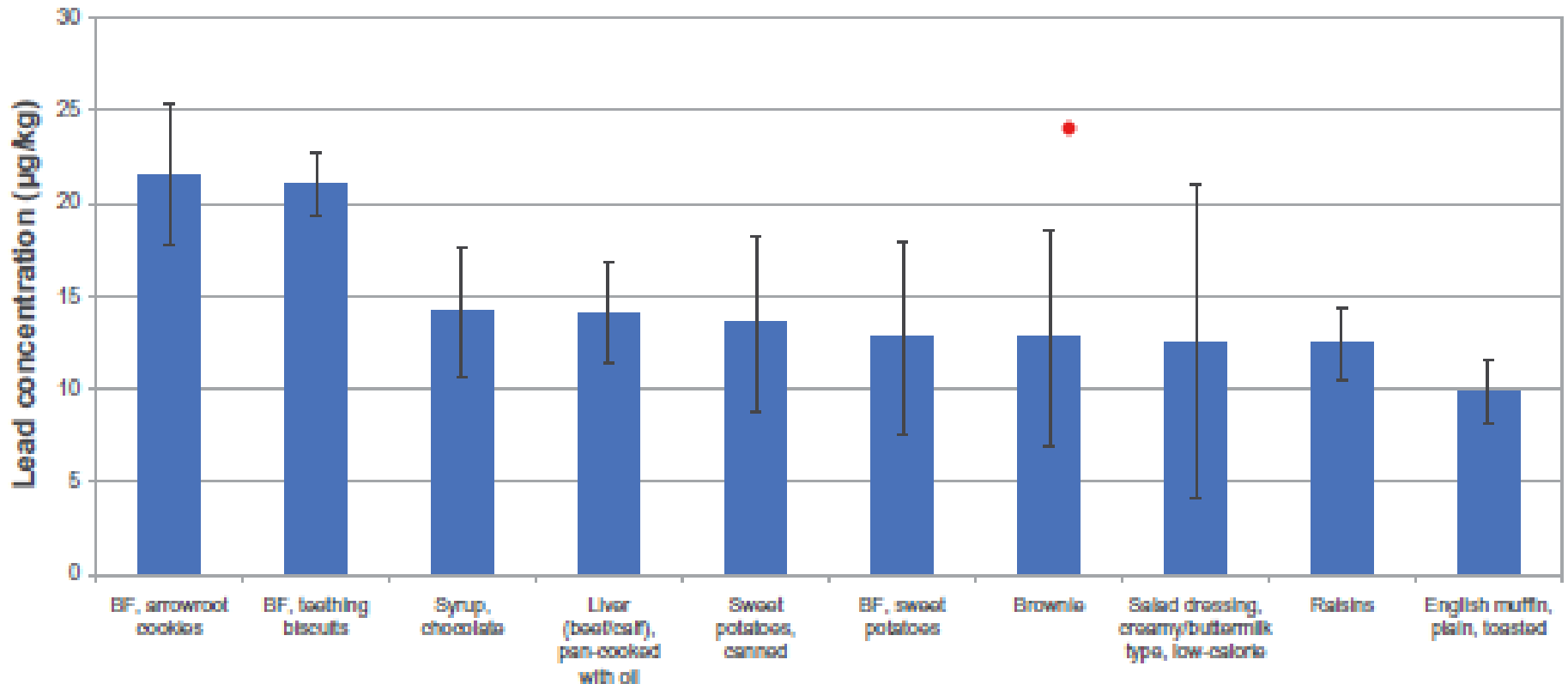
Dietary Cd exposures for young children have remained fairly constant in recent years



# TDS 2014-2016 Pb Data

- The limit of detection (LOD) and limit of quantification (LOQ) for lead in TDS foods ranged from 0.05 to 4.0  $\mu\text{g}/\text{kg}$  and 0.4–38  $\mu\text{g}/\text{kg}$ , respectively.
- Among the 2923 samples analysed in 2014–16, 2124 (73%) had lead levels below the LOD.
- Lead was not detected at all in samples of 95 (32%) of the 268 foods.
- For 18 foods (6%), lead concentrations were at or above the LOD in every sample.

# Ten TDS foods with highest mean Pb concentrations



# FDA Interim Reference Levels (IRLs) for Pb (Flannery et al., 2020)

	CDC Blood Pb Reference Value	Conversion Factor	Dietary Intake Corresponding to CDC Reference Value	BLL to Dietary Intake UF	IRL
	µg/dL	µg/dL per µg Pb per day	µg/day		µg/day
<b>Population</b>					
Young children (0 through 6 y)	5	0.16	30	10	3
Older children (7 through 17 y)	5	0.16	30	10	3
Women of childbearing age (16 through 49 y)	5	0.04	125	10	12.5





# Estimated Pb exposures: MF 1-6 y ( $\mu\text{g}/\text{day}$ )

Age group	Mean			90th %ile		
	Lower Bound	Upper Bound	Hybrid	Lower Bound	Upper Bound	Hybrid
	ND = 0	ND = LOD	ND = 0.5 * LOD if history of contamination	ND = 0	ND = LOD	ND = 0.5 * LOD if history of contamination
1 through 6 y	1.2	3.2	1.9	2.0	4.6	2.9
1 through 3 y	1.0	3.0	1.7	1.8	4.4	2.6
4 through 6 y	1.3	3.4	2.0	2.1	4.8	3.1



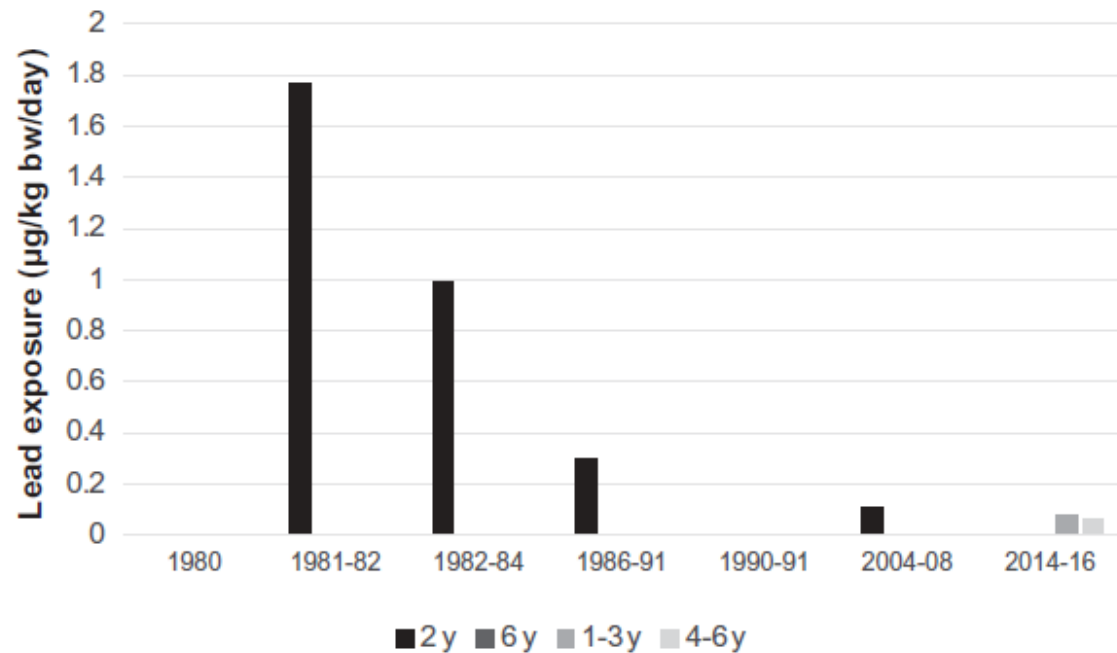
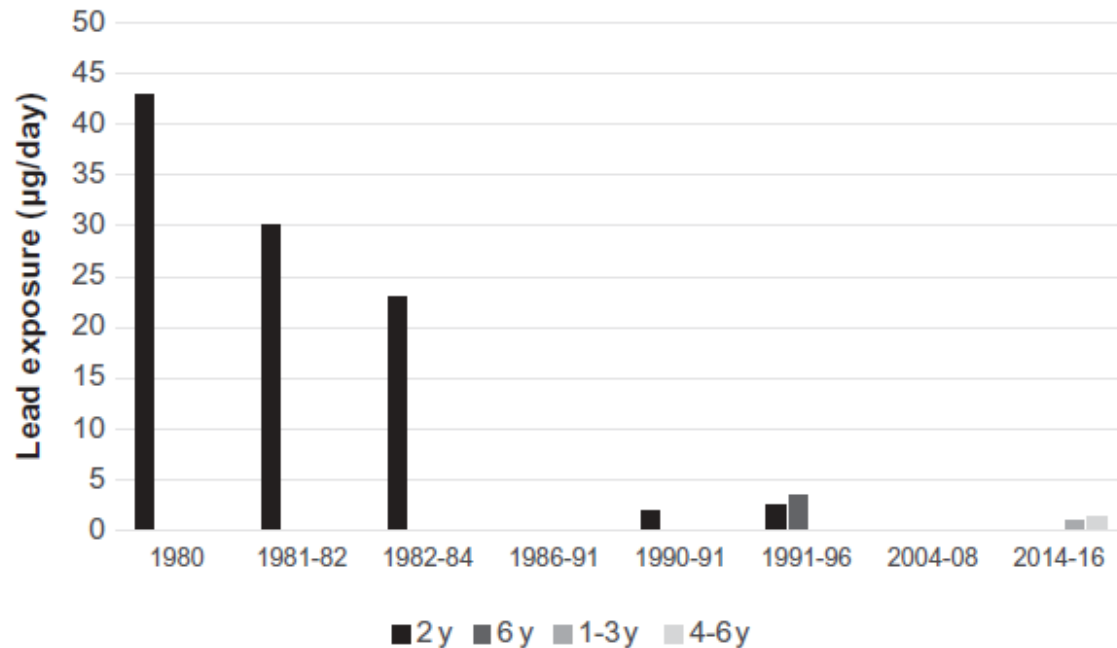
# Estimated food group intakes and contributions to Pb exposures, MF 1-6 y



Food Group	Food Intakes	Dietary Pb exposures	
	g/day	µg/day	% total
Baby Food	18	0.02	1.6
Beverages	299	<0.01	0.3
Dairy	428	0.19	16.8
Eggs	16	0.00	0.0
Fats/oils	2	0.01	0.8
Fruits	243	0.29	24.7
Grains	131	0.32	27.5
Legumes, nuts, seeds	11	0.02	1.8
Meat, poultry, fish	66	0.03	3.0
Mixtures	147	0.18	15.5
Sweets	17	0.04	3.5
Vegetables	66	0.05	4.7
Total	1444	1.2	100



Dietary Pb exposures for young children have declined in recent years



# Estimated Pb exposures: MF 7+ y, F 16-49 y, and MF 18+ y ( $\mu\text{g}/\text{day}$ )

Age group	Mean			90th %ile		
	Lower Bound	Upper Bound	Hybrid	Lower Bound	Upper Bound	Hybrid
	ND = 0	ND = LOD	ND = 0.5 * LOD if history of contamination	ND = 0	ND = LOD	ND = 0.5 * LOD if history of contamination
MF 7-17 y	1.4	4.0	2.2	2.3	5.8	3.4
F 16-49 y	1.6	4.6	2.4	2.8	6.7	4.0
MF 18+ y	1.7	5.3	2.7	3.2	7.8	4.5





# Estimated contributions to Pb exposures, MF 7+ y, F 16-49 y, MF 18+ y

Food Group	Dietary Pb exposures					
	MF 7-17 y		F 16-49 y		MF 18+ y	
	µg/day	% total	µg/day	% total	µg/day	% total
Baby food	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Beverages	0.01	0.7	0.23	14.6	0.25	14.3
Dairy	0.20	14.5	0.15	9.7	0.17	9.7
Eggs	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fats/oils	0.02	1.7	0.04	2.5	0.04	2.4
Fruits	0.16	11.7	0.16	10.2	0.16	9.3
Grains	0.43	31.1	0.35	22.4	0.42	24.1
Legumes, nuts, seeds	0.02	1.3	0.01	0.9	0.02	1.1
Meat, poultry, fish	0.04	3.2	0.05	3.1	0.06	3.4
Mixtures	0.37	26.4	0.37	23.6	0.39	22.4
Sweets	0.05	3.7	0.04	2.8	0.04	2.5
Vegetables	0.08	5.8	0.16	10.3	0.19	10.7
Total	1.40	100	1.56	100	1.75	100



## Notes regarding Pb in wine



- TDS wine samples had a mean Pb concentration above 5  $\mu\text{g}/\text{kg}$ . The lead exposure from wine consumption potentially contributes to lead exposure from beverages for adults and women of childbearing age.
- Wine can be contaminated with Pb from environmental sources or from brass equipment. As wineries are modernized and brass is replaced with stainless steel, the Pb levels are being reduced (Kaufmann [1998](#); Tariba [2011](#); Towle et al. [2017](#)).



## Notes regarding Pb in chocolate

- Many of the foods with the highest lead concentrations in 2014–2016 contain chocolate. Most of the Pb contamination in chocolate products occurs during the manufacturing process (Rankin et al. [2005](#); Yanus et al. [2014](#)).
- FDA's recommended maximum Pb level in candy likely to be consumed frequently by small children is 100 µg/kg; this level was determined to be achievable using good manufacturing practices and estimated to minimize the risk to all U.S. populations (FDA [2006](#)). The Pb levels found in milk chocolate candy bars from 2014–16 TDS are well below this value.

## Summary of findings

- Estimated mean dietary Cd exposures for young children are about 0.4  $\mu\text{g}/\text{kg}$  bw/day and estimated 90<sup>th</sup> percentile exposures range from 0.6 – 0.7  $\mu\text{g}/\text{kg}$  bw/day.
- Estimated mean dietary Pb exposures for young children are below the IRL of 3  $\mu\text{g}/\text{day}$ . 90<sup>th</sup> %ile Pb exposures were below the IRL under the lower bound (non-detects set to zero) scenario, but above the IRL based on the upper bound (non-detects set to limit of detection) scenario. Mean Pb exposures have declined in recent years.
- Estimated dietary Pb exposures are below the FDA IRLs for adults and women of childbearing age.
- For older children (7–17 years):
  - Estimated mean dietary Pb exposures are below the FDA IRL of 3  $\mu\text{g}/\text{day}$  based on lower-bound and hybrid concentrations, but above the IRL based on upper-bound concentrations.
  - Estimated 90<sup>th</sup> %ile exposures are below the IRL based on lower-bound concentrations, but above the IRL based on both hybrid and upper-bound concentrations.
  - There are uncertainties in using the IRL of 3  $\mu\text{g}/\text{day}$  for this age group.

# Current efforts



- Closer to Zero (C2Z) Action Plan
  - FDA is working to identify actions the agency will take to reduce exposure to toxic elements from foods eaten by babies and young children—to as low as feasible.
- TDS revisions, including new scheme for mapping TDS data to NHANES/WWEIA data
- Continuing research to characterize risks of exposures to toxic elements



# Thanks!



*For more information:*

- <https://www.fda.gov/food/science-research-food/total-diet-study>
- <https://www.fda.gov/food/metals-and-your-food/closer-zero-action-plan-baby-foods>
- Spungen JH. 2019. Children's exposures to lead and cadmium: FDA total diet study 2014–16. *Food Addit Contam Part A*. 36(6):893–903.
- Gavelek A, Spungen JH, Hoffman-Pennesi D, Flannery B, Dolan L, Dennis S, Fitzpatrick S. 2020. Lead exposures in older children (males and females 7-17 years), women of childbearing age (females 16-49 years) and adults (males and females (18+ years): FDA total diet study 2014-16. *Food Addit Contam Part A*. 37(1): 104-109.

