Abt Memorandum

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To Jane Houlihan, Healthy Babies Bright Futures

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Subject Inorganic arsenic intakes for babies and toddlers ages 0 to 2 years (updated to include rice intakes in g/day and inorganic arsenic intakes in µg/day)

Introduction

At the request of Healthy Babies Bright Futures (HBBF), Abt Global (Abt) conducted an analysis to determine the proportion of inorganic arsenic intake contributed by select food categories including infant rice cereal, juices, infant formula, and other rice products. Arsenic intakes and percentages by food category were estimated for children 2 years of age and under (0-24 months old). For this analysis, Abt utilized four data sources:

- (1) CDC's National Health and Nutrition Examination Survey (NHANES) collects health and nutrition information on the U.S. civilian, non-institutionalized population. NHANES includes a household interview and an examination component (CDC 2023). The examination includes dietary interviews, also called What We Eat in America (WWEIA). Dietary data are collected as 24-hour recalls for up to two days for each respondent.

- (2) FDA's Total Diet Study (TDS) is a monitoring program that collects contaminant and nutrient data in food and beverages commonly consumed in the US. FDA buys food products that make up at least 50% of the market share for that product and prepares them as a consumer would (FDA 2023). Food products are sampled in six major US regions and by season to account for contaminant and nutrient variation by time of year. Nationally representative estimates of contaminant levels are published for more than 280 types of food and beverages.

- (3) A supplemental FDA arsenic testing survey: Analytical Results from Inorganic Arsenic in Rice Cereals for Infants, Non-rice Infant Cereal and Other Foods Commonly

Eaten by Infants and Toddlers (FDA 2016).

- (4) Arsenic testing data provided by HBBF for the years 2017 through 2022.

An overview of the steps and methods used in the analysis are as follows:

1. Create matching files to map the foods tested in FDA supplemental arsenic content dataset and HBBF arsenic content dataset to TDS codes, or if appropriate, directly to an NHANES food code.
2. Aggregate FDA TDS, FDA supplemental arsenic survey testing, and HBBF arsenic testing data and estimate mean concentrations of inorganic arsenic by TDS number.
    a. Aggregate TDS data cycles from 2014 to 2020.
    b. Estimate mean arsenic concentration in food by TDS code.
    c. When more than one data source supplied arsenic values for a TDS code, estimate mean arsenic level using all available testing values.
    d. See Table 1 for assumptions of inorganic arsenic content in the TDS and HBBF datasets that were only tested for total arsenic content.
3. Transfer combined HBBF-TDS-FDA arsenic testing data to NHANES food codes.
    a. Use an existing mapping file that maps TDS codes to NHANES food codes ("TDSMapping_2003-2014.xlsx" received via email from FDA on 1/26/2023).
    b. Add mean arsenic values that were mapped to specific NHANES food codes (n=12) (e.g., organic white rice cereal).
4. Merge relevant demographic variables and dietary data and aggregate NHANES cycles from 2003-2018. All analyses used NHANES survey weights.
5. Merge combined arsenic testing data files with NHANES dietary recall data.
6. Estimate arsenic exposure for each participant for both recall days
    a. mean arsenic concentration (μg/kg)*(1kg/1000g)*(food consumed (g))/kg bodyweight=μg/kgBW/day
7. Estimate 2-day average arsenic intake for each participant for each category of food of interest.
8. Estimate percentage of arsenic intake/total arsenic intake for food categories of interest by age and racial/ethnic group.

To facilitate the mapping of HBBF arsenic testing data to NHANES dietary recall, we created a new category for winter squash which combines HBBF testing data from three different types of winter squash. We also created another new category for pears by combining HBBF testing data for canned pears and pears in syrup. We reviewed rice dishes in the TDS to NHANES mapping file, and where appropriate, reassigned TDS numbers to NHANES food codes. For example, in the original file, "rice milk" was mapped to "milk, whole, fluid", and rice crackers, puffed rice cakes, and rice paper were all mapped to "crackers, saltine". These products were reassigned to the TDS number for "Rice, white, enriched, cooked" to better represent arsenic exposure.

Abt used NHANES cycles (2003-2018). We estimated the contribution of inorganic arsenic from food groups including formula, snacks, juices, infant rice cereal, rice product not branded for infants, toddlers, or babies, and homemade and other foods not specifically

labeled or branded for babies. The homemade and other foods category includes any foods that do not contain the terms “infant”, “baby”, or “toddler” in the NHANES food code description. Snacks are foods described as cookies, puffs, teethers, crunchy snacks, fruit bars, fruit-flavored snacks, cereal bars with fruit filling, and finger snacks with “baby” or “toddler” food in description. Categories for white rice and brown rice were created and include foods where white or brown rice is described as the major ingredient, for instance, “rice, white, cooked”, “rice with beans and tomatoes”, or “rice, fried, with shrimp.” The brown rice category includes only rice dishes with “brown” rice in the description. The white rice category includes rice dishes with “white”, “yellow”, or “Spanish” in the description, and any dish with rice as the major ingredient and no further descriptor of the color or type of rice. All consumers were included in the analysis, meaning individuals who did and did not report consuming a food were included.

Inorganic arsenic concentrations were measured in select baby and toddler foods in FDA’s supplemental arsenic testing survey. The TDS and HBBF datasets measured total arsenic, which was adjusted to inorganic arsenic values by applying scaling factors (Table 1) (HBBF 2019, Appendix E). Values below the limit of detection were replaced by the LOD/2.

Table 1. Percent of total arsenic assumed to be inorganic arsenic (HBBF 2019, Appendix E).

Food category	**Percent inorganic arsenic (%)**
Beverages	95
Bottled water	100
Fruit	80
Rice	60
Wheat	95
Fish and shellfish, including New England clam chowder and tuna casserole	5
Vegetables	90
Infant rice cereal	61
Infant multi-grain and non-rice cereals	53
Grape juice	73
Oat ring cereal	59
Teething biscuits	56
All other foods	70

Results

Table 2 presents the percentage of total inorganic arsenic intake contributed by food category for ages 0–2 years and by age categories 0–6 months, 6–12 months, 12–18 months, and 18–24 months. Tables 3–7 present the percentages by racial/ethnic group for each of these age categories. Tables 8 and 9 provide results including breastfed babies 0-6 months old (the only population group that contains breastfed-only babies in the NHANES dataset), which are excluded in all other results due to zero arsenic intake for all food categories and no arsenic concentration applied for breastmilk. Table 8 lists results for babies 0–6 months old and Table 9 provides results for babies and toddlers 0–2 years old. In addition to these results, we also provided results for select food groups by a race variable only available in NHANES cycles 2011-2018. For non-Hispanic Asians ages 0–2 years (n=98), the percentage of inorganic arsenic consumed through white and brown rice dishes that were not branded specifically for babies or toddlers was 30.45%, and for 18–24-month-olds (n=19) the

percentage was 54.44% (excluding breastfed babies). The absolute mean intake of inorganic arsenic in μg per day for each age and racial/ethnic group is also provided in Tables 2–9. Table 10 presents mean intakes for rice (white and brown rice foods from foods without the baby food label). Table 11 presents the mean intake of inorganic arsenic by race/ethnicity and age group. Table 10 includes children that have missing variables such as body weight that were excluded in Table 11, making the sample size slightly larger.

Table 2. Percent of inorganic arsenic intake (μg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (μg/day) by age, NHANES 2003-2018.

Ages	0-2 years	0-6 mo	6-12 mo	12-18 mo	18-24 mo
	n=4318	n=1463	n=1305	n=877	n=768
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	17.17	28.43	30.17	4.20	2.47
Juice, all (with and without baby label)	10.32	3.34	9.15	14.90	15.55
Infant formula	21.29	62.30	15.44	1.24	0.45
Snack, labeled for babies	2.09	0.89	4.64	1.97	0.50
Other foods (not baby food brands)	49.12	5.03	40.60	77.69	81.03
SUBCATEGORIES					
Rice products, labeled for baby	8.07	16.05	12.90	1.08	0.29
Rice products, not labeled for babies	9.19	0.50	8.77	14.14	14.15
Brown rice, not labeled for babies	0.75	0.04	0.85	1.23	1.02
White rice, not labeled for babies	6.71	0.41	6.66	9.91	10.34
Rice puff/crispies, not labeled for babies	0.06	0.00	0.01	0.17	0.08
Rice cake, not labeled for babies	0.08	0.00	0.06	0.12	0.15
Rice snack, not labeled for babies	0.02	0.00	0.01	0.03	0.07
Apple juice, not labeled for babies	3.68	0.41	2.26	5.63	7.69
Apple juice, all (with and without baby label)	4.77	1.62	4.31	6.15	8.07
Juice, not labeled for babies	8.03	0.75	5.08	13.56	14.82
Infant rice cereal	7.02	15.25	10.20	0.69	0.19
	Mean inorganic arsenic intake (μg/day)				
Absolute inorganic arsenic intake	2.56	1.34	2.68	3.11	3.29

Table 3. Percent of inorganic arsenic intake (μg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (μg/day) by race, ages 0-2 years, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=1299	n=415	n=1401	n=853	n=350
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	12.65	12.02	19.78	16.92	15.63
Juice, all (with and without baby label)	9.55	10.48	9.57	15.84	7.63
Infant formula	24.67	21.55	19.07	25.82	20.49
Snack, labeled for babies	2.11	2.12	2.21	1.48	2.18
Other foods (not baby food brands)	51.02	53.83	49.37	39.94	54.07
SUBCATEGORIES					

Rice products, labeled for baby	5.99	5.69	9.16	9.00	6.36
Rice products, not labeled for babies	12.89	17.39	5.24	8.86	19.63
Brown rice, not labeled for babies	0.69	0.62	0.78	0.79	0.72
White rice, not labeled for babies	10.66	13.44	2.78	6.51	17.65
Rice puff/crispies, not labeled for babies	0.11	0.00	0.02	0.19	0.00
Rice cake, not labeled for babies	0.01	0.07	0.12	0.01	0.10
Rice snack, not labeled for babies	0.01	0.00	0.04	0.01	0.03
Apple juice, not labeled for babies	3.65	3.69	3.40	5.54	2.42
Apple juice, all (with and without baby label)	5.16	5.05	4.26	7.04	3.09
Juice, not labeled for babies	6.54	7.20	7.70	12.95	6.10
Infant rice cereal	5.31	4.91	8.00	7.78	5.15
	Mean inorganic arsenic intake (µg/day)				
Absolute inorganic arsenic intake	2.44	3.47	2.34	2.76	3.01

Table 4. Percent of inorganic arsenic intake (µg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (µg/day) by race, ages 0-6 months, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=479	n=147	n=459	n=272	n=106
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	20.16	20.07	34.91	22.86	26.86
Juice, all (with and without baby label)	3.96	6.29	2.56	3.68	3.14
Infant formula	66.21	63.76	57.73	70.82	64.27
Snack, labeled for babies	2.18	0.46	0.52	0.65	0.95
Other foods (not baby food brands)	7.50	9.42	4.28	2.00	4.77
SUBCATEGORIES					
Rice products, labeled for baby	10.36	9.96	20.05	15.47	11.86
Rice products, not labeled for babies	1.37	0.14	0.15	0.22	1.50
Brown rice, not labeled for babies	0.04	0.00	0.06	0.00	0.00
White rice, not labeled for babies	1.29	0.12	0.03	0.21	1.42
Rice puff/crispies, not labeled for babies	0.00	0.00	0.01	0.00	0.00
Rice cake, not labeled for babies	0.01	0.00	0.01	0.00	0.00
Rice snack, not labeled for babies	0.00	0.00	0.00	0.00	0.00
Apple juice, not labeled for babies	0.41	0.86	0.37	0.36	0.32
Apple juice, all (with and without baby label)	2.04	2.82	1.28	1.97	0.78
Juice, not labeled for babies	0.80	1.36	0.58	0.96	0.76
Infant rice cereal	9.38	9.46	19.26	14.84	10.84
	Mean inorganic arsenic intake (µg/day)				
Absolute inorganic arsenic intake	1.18	1.54	1.27	1.77	1.22

Table 5. Percent of inorganic arsenic intake (µg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (µg/day) by race, ages 6-12 months, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=400	n=128	n=448	n=221	n=108
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	20.27	24.64	32.88	36.17	29.74
Juice, all (with and without baby label)	10.99	9.52	7.98	13.84	5.64
Infant formula	18.62	14.85	13.53	18.66	16.97
Snack, labeled for babies	4.29	5.35	4.90	3.84	4.21
Other foods (not baby food brands)	45.84	45.64	40.71	27.49	43.43
SUBCATEGORIES					
Rice products, labeled for baby	8.63	11.48	13.84	16.64	11.82
Rice products, not labeled for babies	13.73	19.84	5.07	5.87	18.53
Brown rice, not labeled for babies	0.51	1.19	0.87	1.03	1.01
White rice, not labeled for babies	11.96	13.89	3.22	4.30	16.02
Rice puff/crispies, not labeled for babies	0.00	0.00	0.03	0.00	0.00
Rice cake, not labeled for babies	0.00	0.33	0.06	0.03	0.04
Rice snack, not labeled for babies	0.01	0.00	0.01	0.00	0.00
Apple juice, not labeled for babies	2.60	1.47	1.91	4.19	1.56
Apple juice, all (with and without baby label)	5.90	4.07	3.32	7.04	3.51
Juice, not labeled for babies	4.86	4.50	4.94	7.83	2.87
Infant rice cereal	7.50	9.45	10.87	12.67	8.71
	Mean inorganic arsenic intake (µg/day)				
Absolute inorganic arsenic intake	2.76	3.73	2.46	2.85	2.92

Table 6. Percent of inorganic arsenic intake (µg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (µg/day) by race, ages 12-18 months, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=247	n=73	n=274	n=206	n=77
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	4.00	2.68	4.38	4.99	3.71
Juice, all (with and without baby label)	13.21	11.56	13.83	25.02	11.98
Infant formula	0.60	0.88	1.86	0.37	0.49
Snack, labeled for babies	0.92	2.69	2.29	1.21	2.73
Other foods (not baby food brands)	81.27	82.19	77.63	68.41	81.09
SUBCATEGORIES					
Rice products, labeled for baby	2.01	0.89	0.68	1.58	0.95
Rice products, not labeled for babies	20.41	28.75	7.52	15.29	25.03
Brown rice, not labeled for babies	1.04	0.61	1.50	1.14	0.70
White rice, not labeled for babies	16.84	21.63	3.48	10.34	22.23
Rice puff/crispies, not labeled for babies	0.40	0.00	0.04	0.58	0.00
Rice cake, not labeled for babies	0.00	0.00	0.21	0.00	0.13
Rice snack, not labeled for babies	0.03	0.00	0.03	0.01	0.03

Apple juice, not labeled for babies	6.22	5.06	5.00	9.17	3.18
Apple juice, all (with and without baby label)	6.56	5.13	5.67	10.00	3.20
Juice, not labeled for babies	12.00	9.95	12.42	23.22	11.70
Infant rice cereal	1.66	0.18	0.32	1.22	0.54
	Mean inorganic arsenic intake (µg/day)				
Absolute inorganic arsenic intake	3.19	4.25	2.76	3.32	3.61

Table 7. Percent of inorganic arsenic intake (µg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (µg/day) by race, ages 18-24 months, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=210	n=77	n=248	n=170	n=63
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	1.18	5.22	2.99	1.21	0.38
Juice, all (with and without baby label)	11.04	14.96	15.82	23.76	10.10
Infant formula	0.13	0.45	0.37	1.15	0.54
Snack, labeled for babies	0.35	0.32	0.69	0.24	0.06
Other foods (not baby food brands)	87.29	79.05	80.13	73.64	88.92
SUBCATEGORIES					
Rice products, labeled for baby	0.49	0.57	0.22	0.19	0.20
Rice products, not labeled for babies	19.31	21.37	8.36	15.65	34.28
Brown rice, not labeled for babies	2.01	0.89	0.69	1.09	1.18
White rice, not labeled for babies	14.60	18.74	4.29	12.42	32.01
Rice puff/crispies, not labeled for babies	0.00	0.00	0.12	0.12	0.00
Rice cake, not labeled for babies	0.04	0.00	0.20	0.11	0.24
Rice snack, not labeled for babies	0.01	0.00	0.11	0.02	0.11
Apple juice, not labeled for babies	6.55	7.76	7.84	9.33	6.12
Apple juice, all (with and without baby label)	6.89	8.63	8.13	9.93	6.32
Juice, not labeled for babies	10.43	13.63	15.15	23.00	9.46
Infant rice cereal	0.47	0.57	0.04	0.19	0.14
	Mean inorganic arsenic intake (µg/day)				
Absolute inorganic arsenic intake	2.97	4.51	3.03	3.36	4.41

Table 8. Percent of inorganic arsenic intake (µg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (µg/day) by race, ages 0-6 months, exclusively breastfed babies included, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=533	n=165	n=583	n=297	n=129
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	17.95	17.81	27.09	21.02	21.44
Juice, all (with and without baby label)	3.52	5.58	1.99	3.38	2.50

Infant formula	58.95	56.59	44.79	65.14	51.31
Snack, labeled for babies	1.94	0.41	0.40	0.60	0.76
Other foods (not baby food brands)	6.68	8.36	3.32	1.84	3.81
SUBCATEGORIES					
Rice products, labeled for baby	9.22	8.84	15.56	14.23	9.47
Rice products, not labeled for babies	1.22	0.12	0.11	0.20	1.19
Brown rice, not labeled for babies	0.04	0.00	0.05	0.00	0.00
White rice, not labeled for babies	1.15	0.11	0.03	0.19	1.13
Rice puff/crispies, not labeled for babies	0.00	0.00	0.01	0.00	0.00
Rice cake, not labeled for babies	0.01	0.00	0.00	0.00	0.00
Rice snack, not labeled for babies	0.00	0.00	0.00	0.00	0.00
Apple juice, not labeled for babies	0.36	0.76	0.29	0.33	0.25
Apple juice, all (with and without baby label)	1.81	2.50	0.99	1.82	0.62
Juice, not labeled for babies	0.71	1.21	0.45	0.88	0.61
Infant rice cereal	8.35	8.40	14.94	13.65	8.65
	Mean inorganic arsenic intake (µg/day)				
Absolute inorganic arsenic intake	1.05	1.37	0.98	1.63	0.98

Table 9. Percent of inorganic arsenic intake (µg/kgBW/day) by food category and absolute mean inorganic arsenic intakes (µg/day) by race, ages 0-2 years, exclusively breastfed babies included, NHANES 2003-2018.

Race/Ethnicity	Mexican American	Hispanic Other	Non-Hispanic White	Non-Hispanic Black	Other
	n=1353	n=433	n=1525	n=878	n=373
MAJOR FOOD CATEGORIES	**% of inorganic arsenic intake**				
All baby foods, labeled for babies/toddlers	12.21	11.61	18.41	16.49	14.72
Juice, all (with and without baby label)	9.21	10.12	8.91	15.44	7.19
Infant formula	23.80	20.81	17.76	25.17	19.30
Snack, labeled for babies	2.04	2.04	2.06	1.45	2.05
Other foods (not baby food brands)	49.24	51.97	45.97	38.93	50.91
SUBCATEGORIES					
Rice products, labeled for baby	5.78	5.49	8.53	8.77	5.99
Rice products, not labeled for babies	12.44	16.79	4.88	8.64	18.49
Brown rice, not labeled for babies	0.67	0.60	0.73	0.77	0.68
White rice, not labeled for babies	10.29	12.98	2.59	6.34	16.62
Rice puff/crispies, not labeled for babies	0.10	0.00	0.02	0.18	0.00
Rice cake, not labeled for babies	0.01	0.07	0.11	0.01	0.09
Rice snack, not labeled for babies	0.01	0.00	0.03	0.01	0.03
Apple juice, not labeled for babies	3.52	3.56	3.16	5.40	2.28
Apple juice, all (with and without baby label)	4.98	4.88	3.97	6.87	2.91
Juice, not labeled for babies	6.31	6.95	7.17	12.63	5.74
Infant rice cereal	5.12	4.74	7.45	7.58	4.85
	Mean inorganic arsenic intake (µg/day)				

Absolute inorganic arsenic intake	2.36	3.35	2.18	2.69	2.84

Table 10. Mean intakes in grams/day of white rice and brown rice not labeled as baby food by race and age group (0-2 years and 18-24 months), NHANES 2011-2018.

Ages	**0-2 years**		**18-24 months**	
Race/Ethnicity	**Mean rice intake (g/day)**	**N**	**Mean rice intake (g/day)**	**N**
Mexican American and Hispanic	17.88	644	24.11	92
Mexican American	15.60	426	19.78	56
Hispanic Other	22.60	218	31.43	36
White	2.97	672	6.23	89
Black	8.07	400	16.01	66
Asian	41.29	103	87.22	19
Other	10.90	136	12.47	21
All	9.55	1955	16.89	287

Table 11. Absolute mean inorganic arsenic intakes (µg/day) by race and age group (0-2 years and 18-24 months), NHANES 2011-2018.

Ages	**0-2 years**		**18-24 months**	
Race/Ethnicity	**Mean inorganic arsenic intake (µg/day)**	**N**	**Mean inorganic arsenic intake (µg/day)**	**N**
Mexican American and Hispanic	2.96	612	3.45	91
Mexican American	2.60	404	2.95	55
Hispanic Other	3.69	208	4.29	36
White	2.41	594	2.95	88
Black	2.90	383	3.24	65
Asian	3.67	98	5.07	19
Other	2.72	125	3.09	21
All	2.69	1812	3.24	284

Limitations

The databases used in this analysis did not contain information for breastmilk or tap water, and these potential sources of arsenic exposure are therefore not included. We provide results with and without the inclusion of breastfed-only babies to demonstrate the impact of including a population assumed to have zero arsenic intake on the food category percentages. However, since breastmilk does contain a small amount of arsenic, results including

breastfed-only babies underestimate arsenic exposure. If an arsenic value for breastmilk were included, the percentage estimates for the “Other foods” category would be slightly larger (assuming breastmilk is categorized in “Other foods”), while all other major food category percentages would be slightly smaller.

Food categories for white and brown rice included dishes that were described as having rice as a prominent ingredient. While this method for categorization may overestimate arsenic exposure by applying the arsenic concentrations for rice only to mixed rice dishes, it excludes many dishes that contain rice in smaller proportions and may lead to underestimation of arsenic exposure. A refinement to this analysis would be to integrate recipes supplied by the U.S. Department of Agriculture Food and Nutrient Database for Dietary Studies to calculate the contribution of arsenic intake across all rice-containing dishes. Additionally, some foods are not included in the analysis as they have not been tested for arsenic in the datasets used for this analysis.

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