What's in my baby's food?

A national investigation finds 95 percent of baby foods tested contain toxic chemicals that lower babies' IQ, including arsenic and lead

Report includes safer choices for parents, manufacturers and retailers seeking healthy foods for infants

Healthy Babies Bright Futures

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Healthy Babies Bright Futures | Jane Houlihan, Research Director and Charlotte Brody, National Director | October 2019

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What's in my Baby's Food?

Our findings show what parents, baby food companies and FDA should do to get toxic heavy metals out of babies' diets

EXECUTIVE SUMMARY

Parents shop for baby food expecting the nutrition, convenience and baby-tested flavors of store-bought brands. But nearly every jar, pouch and canister also offers something unexpected for a baby's mealtime—traces of heavy metals, including arsenic and lead.

The problem, uncovered nearly a decade ago, is far from solved. New tests of 168 baby foods commissioned by Healthy Babies Bright Futures (HBBF) found toxic heavy metals in 95 percent of containers tested. One in four baby foods contained all four metals assessed by our testing lab—arsenic, lead, cadmium, and mercury. Even in the trace amounts found in food, these contaminants can alter the developing brain and erode a child's IQ. The impacts add up with each meal or snack a baby eats.

Fresh research continues to confirm widespread exposures and troubling risks for babies, including cancer and lifelong deficits in intelligence from exposures to these common food contaminants. Despite the risks, with few exceptions there are no specific limits for toxic heavy metals in baby food.

PROMISING SIGNS OF PROGRESS MUST ACCELERATE TO PROTECT BABIES.

The government, parents and baby food companies are paying attention. In 2017 the U.S. Food and Drug Administration charged a team of top agency scientists with "reducing exposures… to the greatest extent possible" by prioritizing and modernizing FDA's approaches (FDA 2018a,b). In early 2019 leading baby food companies supported by non-profit organizations, including HBBF, formed a new Baby Food Council that is "seeking to reduce heavy metals in the companies' products to as low as reasonably achievable using best-in-class management practices" (BFC 2019). And since 2011 public health advocates have regularly tested baby foods and educated parents on issues ranging from arsenic and lead in fruit juice (CR 2011,2019a) to arsenic in infant rice cereal (HBBF 2017a, CR 2012) and heavy metals in a range of baby foods (CR 2018, EDF 2017a, Gardener 2018).

Children are better off for the efforts: Current arsenic contamination levels in rice cereal and juice are 37 and 63 percent lower, respectively, than amounts measured a decade ago because of companies' success in reducing metals levels in their food ingredients to comply with draft FDA guidance. They have shifted growing and processing methods, switched plant varieties, and sourced from cleaner fields.

Despite the gains, 19 of every 20 baby foods tested had detectable levels of one or more heavy metals, according to new tests detailed in this study. Only a dramatically accelerated pace at FDA and the fruition of the new Baby Food Council's pursuit of industry-wide change will be enough to finally solve the problem.

TEST RESULTS: 168 BABY FOODS

95 percent of baby foods tested contained one or more toxic heavy metals

1 in 4 baby foods contained all 4 toxic heavy metals assessed by our testing lab, including arsenic and lead.

How many baby foods had multiple heavy metals in a single container?

4 metals	26% of baby foods
3 metals	40%
2 metals	21%
1 metal	8%
0 metals	5% (9 foods)

In how many baby foods was each heavy metal found?

Arsenic	73% of baby foods
Lead	94%
Cadmium	75%
Mercury	32%

WHAT'S NEW ABOUT THIS STUDY?

Reports of heavy metals in baby food span nearly a decade. HBBF's study advances this work in 4 ways:

Many brands tested: We report on tests of a wider variety of brands than past studies - 61 brands, from big names to niche brands.

First-ever look at IQ loss for babies: We include a new study HBBF commissioned from Abt Associates to quantify for the first time the health impacts posed by heavy metals in baby food. This work gives first-ever estimates of the population-wide decline in IQ from children's exposures to lead and arsenic in food, from birth to 24 months of age. It also gives food-by-food rankings to show the 15 foods commonly consumed by babies and young children that drive more than half of the risk (see Findings section of this report).

Optimized actions for parents: We streamline advice for parents to cover foods posing the greatest risk to babies, based on the newly released IQ loss findings (Abt 2019b). This allows parents to focus on five actions estimated to provide the greatest benefit for babies' brains.

New data on industrial pollutants and additive risks: We also include new data for the industrial chemical perchlorate in baby food. It adds to the risk of IQ loss posed by heavy metals, increasing the urgency for actions to lower the levels of neurotoxic contaminants in baby food.

PARENTS CAN MAKE FIVE SAFER BABY FOOD CHOICES FOR 80 PERCENT LESS TOXIC METAL RESIDUE.

In the meantime, HBBF's new tests help parents navigate the baby food aisle. We found that simple changes can significantly lower a baby's exposures to heavy metal contamination. Parents shopping for baby food can choose five types of safer items, all readily available, over more contaminated foods (see table below). The safer choices contain 80 percent less arsenic, lead and other toxic heavy metals, on average, than the riskier picks.

Notably, parents can't shop their way out of these exposures by choosing organic foods or by switching from store-bought brands to homemade purees. Heavy metals are naturally occurring in soil and water and are found at elevated levels in fields polluted by pesticides, contaminated fertilizer, airborne contaminants and industrial operations. Food crops uptake these metals naturally. Leafy greens and root crops like carrots and sweet potatoes retain more than most other types of fruits and vegetables. How the food is processed may also affect the levels. Organic standards do not address these contaminants, and foods beyond the baby food aisle are equally affected.

Our tests show that simple actions for 5 foods can help lower your babies' exposures to arsenic, lead and other toxic heavy metals

	Higher risk foods for heavy metal exposure	Safer alternative	Toxic heavy metal level
Snacks	Puff snacks (rice)	Rice-free snacks	**93% less**
Teething Foods	Teething biscuits and rice rusks	Other soothing foods for teething—frozen banana or chilled cucumber	**91% less**
Cereal	Infant rice cereal	Other infant cereals like multi-grain and oatmeal	**84% less**
Drinks	Fruit juice	Tap water	**68% less**
Fruits & Veggies	Carrots and sweet potatoes	Variety: A variety of fruits and veggies that includes carrots, sweet potatoes, and other choices	**Up to 73% less**

Source: HBBF analysis of tests of 168 baby foods by Brooks Applied Labs, Bothell Washington and FDA market basket data, 2014-2017. Exposures reductions consider average total heavy metal levels in each food (inorganic arsenic, lead, cadmium, mercury) except for cereal, which considers inorganic arsenic only.

FIFTEEN FOODS ACCOUNT FOR MORE THAN HALF OF THE RISK. RICE-BASED FOODS TOP THE LIST.

Our research substantiates the widespread presence of toxic heavy metals in baby foods found in prior studies, almost no enforceable limits or guidelines on what's allowed, and the common occurrence of arsenic and lead in excess of recommended levels to protect children's health (Table 1, page 12).

Although many foods are contaminated, a few stand out: 15 foods consumed by children under 2 years of age account for 55 percent of the risk to babies' brains, according to a new study commissioned by HBBF and detailed in this report (see Findings section and Appendix E). These include apple and grape juice, oat ring cereal, macaroni and cheese, puff snacks and 10 other foods.

But topping the list are rice-based foods—infant rice cereal, rice dishes and rice-based snacks. These popular baby foods are not only high in inorganic arsenic, the most toxic form of arsenic, but also are nearly always contaminated with all four toxic metals. The new study, completed by the nationally recognized toxicology and economic research firm Abt Associates, estimates that lead and arsenic in rice-based foods account for one-fifth of the more than 11 million IQ points children lose from birth to 24 months of age from all dietary sources. This concentrated risk underscores the need for swift action from FDA and baby food companies to reduce arsenic levels in rice-based foods.

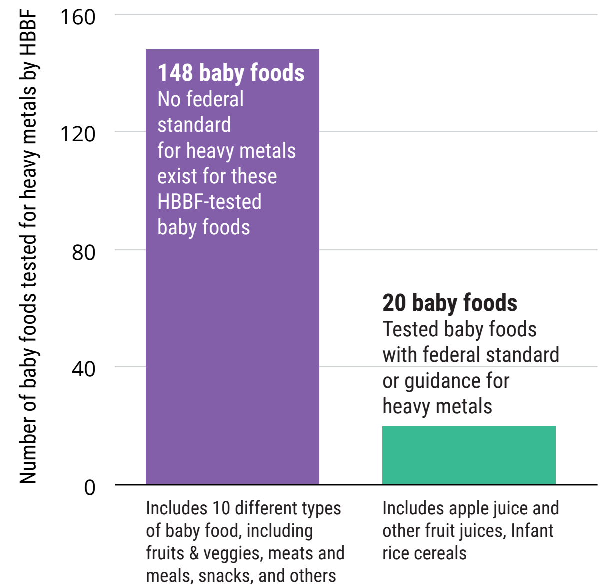
PARENTS, BABY FOOD COMPANIES, FARMERS, AND FDA ALL HAVE A ROLE IN MEASURABLY REDUCING BABIES' EXPOSURES.

A number of baby food companies are setting their own standards in the absence of enforceable federal limits or guidance. As these initiatives advance, packaged baby foods may be increasingly likely to have lower amounts of heavy metals than homemade varieties.

Our findings raise concerns, but on the spectrum from worry to action, parents can choose to act. While no amount of heavy metals is considered safe, less is better, and parents can lower their babies' exposures by serving a variety of foods and by following the five safer choices for baby foods provided above.

Many factors can influence a child's IQ, from nutrition and genetics to environmental toxins like heavy metals (e.g., Makharia 2016). And many sources ratchet up children's exposures to heavy metals, from drinking water and old plastic toys to lead in dust from chipping paint and soil tracked into the house. But among these factors and sources, heavy metals in food constitute both a significant and a solvable problem. The government, companies and parents can all act — and are, in many cases, already acting — to measurably lower levels in food and to lessen exposures for babies.

88 percent of baby foods we tested have no enforceable federal safety limit for arsenic, lead and other heavy metals



RECOMMENDATIONS

Baby food companies

Our research shows that baby food companies need to take additional steps to reduce heavy metals in their products. This action is especially important for foods posing the greatest risk to baby's development, with arsenic in rice topping the list, based on a new analysis of children's IQ loss from lead and arsenic in baby food detailed in this study.

To reduce arsenic levels, solutions suggested by FDA and other experts include sourcing rice from fields with lower arsenic levels in soil, growing it with natural soil additives that reduce arsenic uptake by the roots, growing rice strains less prone to arsenic uptake, altering irrigation practices, preparing rice with excess water that is poured off, and blending it with lower arsenic grains in multi-grain products.

We found no evidence to suggest that any brand has reduced heavy metals levels in rice to amounts comparable to those found in other types of grains, despite at least 10 years of significant public attention to the issue that has included widespread consumer alerts and a proposed federal action level (Consumer Reports 2012 and 2014, HBBF 2017, FDA 2016). Four of seven infant rice cereals tested in this study contained inorganic arsenic in excess of FDA's action level.

FDA

FDA should establish and finalize health-protective standards for heavy metals, prioritizing foods that offer the greatest opportunity to reduce exposure, considering additive effects of the multiple metals detected in foods, and explicitly protecting against neurodevelopmental impacts.

FDA should implement a proactive testing program for heavy metals in foods consumed by babies and toddlers, similar to the Consumer Product Safety Commission's program for children's toys (CPSC 2019).

Because inorganic arsenic in rice is a top source of neurodevelopmental risk for children, FDA should act immediately to establish a health-based limit for this chemical in infant rice cereal and other rice-based foods. In setting its 2016 proposed action level, the agency did not consider IQ loss or other forms of neurological impact, allowed cancer risks far outside of protective limits, and failed to account for children who have unusually high exposures to arsenic in rice (HBBF 2016). Rapid action by FDA to set a protective level will protect children from high levels of arsenic in rice.

Parents

HBBF encourages parents to follow our simple actions for five foods to lower children's exposures to toxic heavy metals, shown in the Executive Summary and in the report section entitled "What parents can do." The safer choices we list contain 80 percent less arsenic, lead and other toxic heavy metals, on average, than the riskier foods.

BABY FOOD PURCHASED FOR THE STUDY: STORES, BRANDS, AND FOOD TYPES

We selected 168 individual containers of 13 different food types under 61 baby food brand names. Testing for 4 toxic heavy metals—arsenic, lead, cadmium, and mercury—was performed at Brooks Applied Labs in Bothell, Washington. Only 9 of 168 samples had no detected toxic metals.

4 toxic heavy metals tested

168 containers

61 baby food brands

Plum organics · Beech-Nut · Enfamil · Gerber · Happy Baby · Parent's Choice · up&up · Ella's Kitchen · Sprout · Similac · Earth's Best Organic

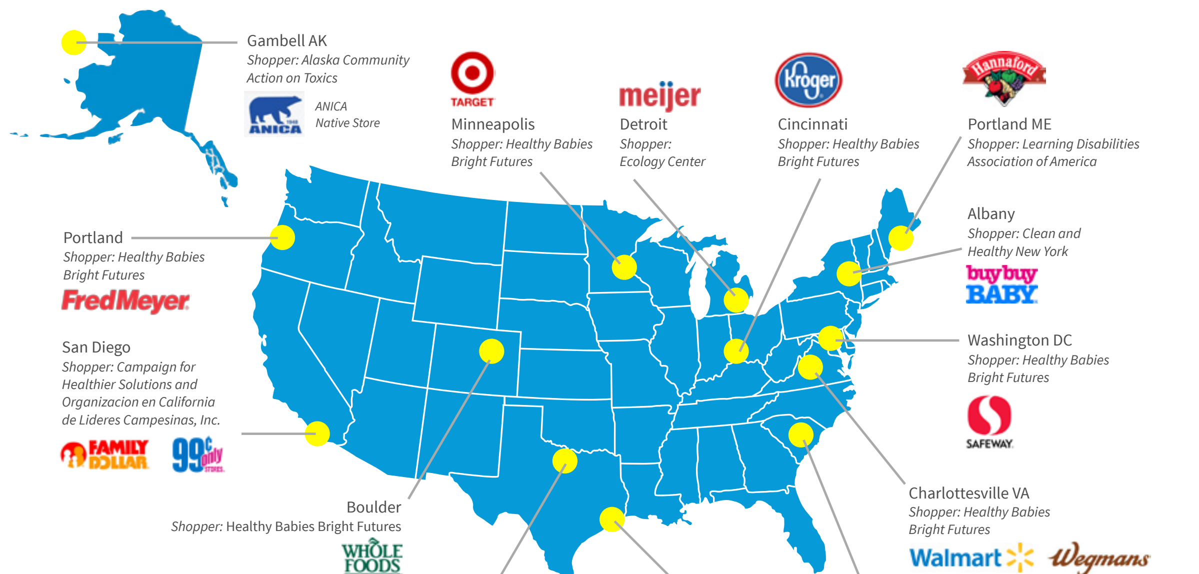
and 50 other brands

13 types of baby food

- Puffs and other snacks
- Teething biscuits, including rice rusks
- Infant rice cereal
- Infant cereal: multi- and non-rice grains
- Fruit
- Vegetables
- Mixed fruits & veggies
- Meat (jars)
- Meals (veggies, grains, pasta, meat combos)
- Infant formula
- Apple juice
- 100% fruit juice
- Other drinks for toddlers/babies

14 metropolitan areas and 17 retailers from whom the foods were purchased:

- **supermarkets**
- **dollar stores**
- **baby stores**
- **superstores**



SUMMARY: EIGHT FINDINGS FROM NEW BABY FOOD TESTS

HBBF and a national, volunteer network of seven other non-profit organizations purchased baby food from stores in 14 metropolitan areas across the country. We purchased foods from 15 retail chains - supermarkets, dollar stores, baby stores, superstores - and two online-only retailers.

We commissioned a nationally recognized laboratory with expertise in heavy metal analysis, Brooks Applied Labs (BAL) near Seattle Washington, to test for four toxic heavy metals—arsenic, lead, cadmium and mercury—in the 168 baby food containers included in this study. We also commissioned this lab to test 25 of those foods, those with the highest arsenic levels, for the specific form of arsenic most toxic to people, inorganic arsenic.

We commissioned a second laboratory, Southwest Research Institute, to test 25 of those foods for an additional neurotoxic contaminant called perchlorate, to further illustrate the need for standards that consider the wide range of neurotoxins in food. Test results, analytical methods and quality control procedures are in Appendices A, C and D. HBBF's analysis of test results shows:

1. TOXIC HEAVY METALS WERE FOUND IN NEARLY EVERY BABY FOOD TESTED.

Ninety-five percent of baby foods tested were contaminated with one or more of four toxic heavy metals—arsenic, lead, cadmium and mercury. All but nine of 168 baby foods contained at least one metal; most contained more than one. One in four foods had detectable levels of all four metals, in the same baby food container. We tested a wider range of foods than FDA includes in their annual market basket studies, but our results are consistent with the agencies' findings. In 2017 FDA detected one or more of these four metals in 33 of 39 types of baby food tested (FDA 2019c).

2. BABIES ARE EXPOSED DAILY, WITH IMPACTS TO HEALTH.

The four heavy metals we found in baby food have a unique significance: All are developmental neurotoxins (e.g., Grandjean and Landrigan 2006, Sanders 2015). They can harm a baby's developing brain and nervous system, both *in utero* and after birth, for impacts that include the permanent loss of intellectual capacity and behavioral problems like attention-deficit hyperactivity disorder (ADHD). All four metals are linked to IQ loss from exposures early in life. The scientific evidence spans decades and continues to build: at least 23 studies published in the past seven years confirm these four heavy metals' impacts to a child's healthy development (Appendix B). These metals are so prevalent in foods eaten by babies and toddlers that every child could be exposed daily to all three of the most common heavy metals detected in food - lead, arsenic, and cadmium - based on an analysis of federal surveys of children's dietary patterns and heavy metals levels in food (Abt 2019b).

3. FEW SAFETY STANDARDS EXIST.

For 88 percent of baby foods tested by HBBF—148 of 168 baby foods—FDA has failed to set enforceable limits or issue guidance on maximum safe amounts. In 2016 FDA proposed limiting inorganic arsenic in infant rice cereal to 100 ppb (FDA 2016). Inorganic arsenic exceeded this amount in four of the seven infant rice cereals tested by HBBF (Appendix A). FDA has also proposed limiting inorganic arsenic in apple juice and has issued guidance for limiting lead in fruit juice, but has failed to set specific limits for metals in any other type of baby food (FDA 2013,2014).

Baby food:
Cases of excessive heavy metal contamination, but few safety standards

Four of seven rice cereals tested:

Contain inorganic arsenic in excess of FDA's proposed limit of 100 ppb.

88 percent of foods tested:

Lack any federal standards or guidance on maximum safe levels of toxic heavy metals like arsenic and lead.

4. RECOMMENDED LIMITS ARE OFTEN EXCEEDED.

Arsenic exceeded FDA's guidance level in four of seven infant rice cereals tested. In the absence of protective federal standards for other baby foods, public health organizations have recommended limits and urged their adoption by companies and FDA. Eighty-three percent of baby foods tested had more lead than the 1-ppb limit endorsed by public health advocates (EDF 2017). Recent FDA tests also found heavy metals in baby food above safe limits, including maximum allowable amounts for children established by the European Food Safety Authority and the U.S. Agency for Toxic Substances and Disease Registry (Spungen 2019). Table 1 (page 12) shows other exceedances.

5. POPULAR BABY FOODS ESTIMATED TO POSE THE GREATEST RISK ARE AMONG THE MANY FOODS THAT LACK SPECIFIC LIMITS FOR HEAVY METALS.

HBBF commissioned a new analysis from Abt Associates, a nationally recognized toxicology and economic research group, to accompany our laboratory tests. The work included an assessment of IQ loss attributed to lead and arsenic in baby food and provided food-by-food rankings to show which foods are driving the bulk of the risk. Abt's analysis estimates that children age 0 to 24 months lose more than 11 million IQ points from exposure to arsenic and lead in food. Just 15 foods consumed by these children account for 55 percent of the total estimated IQ loss. Heavy metals in 10 of these foods are unregulated, lacking any FDA guidance or regulation to limit the levels. Abt's analysis is described in Appendix E. The analysis considers all foods consumed by children under 2, from store-bought and homemade foods for babies to the wider range of packaged and homemade foods that toddlers eat.

Milk and infant formula appear on the list of 15 foods not because of high metals levels—arsenic and lead concentrations are relatively low in both compared to some other types of baby food, according to HBBF and FDA tests—but because American children drink so much of them. These are nutritious foods, and there is no action needed by parents to change what they serve their children. But FDA action to set limits in milk and formula for arsenic and lead—and cadmium as well, which is often detected—would create benefits extending to millions of children.

Similarly, bottled water appears on the list not because high metals levels are common, but because so many children drink it. Bottled water is no safer than filtered tap water and generates plastic waste that is easily avoided by choosing tap water.

Two results stand out from the IQ analysis. First, during the first two years of life, American children lose four times more IQ points from arsenic contamination in food than from lead contamination. Second, rice-based foods—including infant rice cereal, rice dishes and rice-based snacks—contribute nearly one-fifth of the total estimated IQ loss. These results show a crucial need for swift action from FDA and baby food companies to dramatically reduce arsenic levels in rice-based foods.

Results of IQ analysis: 15 foods account for 55% of total IQ loss from children's dietary exposures to arsenic and lead in baby food

Food consumed by child age 0 - 24 months	**Percent of total harm** (fraction of total IQ points lost for children under 2, from lead and arsenic in food)	**Primary toxic metal of concern**
Rice dishes, including with beans & veggies	10.0%	**Arsenic**
Milk, whole*	8.4%	**Arsenic**
Rice, white and brown	7.0%	**Arsenic**
Apple juice	6.1%	**Arsenic**
Infant formula*	5.3%	**Lead**
Fruit juice blend (100% juice)	4.1%	**Arsenic**
Infant rice cereal	2.7%	**Arsenic**
Grape juice	2.0%	**Lead and arsenic**
Cheerios and other oat ring cereals	1.6%	**Arsenic**
Sweet potato (baby food)	1.6%	**Lead and arsenic**
Soft cereal bars and oatmeal cookies	1.4%	**Arsenic**
Macaroni and cheese	1.4%	**Lead and arsenic**
Puffs and teething biscuits	1.3%	**Lead and arsenic**
Bottled drinking water	1.2%	**Arsenic**
Fruit yogurt	1.2%	**Lead**

*Note: Milk and infant formula appear on the list not because of high metals levels — arsenic and lead concentrations are relatively low in both compared to some other types of baby food, according to HBBF and FDA tests — but because American children drink so much of them. These are nutritious foods, and there is no action needed by parents to change what they serve their children.

Source: HBBF-commissioned analysis of federal data in national surveys of food contamination and consumption (see Appendix E and Abt 2019b for details).

6. ADDITIONAL BABY FOOD TESTS BY HBBF DETECTED ANOTHER NEUROTOXIC CONTAMINANT—PERCHLORATE.

HBBF's tests uncovered one additional neurotoxin in food. We sent new containers of 25 of the foods tested for heavy metals to a separate laboratory, to be analyzed for a neurotoxic pollutant called perchlorate. The lab detected it in 19 of 25 foods tested (Appendix D and SWRI 2019). All 19 foods with detectable perchlorate also contained heavy metals, and 12 contained all four heavy metals included in our tests.

Perchlorate disrupts thyroid functions crucial to brain development and has been linked to IQ loss among children born to mothers with thyroid dysfunction, who are more vulnerable to perchlorate toxicity (Taylor 2014). It is a rocket fuel component used since the Cold War. In 2005 FDA approved its use as an antistatic in plastic food packaging, and in 2016 expanded the approval to cover dry food handling equipment. Perchlorate is also a degradation product of hypochlorite used to disinfect food processing equipment. Levels in children's food increased dramatically from 2005 to 2012 (Abt 2016, EDF 2017b).

Our tests did not find the high spikes seen previously (EDF 2017b), but our results suggest a prevalence that could pose risks during pregnancy and infancy. The results support the need for FDA to ban all food uses, especially given that perchlorate adds to neurodevelopmental risks already imposed by the heavy metal contamination in baby food.

New tests by HBBF find perchlorate contamination in 19 of 25 baby foods

Number of baby foods with perchlorate, of total tested (and maximum level found):

Infant rice cereal:	2 of 5 - 7.1 ppb
Other infant cereals:	9 of 9 - 7.8 ppb
Infant formula:	2 of 3 - 11.4 ppb
Fruits & vegetables:	4 of 4 - 19.8 ppb
Snacks:	2 of 4 - 4.6 ppb

See Appendix D for details. "ppb" = parts per billion, or micrograms per kilogram.

7. EXPOSURES AND IMPACTS ADD UP, INCREASING URGENCY FOR ACTION.

Heavy metals and perchlorate are not the only food contaminants raising the specter of IQ loss and other neurodevelopmental deficits for babies. Among recent examples, apples and spinach are often tainted with organophosphate pesticides, cheeses including mac 'n' cheese powder contain phthalate plasticizers, and a wide range of breakfast cereals, grains and beans are contaminated with the pesticide glyphosate (Roundup). All of these pollutants and pesticides are neurotoxic or linked to babies being born small (from mothers' exposures), with resulting risks for lower IQ and other neurological or behavioral impacts (e.g., Flensborg-Madsen 2017, Parvez 2018, Gillam 2017, FOE 2019, EWG 2019 and 2020, CSFPP 2017).

8. ACTIONS NEEDED BY FDA AND BABY FOOD COMPANIES GO BEYOND HEAVY METALS.

Exposures and impacts add up. The new analysis of children's IQ loss (Abt 2019b) provides a starting point for understanding these combined impacts. It considers one health impact—IQ loss—associated with 2 metals in food, arsenic and lead. Mercury in baby food would also contribute to IQ loss, and preliminary data suggests that cadmium would as well; for these metals, data were not yet available to assess the IQ drop expected with each successive exposure for a child. Those data are urgently needed. And other neurotoxic pollutants in food would add to the cumulative impacts, each time a child eats.

For parents, the answer is not switching to homemade purees instead of store-bought baby foods. Federal data shows that baby food sometimes has higher levels and sometimes lower levels of heavy metals, compared to comparable fresh or processed foods purchased outside the baby food aisle. For example, peaches and green beans from the baby food aisle are less likely to contain detectable levels of lead than canned versions of these foods, while carrot and sweet potato baby foods have higher lead detection rates than their peeled, fresh counterparts (EDF 2019b).

In most cases it's not the amount of a particular contaminant in baby food that causes concern. Our tests show that most metals are at low levels and by themselves in any given food raise little concern. It's babies' daily exposures to the many neurotoxins in baby foods that drive the urgency for action. When FDA and baby food companies address one contaminant in one type of food, children benefit. But truly protecting children necessitates addressing the many contaminants that collectively harm a child's healthy development. HBBF supports the FDA's and baby food companies' efforts to continually lower the levels of heavy metals and other neurotoxic contaminants in all baby foods. Specific recommendations include:

FDA:

HBBF agrees with the mission of FDA's Toxic Elements Working Group to reduce exposures to the greatest extent possible. We urge the agency to:

- Set health-protective standards for heavy metals, prioritizing foods that offer FDA the greatest opportunity to reduce exposure, considering additive effects of the multiple metals detected in foods, and explicitly protecting against neurodevelopmental impacts.

- Strengthen and finalize standards for arsenic in apple juice and infant rice cereal, and expand the range of foods covered. HBBF supports recommendations for a 3-ppb inorganic arsenic standard and 1-ppb lead standard that apply to all fruit juice, and a health-protective standard for arsenic in infant rice cereal and all other rice-based foods.

- Implement a proactive testing program for heavy metals in foods consumed by babies and toddlers, similar to the Consumer Product Safety Commission's program for children's toys (CPSC 2019).

- Ensure lead is not present in food contact materials where it could get into food.

- Establish a goal of no measurable amounts of cadmium, lead, mercury, and inorganic arsenic in baby and children's food, in recognition of the absence of a known safe level of exposure, and work with manufacturers to achieve steady progress.

Baby food companies:
HBBF is a member of the Baby Food Council and supports its goal to reduce heavy metals in baby food to levels as low as reasonably achievable. Other companies can join this effort, as described below from the organization's charter:

The Baby Food Council is a group of infant and toddler food companies, supported by key stakeholders, seeking to reduce heavy metals in the companies' products to as low as reasonably achievable usage best-in-class management practices. The Council was created in January 2019 in partnership with Cornell University and the Environmental Defense Fund. All companies that source ingredients, manage the upstream supply chain, and nationally market foods for children six to 24 months of age in the United States are welcome to participate in the Council. Since its creation, Healthy Babies Bright Futures has joined the Council as a member and the American Academy of Pediatrics and the Food and Drug Administration have agreed to serve as technical advisors to the effort. For more information, contact Randy Worobo of Cornell University at rww8@cornell.edu.

– The Baby Food Council, 2019

HBBF urges all baby food companies to establish a goal of no measurable amounts of cadmium, lead, mercury, and inorganic arsenic in baby and children's food, in recognition of the absence of a known safe level of exposure, and to achieve steady progress toward that goal.

WHAT PARENTS CAN DO

THE SAFER FOOD CHOICES OUTLINED HERE HAVE 80 PERCENT LOWER HEAVY METAL LEVELS, ON AVERAGE, THAN THE HIGHER RISK FOODS.

An abundance of online advice instructs parents on ways to reduce children's exposures to heavy metals in foods. HBBF has streamlined those tips down to simple actions that cover five foods posing high risks to babies' neurological development, based on Abt's new analysis (Abt 2019b). This allows parents to focus on changes that are estimated to provide the greatest benefit for babies' brains.

Note: For each pair of foods shown, concentrations shown and the comparative term "less toxic metals" are based on the average of the sum of four metals (inorganic arsenic, lead, cadmium and mercury) for the available samples of each food, unless noted otherwise. Averages were computed using data from the current study combined with data from FDA's market basket study (the Total Diet Study, FDA 2014-2017). The abbreviation "ppb" refers to parts per billion.

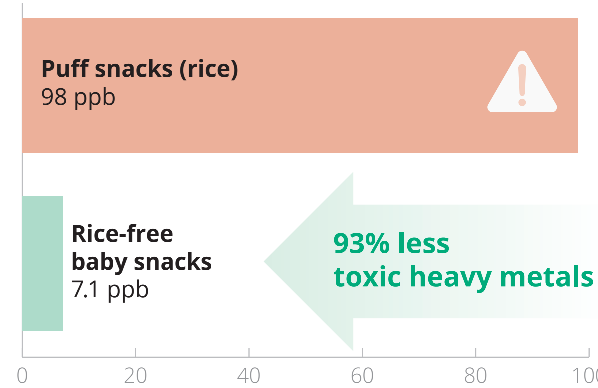
1 **Puffs and other snacks made with rice flour** contain arsenic, lead and cadmium at relatively high levels compared to other baby foods. Parents can reduce children's exposures by choosing rice-free packaged snacks instead, which have 93 percent less toxic metal residues, on average. Multi-grain snacks that include rice would also have lower levels than snacks containing rice as the only grain. Other alternatives come from Consumer Reports, which recommends snacks that are rich in nutrients and low in metals, and that can be prepared and served to be appropriate for young children (such as soft-cooked, diced or mashed): **apples, applesauce (unsweetened), bananas, barley with diced vegetables, beans, cheese, grapes (cut lengthwise), hard-boiled eggs, peaches, and yogurt** (CR 2018). A caveat for non-rice snacks—HBBF tests showed lower metals levels in non-rice snacks, including crackers, bars and yogurt snacks, but federal data shows relatively high arsenic in a popular snack we did not test: oat ring cereals like Cheerios (FDA 2019c). We recommend avoiding this choice for snacks.

2 **Teething biscuits and rice rusks** often contain arsenic, lead, and cadmium. They also lack nutrients and can cause tooth decay. Doctors and dentists recommend other solutions for baby teething pain (Colgate 2020, AAP 2020). Options include **a frozen banana, a peeled and chilled cucumber, a clean, cold wet washcloth or spoon**. Healthcare professionals advise parents to stay with their baby to watch for any choking.

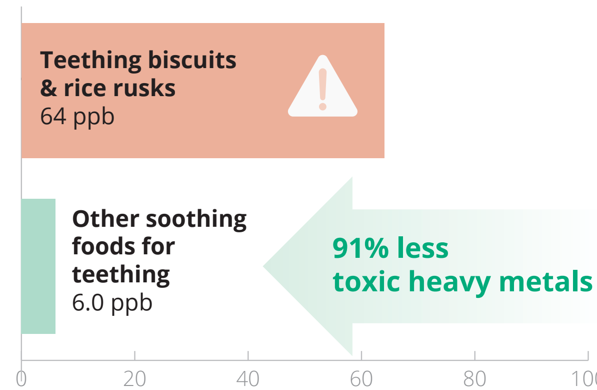
3 **Infant rice cereal** is the top source of arsenic in infant's diets. HBBF's 2017 study of infant cereals found that **non-rice and multi-grain varieties** on grocery shelves nationwide—**including oatmeal, corn, barley, quinoa, and others**—contain 84 percent less inorganic arsenic than leading brands of infant rice cereal, on average. Federal data shows 64 percent less total heavy metals, on average, in infant non-rice cereals compared to rice varieties. The alternates include reliable and affordable choices for parents seeking to reduce infants' exposures to arsenic (HBBF 2017a).

Rice is a leading source of arsenic exposure for young children. Parents can serve other grains like oats, wheat and barley instead of rice to help cut their family's exposures. Cooking rice in extra water that is poured off before serving can cut the arsenic levels by up to 60 percent, according to FDA studies (FDA 2016). The lowest arsenic levels are found in basmati rice grown in California, India, and Pakistan. White rice has less arsenic than brown rice. Rice from Arkansas, Louisiana, Texas, or simply "U.S." has the highest levels, according to testing by Consumer Reports (CR 2014).

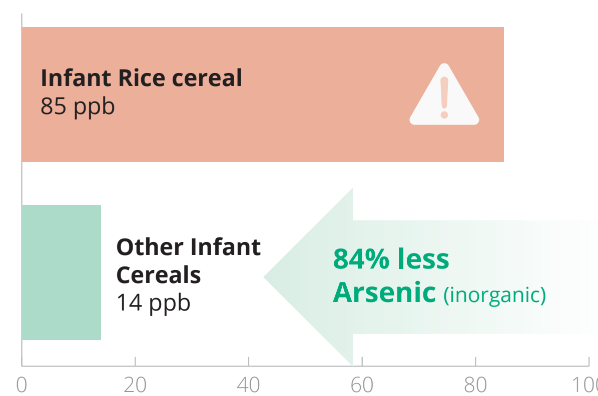
1 SNACKS



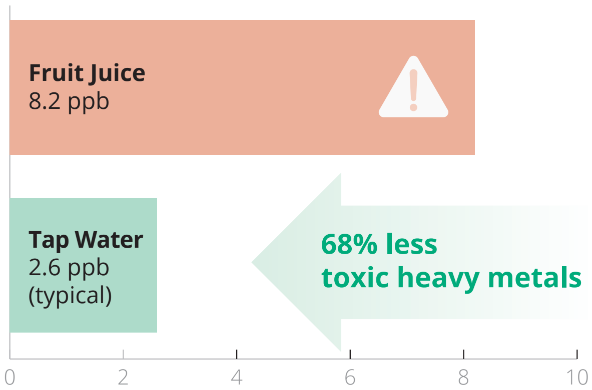
2 TEETHING FOODS



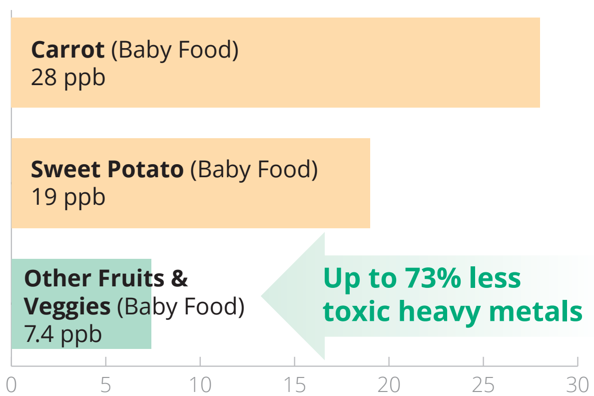
3 CEREAL



4 DRINKS



5 FRUITS & VEGGIES



4 **Apple, pear, grape and other fruit juices** contain traces of lead and arsenic. Levels aren't as high as in some other foods, but toddlers drink juice often, so it's a top exposure source. **Tap water** is a better drink for thirsty toddlers. Another alternative is **whole or pureed fruits** (like applesauce), which offer more fiber and nutrients than juice. The American Academy of Pediatrics warns parents of juice's high caloric and sugar content. It advises no fruit juice for children under 1 year of age, and half a cup or less daily for children under 3. AAP recommends that if fruit juice is given, it should be offered as part of a meal, not diluted with water and sipped over time, because of tooth decay risks (AAP 2017b, Heyman 2017).

5 **Carrots and sweet potatoes** are a great source of Vitamin A and other nutrients your baby needs. But they also contain higher levels of lead and cadmium than other fruits and vegetables, on average. Yet they are an important part of a child's diet, and a common baby food ingredient. **Variety is the solution**: parents can serve these vegetables along with other fruits and vegetables during the week, for benefits without the excess risk.

Table 1: Three take-aways:
Our research substantiated the widespread presence of four toxic heavy metals in baby foods, almost no enforceable federal standards to limit what's allowed, and the common occurrence of arsenic and lead in excess of recommended levels to protect children's health.

What did our tests of 168 baby foods find?	1. Widespread detections of toxic heavy metals				2. Few enforceable limits for baby food				3. Gaps in protecting babies' health			
	95 percent of baby foods tested were contaminated with one or more toxic heavy metals, including arsenic and lead. No food type was free of contamination.				For 10 of 13 baby food types tested, there is no FDA guidance on safe limits for toxic heavy metals.				83% of baby foods tested had more lead than the 1-ppb limit endorsed by public health advocates. Arsenic exceeded FDA's guidance level in 4 of 7 infant rice cereals tested.			
	Our tests found four toxic heavy metals in baby food (⚠ = detected)				Has FDA issued a safe limit for toxic heavy metals in the baby foods we tested? Limits endorsed by health organizations are also shown.				Did our test results exceed recommended safe limits for baby food? (⚠ = safe level exceeded in HBBF tests)			
	Arsenic	Lead	Cadmium	Mercury	Arsenic (inorganic)	Lead	Cadmium	Mercury	Arsenic	Lead	Cadmium	Mercury
Puffs and other snacks	⚠ 19 of 21 foods	⚠ 21 of 21 foods	⚠ 19 of 21 foods	⚠ 14 of 21 foods	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ All 21 foods exceed 1 ppb limit.	No limit exists	No limit has been set for mercury in baby food, but levels are low compared to amounts in canned tuna and other seafood.
Teething biscuits, including rice rusks	⚠ 10 of 10 foods	⚠ 10 of 10 foods	⚠ 10 of 10 foods	⚠ 10 of 10 foods	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ All 10 foods exceed 1 ppb limit.	No limit exists	
Infant formula	⚠ 8 of 13 containers	⚠ 13 of 13 containers	⚠ 8 of 13 containers	⚠ 1 of 13 containers	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 12 of 13 containers exceed 1 ppb limit.	No limit exists	
Infant rice cereal	⚠ 7 of 7 cereals	⚠ 7 of 7 cereals	⚠ 7 of 7 cereals	⚠ 7 of 7 cereals	**Yes - limits:** 100 ppb (FDA) 25 ppb (HBBF)	**No** 1 ppb (EDF)	**No**	**No**	⚠ 7 cereals tested. 4 exceed FDA limit. 7 exceed HBBF limit.	⚠ All 7 cereals exceed 1 ppb limit.	No limit exists	
Infant cereal - multi & single non-rice grains	⚠ 11 of 11 cereals	⚠ 10 of 11 cereals	⚠ 11 of 11 cereals	⚠ 2 of 11 cereals	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 9 of 11 cereals exceed 1 ppb limit.	No limit exists	
Meals (veggies, grains, pasta, meat combos)	⚠ 7 of 10 foods	⚠ 10 of 10 foods	⚠ 10 of 10 foods	⚠ 2 of 10 foods	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ All 10 meals exceed 1 ppb limit.	No limit exists	
Veggies	⚠ 25 of 38 containers	⚠ 38 of 38 containers	⚠ 34 of 38 containers	⚠ 9 of 38 containers	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 33 of 38 containers exceed 1 ppb limit.	No limit exists	
Fruits	⚠ 8 of 16 containers	⚠ 10 of 16 containers	⚠ 5 of 16 containers	⚠ 3 of 16 containers	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 8 of 16 containers exceed 1 ppb limit.	No limit exists	
Mixed fruits and veggies	⚠ 10 of 14 containers	⚠ 14 of 14 containers	⚠ 12 of 14 containers	⚠ 3 of 14 containers	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 11 of 14 containers exceed 1 ppb limit.	No limit exists	
Meat (jars)	⚠ 1 of 6 jars	⚠ 5 of 6 jars	⚠ 1 of 6 jars	⚠ 1 of 6 jars	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 2 of 6 jars exceed 1 ppb limit.	No limit exists	
Apple juice	⚠ 3 of 4 juices	⚠ 4 of 4 juices	**None found** 0 of 4 juices	**None found** 0 of 4 juices	**Yes - limits:** 10 ppb (FDA) 3 ppb (CR)	**Yes - limits:** 50 ppb (FDA) 1 ppb (AAP)	**No** 1 ppb (CR)	**No**	⚠ 4 juices tested. 0 exceed FDA's 10 ppb limit. 2 exceed a 3 ppb limit.	⚠ 4 juices tested. 0 exceed FDA's 50 ppb limit. 1 exceeds 1 ppb limit.	★ 4 juices tested. 0 exceed 1 ppb limit.	
Juice - 100% fruit, non-apple	⚠ 4 of 5 juices	⚠ 4 of 5 juices	⚠ 2 of 5 juices	**None found** 0 of 5 juices	**No** 3 ppb (CR)	**Yes - limits:** 50 ppb (FDA) 1 ppb (AAP)	**No** 1 ppb (CR)	**No**	⚠ 5 juices tested. 2 exceed 3 ppb limit.	⚠ 5 juices tested. 0 exceed FDA's 50 ppb limit. 3 exceed AAP limit.	★ 5 juices tested. 0 exceed 1 ppb limit.	
Other drinks for babies and toddlers	⚠ 3 of 5 drinks	⚠ 4 of 5 drinks	⚠ 2 of 5 drinks	**None found** 0 of 5 drinks	**No**	**No** 1 ppb (EDF)	**No**	**No**	No limit exists	⚠ 2 of 5 drinks exceed 1 ppb limit.	No limit exists	

Information on safety standards and recommended limits can be found in these references: FDA – 100 ppb arsenic in infant rice cereal (FDA 2016); HBBF (Healthy Babies Bright Futures) – 25 ppb arsenic in infant rice cereal (HBBF 2017a,b); FDA – 10 ppb arsenic in apple juice (FDA 2013); CR (Consumer Reports) – 3 ppb arsenic in apple and other fruit juice (CR 2019a,b); FDA – 50 ppb limit for lead in fruit juice (FDA 2004); CR and EDF (Environmental Defense Fund) – endorsement of AAP (American Academy of Pediatrics) 1-ppb lead-in-water limit to apply to fruit juice (CR 2019a,b; AAP 2017a); EDF – goal of 1 ppb for lead in baby food (EDF 2017a).

HEALTH RISKS: THE SCIENTIFIC EVIDENCE

Fresh research continues to confirm widespread exposures and troubling risks for babies exposed to the four heavy metals included in this study, including at least 23 peer-reviewed studies published in the past seven years revealing IQ loss, attention deficits, and other learning and behavioral impacts among children who are exposed through food and other sources (Appendix B). Three of the metals, arsenic, lead and cadmium, are also potent human carcinogens.

Widespread exposure to toxic heavy metals shifts the population-wide IQ curve down. It nudges more children into special education, and ratchets down the IQ of the most creative and intellectually gifted children. For an individual child, the harm appears to be permanent (e.g., Grandjean and Landrigan 2014, Wasserman 2007 and 2016, Hamadani 2011).

Instead of overt poisoning, the low, daily exposures children face from heavy metals in food and other sources create "subclinical decrements in brain function" with impacts on a global scale. Scientists write that the exposures "diminish quality of life, reduce academic achievement, and disturb behaviour, with profound consequences for the welfare and productivity of entire societies" (Grandjean and Landrigan 2014).

ARSENIC

Arsenic widely contaminates food and drinking water from its long-time use as a pesticide and an additive in animal feed, from its release at mining and industrial operations, and from natural sources. Arsenic causes bladder, lung and skin cancer and also harms the developing brain and nervous system. In the peer-reviewed scientific literature, at least 13 studies link arsenic to IQ loss for children exposed in utero or during the first few years of life (Rodriguez-Barranco 2013).

Among evidence supporting arsenic's ability to harm the brain is a 2014 assessment of nearly 300 third to fifth graders in Maine, finding an average loss of 5-6 IQ points among those who drank well water contaminated with arsenic at or above 5 parts per billion. This level is common in some parts of the U.S. and is lower than the legal limit in public water supplies (10 parts per billion) (Wasserman 2014). Studies find lasting impacts when children are exposed to arsenic early in life, including persistent IQ deficits in children two years after their polluted drinking water was replaced, cognitive deficits among school-age children exposed early in life, and neurological problems in adults who were exposed to arsenic-poisoned milk as infants (Wasserman 2007 and 2016, Hamadani 2011, Tanaka 2010). There is no evidence that the harm caused by arsenic is reversible.

LEAD

Over the past 40 years lead has been restricted in children's toys and phased out of gasoline, pesticides, paint, and food contact surfaces, including lead solder from cans. But lead that lingers in homes, soil, and water remains a festering problem. The toxic metal continues to contaminate the blood of nearly every child tested. Although exposures are lower now than in the past, lead-induced brain damage still accounts for an estimated 23 million IQ points lost among children under five (Bellinger 2012). Even very low exposure levels cause lower academic achievement, attention deficits and behavior problems. No safe level of exposure has been identified.

Evidence of lead's toxicity spans decades. Among recent studies are two that included 80,000 Detroit and Chicago school children, 3rd grade through middle school, whose standardized math and reading tests were correlated to their blood lead levels measured at birth or early childhood. "Early childhood lead exposure is associated with poorer achievement… even at very low blood lead levels," concluded one of the research teams (Zhang 2013, Evens 2015).

Lead widely contaminates food from its long-time use as a pesticide, its presence in food processing equipment (in older brass, bronze, plastic, and coated materials), and its presence at elevated levels in soil, either natural or accumulated from industrial pollution. In October 2018 FDA cut in half its maximum daily intake limit for lead in children's food. An estimated 2.2 million children six years or younger exceed the new intake limit (EDF 2019a).

Beyond Food: Other sources of lead exposure

For many children the biggest source of lead exposure is not food, but lead paint in homes built before 1978. Lead from chipping and peeling paint builds up in house dust and sticks to children's hands. It also flakes off of a home's exterior to contaminate soil in the yard.

To learn if you have lead paint, have your home inspected by a licensed lead inspector. You can also use a simple test kit sold at many hardware stores. Learn more: https://www.epa.gov/lead/protect-your-family-exposures-lead

CADMIUM

Cadmium is a heavy metal linked to neurotoxicity and cancer, and to kidney, bone and heart damage. It has many industrial uses and is a common contaminant in food and the environment. It lacks the name recognition of arsenic and lead, but may deserve an equal share of attention from parents, companies, and regulators, since it also displays a troubling ability to cause harm at low levels of exposure.

A 2015 review of recent scientific literature identified 16 studies on the neurotoxic impacts of cadmium on children. Among these is research by Harvard scientists reporting a tripling of risk for learning disabilities and special education among children with higher cadmium exposures, at levels common among U.S. children and previously thought to be safe (Ciesielski 2012).

A 2019 study by FDA found that cadmium in food exceeds amounts safe for children: In its 2014-2016 market basket tests, FDA detected cadmium in 65 percent of nearly 3000 food samples tested, and estimated that children's average exposures exceed safe limits established by both the European Food Safety Authority and the U.S. Agency for Toxic Substances and Disease Registry (Spungen 2019).

MERCURY

Mercury is a global pollutant released from coal-fired power plants, mining operations and other sources. It contaminates the biosphere and the food chain. Seafood is the dominant source of mercury exposure for children and adults. It contains a particularly toxic form of mercury called methylmercury that increases risk for cardiovascular disease for adults and poor performance on tests of vision, intelligence, and memory for children exposed in utero.

Evidence that the developing brain is particularly sensitive to mercury extends back decades, covering two mass poisonings and major longitudinal studies of lower exposures from seafood, among other research (NAS 2000). Recently, scientists found a four-fold higher risk for IQ scores under 80, the clinical cut-off for borderline intellectual disability, among school-age children exposed to high levels of mercury in utero (Jacobsen 2015).

Although mercury was detected in 32 percent of the 168 baby foods tested in this study, levels were far lower than typical amounts in tuna and other seafood. FDA and EPA's joint advisory gives safer seafood choices for pregnant women and young children (EPA and FDA 2019). A number of NGOs have published more conservative advice to protect women who eat seafood frequently (EWG 2014, MBASW 2020). Mercury levels in canned tuna exceed the legal limit under California's Proposition 65, but an attempt to require the law's mandated warnings on canned tuna failed in 2006 when an appeals court found that the California law was preempted by the FDA/EPA seafood advisory (Kone 2006).

The four toxic metals covered in this study—arsenic, lead, cadmium and mercury—were regulated decades ago in sources as wide-ranging as drinking water, gasoline and children's toys.

Regulations have also eliminated lead from food contact surfaces, including lead solder from food cans (Bolger 1996). But they remain without an enforceable limit or guideline in nearly every type of baby food, despite being widely acknowledged as toxic during a child's development and prevalent in popular baby and toddler foods.

All four metals are neurotoxic. Three—arsenic, lead and mercury—have been shown to permanently reduce children's IQ. Three are also human carcinogens, arsenic, cadmium and lead.

FDA can use its testing programs, recall authority, and guidance to industry, among other tools, to characterize and control heavy metal levels in food. The agency tests a fraction of imported food in their Import Program, prioritizing food likely to pose risks to consumers, including those with high heavy metals levels. Federal law gives FDA the authority to require a recall of food it deems to be adulterated, that "bears or contains any poisonous or deleterious substance which may render it injurious to health," including heavy metals. In the past three years FDA has issued recalls for eight foods with excessive lead or arsenic, none of which were baby foods (FDA 2019d). In September 2019 the agency issued an import alert for lead and arsenic in grape and pear juice concentrates, advising their inspectors to target these products for testing (FDA 2019e).

FDA also tests a variety of foods on store shelves in their Total Diet Study market basket program, focusing on foods that are commonly eaten or likely to have high levels of metals (FDA 2019c). FDA's compliance program conducts occasional testing programs that target select, high-risk foods. These data have helped FDA prioritize its work to reduce heavy metals levels in baby food.

In 2016 FDA proposed limiting inorganic arsenic in infant rice cereal to 100 ppb (FDA 2016). Inorganic arsenic exceeded this amount in four of the seven infant rice cereals tested by HBBF.

FDA has also proposed limiting inorganic arsenic in apple juice and has issued guidance for limiting lead in fruit juice (FDA 2004, 2013), but has failed to set limits for metals in any other type of baby food.

Despite FDA's many areas of authority and its recent emphasis on reducing exposures to heavy metals, for 88 percent of baby foods tested by HBBF—148 of 168 baby foods—FDA has failed to set enforceable limits or issue guidance on maximum safe amounts.

And none of the agency's existing guidance considers the additive neurological impacts of multiple metals in baby food.

FDA'S PROPOSED GUIDANCE FOR ARSENIC IN INFANT RICE CEREAL REMAINS UNFINALIZED DESPITE PROMISES TO COMPLETE IN 2018.

FDA's 2016 proposed limit for inorganic arsenic in infant rice cereal—its 100 parts-per-billion "action level"—falls short of what is needed to protect children. In proposing the level, FDA did not consider IQ loss or other forms of neurological impact, allowed cancer risks far outside of protective limits, and failed to account for children who have unusually high exposures to arsenic in rice (HBBF 2016, HBBF 2017a).

And if the agency finalizes the action level, it will serve only as guidance to the infant cereal industry, not as a standard that FDA is required to enforce. Instead, FDA can choose whether or not to enforce an action level, at its own discretion.

HBBF has advocated that FDA finalize a more protective standard that protects against neurological harm during development and that applies to all rice-based foods eaten by babies and pregnant women. HBBF has also called on cereal companies to reduce levels to 25 ppb, an amount typical of levels in multi-grain cereals (HBBF 2017a,b).

Altogether, six of 30 rice-based baby foods tested by HBBF contained inorganic arsenic above the 100-ppb limit proposed for infant rice cereal—four infant rice cereals and two puff snacks (Appendix A).

FDA'S PROPOSED GUIDANCE FOR ARSENIC IN APPLE JUICE REMAINS UNFINALIZED DESPITE PROMISES TO COMPLETE IN 2018.

In 2013 FDA proposed limiting inorganic arsenic in apple juice to 10 ppb, the federal government's standard for arsenic in drinking water (FDA 2013). This limit still has not been finalized. Consumer Reports, a long-time advocate for reducing toxic metals in food, has argued for a more protective limit of 3 ppb, and for inclusion of other high-arsenic juices, like grape and pear juice (CR 2019a,b).

Arsenic in juice exceeded CR's recommended limit of 3 ppb in two of nine juices tested by HBBF, a white grape juice and an apple juice.

FDA has also issued guidance to limit lead in fruit juice (FDA 2004). This level, 50 ppb, is 3.3 times higher than the federal drinking-water action level, 10 times more than the FDA's bottled-water standard, and 50 times higher than the American Academy of Pediatrics' recommended lead-in-water limit for school drinking fountains.

Experts at Consumer Reports and the Environmental Defense Fund back a far lower limit, arguing for a 1-ppb cap to match the American Academy of Pediatrics' recommended maximum for lead in school drinking fountains (CR 2019a,b; AAP 2017).

While none of the fruit juices tested by HBBF topped FDA's 50-ppb limit, four of nine juices contained more lead than the recommended 1 ppb cap, with a maximum of over 11 ppb in a white grape juice marketed for toddlers. At these levels, the many children who regularly drink juice are getting too much lead. Eighty percent of American families with toddlers and babies serve juice to children. Three-quarters of those families serve it daily; their children face the highest risks (CR 2019b).

PROMISING PROGRESS AT FDA

In April 2017 FDA's Center for Food Safety and Applied Nutrition (CFSAN) announced it had established a Toxic Elements Working Group to modernize safety standards for the toxic metal mixtures Americans are exposed to, including in food. The working group is charged with charged with "achiev[ing] the public health goal of reducing exposure… to the greatest extent possible" (FDA 2017, 2018a,b).

Although FDA has not yet introduced new standards as a result of the initiative, it has made progress. It has lowered the maximum allowed daily lead intake for children from 6 to 3 micrograms per day (ug/day) and set a cap of 12.5 ug/day for women who are pregnant or nursing. These new "Interim Reference Levels" are a critical first step for lowering allowable lead levels in food (FDA 2019b). FDA has also launched new research to understand children's exposures to combinations of metals, and the impacts of these mixtures on the developing brain and nervous system (e.g., Spungen 2019). The agency missed its commitment to finalize the arsenic guidelines for infant rice cereal and apple juice by the end of 2018.

Heavy metal mixtures like those found in baby food pose risks to the developing brain. Setting protective, health-based limits for these contaminants presents an opportunity to make a significant difference in children's health.

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APPENDIX A: LABORATORY TEST RESULTS FOR HEAVY METALS

Results for analysis of heavy metals in a variety of baby foods are listed below. Foods were tested for total recoverable arsenic; speciated arsenic (total inorganic arsenic is shown below); and total recoverable lead, cadmium, and mercury. Testing was commissioned by HBBF and performed by Brooks Applied Labs in Bothell, Washington in 2019. Appendix C provides a summary of analytical methods.

The qualifier "<" indicates that the concentration was below the method detection limit, while The symbol "*" indicates test results that are estimated, that fall between the limit of detection and the limit of quantification. The qualifier "--" indicates that the analysis was not performed.

About estimated values: The table below shows results for all target analytes detected by the lab's instruments. Estimated values shown with the qualifier "*" have greater uncertainty than other results. The starred (*) values are the lab's best estimates of concentration, but the actual amounts may be higher or lower than these best estimates. These estimated test results are near the test's detection limit. They are higher than the detection limit but lower than the test's quantitation limit. In contrast, test results above the quantification limit don't carry the J qualifier - they have lower uncertainty and are not considered to be estimates. The laboratory's detailed reports that accompany this study give detection and quantification limits for each individual test result shown below.

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Infant cereal: rice									
Beech-Nut	Rice Single Grain Baby Cereal - Stage 1, from about 4 months	Cereal - rice	117	86	3.5	5.4	0.582	Charlottesville, VA	Wegmans
BioKinetics	BioKinetics Brown Rice Organic Sprouted Whole Grain Baby Cereal	Cereal - rice	353	144	3.1 *	31.7	2.32	Washington, DC	amazon.com
Earth's Best	Whole Grain Rice Cereal	Cereal - rice	138	113	22.5	14.7	2.41	San Diego, CA	99 Cents Only Stores
Earth's Best	Whole Grain Rice Cereal	Cereal - rice	126	107	17.8	13.4	2.19	Portland, ME	Hannaford
Gerber	Rice Single Grain Cereal	Cereal - rice	106	74	3.9	11.1	1.79	Gambell, AK	ANICA Native Store
Healthy Times	Organic Brown Rice Cereal - 4+ months	Cereal - rice	153	133	67.4	12.1	1.53	Washington, DC	amazon.com
Kitchdee Organic	Baby Cereal Rice and Lentil - 6+ months	Cereal - rice	79.3	78	10.9	13.1	4.06	Washington, DC	amazon.com
Infant cereal: multi- and single non-rice grain									
Gerber	MultiGrain Cereal - Sitter 2nd Foods	Cereal - mixed and multi-grain	37	31	5.3	26.2	0.367 *	Detroit, MI	Meijer
HappyBABY	Oats & Quinoa Baby Cereal Organic Whole Grains with Iron - Sitting baby	Cereal - mixed and multi-grain	10.2	--	0.9 *	12.4	< 0.14	Minneapolis, MN	Target
Beech-Nut	Oatmeal Whole Grain Baby Cereal - Stage 1, from about 4 months	Cereal - oatmeal	23.8	--	2.2	13	< 0.139	Portland, OR	Fred Meyer
Earth's Best	Whole Grain Oatmeal Cereal	Cereal - oatmeal	29.5	27	2 *	20.1	< 0.277	Portland, ME	Hannaford
Gerber	Oatmeal Single Grain Cereal	Cereal - oatmeal	26.9	--	3 *	13	< 0.281	Washington, DC	Safeway
HappyBABY	Oatmeal Baby Cereal, Clearly Crafted - Organic Whole Grains - for sitting baby	Cereal - oatmeal	6.3 *	--	< 0.5	10	< 0.14	Albany, NY	buybuyBABY
Harvest Hill	Instant Oatmeal, Maple & Brown Sugar	Cereal - oatmeal	13.5	--	8.1	5.8	< 0.14	Houston, TX	Dollar Tree
Cream of Wheat	Cream of Wheat Instant Original Flavor	Cereal - other single-grain	19.5	--	21.8	36.7	< 0.14	San Diego, CA	99 Cents Only Stores

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Gerber	Barley Single Grain Cereal- Supported Sitter 1st Foods	Cereal - other single-grain	10.6 *	--	3 *	13.7	< 0.279	Detroit, MI	Meijer
Gerber	Whole Wheat Whole Grain Cereal - Sitter 2nd Foods	Cereal - other single-grain	40.6	39	5.5	50.8	< 0.14	Cincinnati, OH	Kroger
NurturMe	Organic Quinoa Cereals - Quinoa + Sweet Potato + Raisin	Cereal - other single-grain	35.9	26	39.8	20.3	0.389 *	San Diego, CA	99 Cents Only Stores
Infant formula									
365 organic (Whole Foods)	Organic Milk Based Powder Infant Formula with Iron	Formula	4.1 *	--	2.7	0.7 *	< 0.139	Boulder, CO	Whole Foods Market
Baby's Only Organic	Organic Non-GMO Dairy Toddler Formula	Formula	3.8 *	--	1.6 *	< 0.5	< 0.139	Boulder, CO	Whole Foods Market
Earth's Best	Organic Sensitivity - DHR/ARA Infant Formula with Iron Organic Milk-Based Powder	Formula	< 4.4	--	1.6 *	1.4 *	< 0.278	Portland, ME	Hannaford
Enfamil	ProSobee Soy Infant Formula, Milk-Free Lactose-Free Powder with Iron	Formula	6.2 *	--	7.8	6.9	< 0.14	Columbia, SC	Publix
Enfamil	Infant - Infant Formula Milk-Based with Iron - 0-12 months	Formula	< 2.2	--	2	0.7 *	< 0.138	Charlottesville, VA	Wegmans
Gerber	Good Start Gentle HM-O and Probiotics Infant Formula with iron; Milk Based Powder - Stage 1, birth to 12 months	Formula	5.2 *	--	0.9 *	< 0.5	< 0.14	Cincinnati, OH	Kroger
HappyBABY	Organic Infant Formula with Iron, Milk Based Powder - 0-12 months	Formula	< 4.5	--	3.7	< 1.1	< 0.286	Washington, DC	amazon.com
Meijer	Meijer Baby, Infant Formula - Milk-Based Powder with Iron - Birth - 12 months	Formula	< 4.4	--	2.3 *	3.1 *	0.417 *	Detroit, MI	Meijer
Parent's Choice (Walmart)	Organic Infant With Iron Milk-Based Powder - Stage 1 through 12 months	Formula	3.2 *	--	3.9	0.7 *	< 0.134	Charlottesville, VA	Walmart
Plum Organics	Gentle Organic Infant Formula with Iron, Milk-Based Powder - 0-12 months †	Formula	4.6 *	--	4.7	< 1.1	< 0.278	Washington, DC	amazon.com
Similac	Similac Advance OptiGRO Powder - Milk-Based	Formula	4.6 *	--	2	< 0.5	< 0.139	Gambell, AK	ANICA Native Store
Simple Truth Organic (Kroger)	Infant Formula with Iron, Organic Milk-Based Powder	Formula	3.6 *	--	2.7	0.6 *	< 0.135	Portland, OR	Fred Meyer
up & up (Target)	Infant - Infant Formula with Iron, Milk-Based Powder, DHA and Dual Prebiotics	Formula	< 2.2	--	1.5 *	3.1	< 0.138	Minneapolis, MN	Target
Vegetable - single, carrot									
Beech-Nut	Classics Sweet Carrots - 2	Veggie - single - carrot	< 2.1	--	27.2	6.8	0.15 *	Washington, DC	Safeway
Beech-Nut	Classics Sweet Carrots - Stage 2	Veggie - single - carrot	< 2.2	--	23.5	8	0.212 *	Portland, ME	Hannaford
Beech-Nut	Organics Just Carrots - Stage 1	Veggie - single - carrot	2.8 *	--	1.3 *	1.4 *	0.142 *	Minneapolis, MN	Target

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Earth's Best	Carrots Organic Baby Food - 2, 6 months +	Veggie - single - carrot	4.1 *	--	1.1 *	< 0.5	0.224 *	Boulder, CO	Whole Foods Market
Earth's Best	Carrots Organic Baby Food 2 - 6 months+	Veggie - single - carrot	3.5 *	--	1.6 *	5.2	0.24 *	Columbia, SC	Publix
Earth's Best	First Carrots Organic Baby Food - 1, 4 months+	Veggie - single - carrot	5.2 *	--	1.6 *	4.4	0.222 *	Charlottesville, VA	Wegmans
Gerber	Diced Carrots Veggie Pick-Ups™	Veggie - single - carrot	< 2.2	--	11.8	27.7	0.223 *	Washington, DC	Safeway
Gerber	Carrot - Sitter 2nd food	Veggie - single - carrot	< 2.2	--	9.4	31.4	0.214 *	Minneapolis, MN	Target
Gerber	Carrot - Supported Sitter 1st Foods	Veggie - single - carrot	< 2.2	--	11	42.2	0.248 *	Columbia, SC	Publix
Meijer	True Goodness Organic Carrots Baby Food	Veggie - single - carrot	< 2.2	--	1.4 v	7.7	< 0.141	Detroit, MI	Meijer
O Organics (Albertson/Safeway)	Organic Carrots Baby Food - 2	Veggie - single - carrot	3.3 *	--	1.9	5.2	< 0.14	Washington, DC	Safeway
Parent's Choice (Walmart)	Carrot - Stage 2, 6+ months	Veggie - single - carrot	< 2	--	2.3	11.2	< 0.128	Charlottesville, VA	Walmart
Vegetable - single, sweet potato									
Beech-Nut	Naturals Just Sweet Potatoes - Stage 1, from about 4 months	Veggie - single - sweet potato	2.4 *	--	14.1	4	< 0.136	Albany, NY	buybuyBABY
Beech-Nut	Organics Just Sweet Potatoes - Stage 1, from about 4 months	Veggie - single - sweet potato	3.8 *	--	7.3	2.7	< 0.142	Cincinnati, OH	Kroger
Beech-Nut	Classics Sweet Potatoes - Stage 2, from about 6 months	Veggie - single - sweet potato	2.8 *	--	24.1	3.4	< 0.138	Portland, OR	Fred Meyer
Earth's Best	Sweet Potatoes Organic Baby Food - 1, 4 months +	Veggie - single - sweet potato	3.3 *	--	14.7	4.6	< 0.136	Boulder, CO	Whole Foods Market
Earth's Best	Sweet Potatoes Organic Baby Food 2 - from about 6 months	Veggie - single - sweet potato	3.1 *	--	12.9	3	< 0.136	Portland, OR	Fred Meyer
Earth's Best	Sweet Potatoes Organic Baby Food 2 - 6 months+	Veggie - single - sweet potato	4.3 *	--	6.9	1.6 *	< 0.138	Columbia, SC	Publix
Gerber	Sweet Potato Supported Sitter 1st Foods Tub	Veggie - single - sweet potato	2.4 *	--	20.3	4.7	< 0.139	Washington, DC	Safeway
Gerber	Sweet Potato - Sitter 2nd Food	Veggie - single - sweet potato	3.9 *	--	29.3	5.8	< 0.138	Minneapolis, MN	Target
Gerber	Sweet Potato - Supported Sitter 1st Foods	Veggie - single - sweet potato	6.9	--	14.6	3.5	< 0.138	Cincinnati, OH	Kroger
HappyBABY	Organics Sweet Potatoes - Stage 1	Veggie - single - sweet potato	5.8 *	--	1.5 *	1 *	< 0.142	Portland, ME	Hannaford

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
HappyBABY	Organics Sweet Potatoes - Stage 1	Veggie - single - sweet potato	6 *	--	2.2	0.8 *	< 0.14	Detroit, MI	Meijer
HappyBABY	Sweet Potatoes - Stage 1	Veggie - single - sweet potato	27.5	29**	2	1.6 *	< 0.141	Columbia, SC	Publix
Meijer	Meijer Baby Sweet Potatoes - 2nd Stage	Veggie - single - sweet potato	11.9	--	1.3 *	0.8 *	< 0.14	Portland, ME	Hannaford
Meijer	True Goodness Organic Sweet Potatoes Baby Food - Stage 2	Veggie - single - sweet potato	2.6 *	--	0.8 *	0.6 *	< 0.14	Detroit, MI	Meijer
Parent's Choice (Walmart)	Sweet Potato - Stage 1, 4-6 months	Veggie - single - sweet potato	4.3 *	--	4.3	1.4 *	< 0.141	Charlottesville, VA	Walmart
Plum Organics	Just Sweet Potato Organic Baby Food - 1, 4 months & up	Veggie - single - sweet potato	3.1 *	--	5.6	2.3	< 0.142	Boulder, CO	Whole Foods Market
Plum Organics	Just Sweet Potato Organic Baby Food - 1, 4 months & up	Veggie - single - sweet potato	2.3 *	--	14	2.7	< 0.14	Washington, DC	Safeway
Vegetable - single (other than carrot, sweet potato)									
Beech-Nut	Classics Sweat Peas - Stage 2	Veggie - single - other	6.3 *	--	1.1 *	1.6 *	< 0.138	Portland, ME	Hannaford
Beech-Nut	Beechnut Naturals Just Butternut Squash - Stage 1	Veggie - single - other	< 2.2	--	1.3 *	1.2 *	< 0.139	Detroit, MI	Meijer
Beech-Nut	Organic Just Pumpkin - Stage 1, from about 4 months	Veggie - single - other	2.6 *	--	4	1.1 *	< 0.139	Portland, OR	Fred Meyer
Earth's Best	Winter Squash Organic Baby Food - 2, 6 months +	Veggie - single - other	< 2.2	--	0.8 *	< 0.5	< 0.137	Cincinnati, OH	Kroger
Earth's Best	First Peas Organic Baby Food 1 - 4 months+	Veggie - single - other	5.9 *	--	3.8	< 0.5	< 0.14	Columbia, SC	Publix
Gerber	Pea - Sitter 2nd foods	Veggie - single - other	< 2.2	--	0.7 *	< 0.5	< 0.14	Gambell, AK	ANICA Native Store
Gerber	Green Bean - Sitter 2nd Food	Veggie - single - other	< 2.1	--	0.8 *	2.8	< 0.135	Minneapolis, MN	Target
Gerber	Green Bean - Supported Sitter 1st Foods	Veggie - single - other	< 2.2	--	0.7 *	0.6 *	< 0.142	Cincinnati, OH	Kroger
Parent's Choice (Walmart)	Organic Butternut Squash Vegetable Puree - Stage 2, 6+ months	Veggie - single - other	< 2.2	--	4.2	0.9 *	< 0.138	Charlottesville, VA	Walmart

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Fruit - single									
Applesnax	Applesauce with Cinnamon	Fruit - single - apple	< 2.1	--	1.7	< 0.5	< 0.134	Dallas, TX	Dollar Tree
Beech-Nut	Organic Just Apples - Stage 1, from about 4 months	Fruit - single - apple	< 2	--	< 0.5	< 0.5	< 0.126	Charlottesville, VA	Wegmans
Earth's Best	Apples Organic Baby Food 2 - from about 6 months	Fruit - single - apple	6.5	--	1.5 *	< 0.5	< 0.141	Portland, OR	Fred Meyer
Mott's	Mott's Applesauce Apple	Fruit - single - apple	< 2.2	--	< 0.5	< 0.5	< 0.139	San Diego, CA	Family Dollar
Seneca	Cinnamon Apple Sauce	Fruit - single - apple	5.6 *	--	3.7	0.7 *	< 0.138	San Diego, CA	99 Cents Only Stores
Beech-Nut	Naturals Bananas - Stage 1, from about 4 months	Fruit - single - banana	< 2.1	--	< 0.5	< 0.5	< 0.136	Albany, NY	buybuyBABY
Gerber	Banana - Sitter 2nd Foods	Fruit - single - banana	< 2.1	--	< 0.5	< 0.5	< 0.135	Gambell, AK	ANICA Native Store
Meijer	Meijer Baby Bananas - 2nd Stage	Fruit - single - banana	< 2.2	--	< 0.5	< 0.5	< 0.138	Detroit, MI	Meijer
Gerber	Peach - Sitter 2nd Foods	Fruit - single - other	7.3	--	2.4	2.1	0.142 *	Gambell, AK	ANICA Native Store
Orchard Naturals	Mandarin Oranges in Light Syrup	Fruit - single - other	< 2.2	--	< 0.5	< 0.5	< 0.139	Houston, TX	Dollar Tree
Plum Organics	Just peaches - organic baby food - for 4+ months (stage 1)	Fruit - single - other	7.2	--	0.9 *	< 0.5	< 0.139	Albany, NY	buybuyBABY
Earth's Best	First pears - 1, 4 months+	Fruit - single - pear	4.3 *	--	1.2 *	1.5 *	< 0.135	Houston, TX	99 Cents Only Stores
Gerber	Pear - Sitter 2nd foods	Fruit - single - pear	4.2 *	--	1.1 *	2.5	0.169 *	Gambell, AK	ANICA Native Store
HappyBABY	Organic Pears - Stage 1	Fruit - single - pear	7.4	--	1 *	0.8 *	< 0.138	Boulder, CO	Whole Foods Market
HappyBABY	Clearly Crafted Prunes Organic Baby Food, 1, 4+ months	Fruit - single - prune	< 2.1	--	2	< 0.5	< 0.136	Charlottesville, VA	Wegmans
Sprout	Prunes Organic Baby Food - 1 starting solids	Fruit - single - prune	3.9 *	--	6.1	< 0.5	0.245 *	Albany, NY	buybuyBABY
Fruit & Veggie, Mixed									
Beech-Nut	Naturals Beets, Pear & Pomegranate - 2	Fruit and veggie - mixed	< 2.2	--	0.9 *	4.7	< 0.139	Washington, DC	Safeway
Gerber	Organic Mango Apple Carrot Kale - Sitter 2nd foods	Fruit and veggie - mixed	3.3 *	--	1.1 *	11.4	0.212 *	Gambell, AK	ANICA Native Store
Gerber	Carrot Pear Blackberry - Sitter 2nd Foods	Fruit and veggie - mixed	2.7 *	--	3.6	18.2	< 0.141	Washington, DC	gerber.com
Gerber	Organic Apple Blueberry Spinach - Sitter 2nd Food	Fruit and veggie - mixed	5 *	--	1.5 *	1.8	< 0.141	Houston, TX	99 Cents Only Stores

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
HappyBABY	Simple Combos Apples, Spinach & Kale - 2	Fruit and veggie - mixed	3 *	--	4.3	4.9	0.182 *	Portland, ME	Hannaford
O Organics (Albertson/Safeway)	Organic Apple, Sweet Potato & Carrot Baby Food	Fruit and veggie - mixed	2.6 *	--	0.7 *	1.1 *	< 0.142	Washington, DC	Safeway
Plum Organics	Just Prunes Organic Baby Food - 1, 4 months & up	Fruit and veggie - mixed	7.6	--	2.5	< 0.5	0.194 *	Boulder, CO	Whole Foods Market
Sprout	Carrot Apple Mango Organic Baby Food - 2, 6 months & up	Fruit and veggie - mixed	6.1	--	2.1	15.1	< 0.131	Charlottesville, VA	Wegmans
up & up (Target)	Apple and Carrot Baby Food, Fruit + Vegetable Blend, 6+ months	Fruit and veggie - mixed	< 2.3	--	0.7 *	< 0.6	< 0.146	Minneapolis, MN	Target
Gerber	Apple Sweet Potato with Cinnamon - Toddler 12+ months	Fruit and veggie - mixed	< 2.2	--	3.1	0.7 *	< 0.139	Houston, TX	99 Cents Only Stores
Plum Organics	Pumpkin Banana Papaya Cardomom - 6 months and up	Fruit and veggie - mixed	2.4 *	--	1.4 *	2.4	< 0.139	San Diego, CA	99 Cents Only Stores
Beech-Nut	Classics Mixed Vegetables - Stage 2	Veggie - mixed	< 2.2	--	17.9	8.6	< 0.139	Portland, ME	Hannaford
Earth's Best	Spinach and Potato Organic Baby Food - 2, 6+ months	Veggie - mixed	6.4	--	1.4 *	3	< 0.13	Charlottesville, VA	Wegmans
Gerber	Carrot Sweet Potato Pea - Sitter 2nd Foods	Veggie - mixed	2.4 *	--	6.7	2.1	< 0.137	Gambell, AK	ANICA Native Store
Juice - 100% apple									
365 organic (Whole Foods)	100% Juice - Apple from Concentrate	Juice - 100% fruit	2.5 *	--	0.7 *	< 0.5	< 0.13	Boulder, CO	Whole Foods Market
Gerber	Apple Juice from Concentrate - Toddler 12+ months	Juice - 100% fruit	3.1 *	--	2.1	< 0.5	< 0.137	Portland, ME	Hannaford
Juicy Juice	Juicy Juice 100% Juice - Apple	Juice - 100% fruit	3.6 *	--	1 *	< 0.5	< 0.14	Dallas, TX	Dollar Tree
Kidgets	Toddler Apple Juice from Concentrate	Juice - 100% fruit	< 2.2	--	0.6 *	< 0.5	< 0.141	San Diego, CA	Family Dollar
Juice - 100% fruit juice, non-apple or mixed									
Apple & Eve	Elmo's Punch - 100% Juice Organics	Juice - 100% fruit	< 2.1	--	< 0.5	< 0.5	< 0.137	Boulder, CO	Whole Foods Market
Gerber	Apple Prune Juice from Concentrate - Toddler 12+ months	Juice - 100% fruit	5.6 *	--	3.3	< 0.5	< 0.136	Cincinnati, OH	Kroger
Gerber	Variety Pack Juices from Concentrate - White Grape	Juice - 100% fruit	9.9	--	11.1	< 0.5	< 0.135	Portland, OR	Fred Meyer
Gerber	Pear Juice from Concentrate 100% Juice - Toddler 12+ months	Juice - 100% fruit	4 *	--	1.1 *	0.9 *	< 0.136	Charlottesville, VA	Wegmans
Juicy Juice	100% Juice Fruit Punch	Juice - 100% fruit	2.5 *	--	0.6 *	0.6 *	< 0.139	San Diego, CA	Family Dollar
Drinks - not 100% fruit juice									
Good2Grow	Fortified Water - Orange Mango	Drink - not 100% fruit	< 2.1	--	1.8	< 0.5	< 0.136	Dallas, TX	99 Cents Only Stores

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Orgain	Kids Protein Organic Nutrituional Shake Vanilla Flavor - Ages 1 to 13	Drink - not 100% fruit	3.9 *	--	0.6 *	< 0.5	< 0.14	Charlottesville, VA	Wegmans
Pediasure	Grow & Gain Chocolate Shake	Drink - not 100% fruit	3 *	--	1.3 *	2	< 0.136	Portland, ME	Hannaford
Repone	Suero/Electrolyte Solution with Zinc Fruit Flavor	Drink - not 100% fruit	< 2.2	--	< 0.5	< 0.5	< 0.139	San Diego, CA	Family Dollar
Yoo-hoo	Yoo-hoo Chocolate Drink	Drink - not 100% fruit	2.6 *	--	0.8 *	1.1 *	< 0.134	Houston, TX	Dollar Tree
Meals, including fruits & veggies with grains									
Deluxe Pasta	Macaroni & cheese, Original Flavor	Meal	6.7	--	7	25	< 0.14	Houston, TX	Dollar Tree
Earth's Best	Chicken and Brown Rice Organic Baby Food - 2, 6+ months	Meal	34.4	13	18.3	1.9	0.232 *	Washington, DC	amazon.com
Earth's Best	Organic Turkey Quinoa Apple Sweet Potato Homestyle Meal Puree	Meal	< 2.2	--	1.9	1.9	< 0.139	Columbia, SC	Publix
Earth's Best	Organic Chicken Pot Pie Homestyle Meal Puree	Meal	< 2.2	--	1.2 *	2.1	< 0.139	Columbia, SC	Publix
Gerber	Mashed Potatoes & Gravy with Roasted Chicken and a Side of Carrots - Toddler	Meal	< 2.2	--	2.4	17.5	< 0.139	Portland, ME	Hannaford
Gerber	Chicken Rice Dinner - Sitter 2nd Foods	Meal	19.1	--	2.3 *	8.9	< 0.236	Washington, DC	gerber.com
Gerber	Turkey Rice Dinner - Sitter 2nd Foods	Meal	6.2 *	--	5.2	3.4	< 0.139	Washington, DC	gerber.com
Happy Tot	Love My Veggies Bowl - Cheese & Spinach Ravioli with Organic Marinara Sauce - for tots and tykes	Meal	4.8 *	--	8.5	19.6	0.148 *	Columbia, SC	Publix
Kraft	Macaroni & Cheese Dinner, Original Flavor	Meal	8.1	--	2	38.6	< 0.139	Houston, TX	Dollar Tree
Sprout	Garden Vegetables Brown Rice with Turkey - for 8 months & up, Stage 3	Meal	7.2	--	1.6 *	2.5	< 0.138	Albany, NY	buybuyBABY
Earth's Best	Organic Sweet Potato Cinnamon Flax & Oat - Wholesome Breakfast Puree - 2, for 6+ months	Fruit and veggie - with grain/meat/ dairy/legume	< 2.2	--	4.4	4.3	< 0.138	Albany, NY	buybuyBABY
HappyBABY	Apples, Sweet Potatoes & Granola Clearly Crafted Organic Baby Food - 2	Fruit and veggie - with grain/meat/ dairy/legume	3.6 *	--	5.2	1.5 *	< 0.142	Washington, DC	Safeway
Parent's Choice (Walmart)	Organic Strawberry Carrot and Quinoa Fruit & Veg Puree - Stage 2, 6+ months	Fruit and veggie - with grain/meat/ dairy/legume	2.5 *	--	3.6	1.8	< 0.125	Charlottesville, VA	Walmart
Plum Organics	Apple, Raisin & Quinoa Organic Baby Food - 2 †	Fruit and veggie - with grain/meat/ dairy/legume	5.6 *	--	2.2	1.9	0.145 *	Washington, DC	Safeway
Sprout	Butternut Chickpea Quinoa & Dates Organic Baby Food	Fruit and veggie - with grain/meat/ dairy/legume	2.3 *	--	0.8 *	< 0.5	< 0.137	Columbia, SC	Publix

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Meat									
Beech-Nut	Classics Chicken & Chicken Broth - 1	Meat	< 2.2	--	< 0.5	< 0.5	< 0.137	Washington, DC	Safeway
Beech-Nut	Classics Turkey and Turkey Broth - Stage One	Meat	< 2	--	1 *	< 0.5	< 0.128	Charlottesville, VA	Wegmans
Gerber	Lil' Sticks Chicken Sticks - Toddler	Meat	< 2.2	--	3.5	2.3	< 0.138	Washington, DC	Safeway
Gerber	Beef and Gravy 2nd foods	Meat	< 2.1	--	2.1	< 0.5	0.251 *	Columbia, SC	Publix
Gerber	Ham and Gravy 2nd foods	Meat	< 2.2	--	1 *	< 0.5	< 0.141	Columbia, SC	Publix
O Organics (Albertson/Safeway)	Strained Organic Turkey and Turkey Gravy Baby Food - 2	Meat	2.7 *	--	1 *	< 0.5	< 0.137	Washington, DC	Safeway
Snacks - Puffs									
Comforts (Kroger)	Blueberry Little Puffs Cereal Snack	Snack - rice puffs	83.3	61	8.5	36.9	0.835	Cincinnati, OH	Kroger
Earth's Best	Sesame Street Organic Peanut Butter Baked Corn Puffs	Snack - puffs, non-rice	< 4.4	--	1.3 *	26	< 0.278	Washington, DC	amazon.com
HappyBABY	Superfood Puffs - Apple & Broccoli Organic Grain Snack - for crawling baby	Snack - rice puffs	266	83	8.2	11	2.16	Albany, NY	buybuyBABY
HappyBABY	Superfood Puffs Organic Grain Snack - Sweet Potato & Carrot	Snack - rice puffs	295	91	3.7	12.2	1.94	Washington, DC	amazon.com
Gerber	Puffs Banana Cereal Snack - Crawler 8+ months	Snack - rice puffs	44.5	--	9.2	16	0.376 *	Houston, TX	99 Cents Only Stores
O Organics (Albertson/Safeway)	Organic Puffs - Apple Strawberry	Snack - rice puffs	309	133	7.5	15.2	3.29	Washington, DC	Safeway
Simple Truth Organic (Kroger)	Whole Grain Puffs Broccoli & Spinach	Snack - rice puffs	307	126	9.8	13.5	3.68	Cincinnati, OH	Kroger
Sprout	Organic Quinoa Puffs Baby Cereal Snack - Apple Kale	Snack - puffs, contains rice	107	47	39.3	41.5	1.31	Washington, DC	amazon.com
Snacks - Teething biscuits & rice rusks/cakes									
Baby Mum-Mum	Banana Rice Rusks	Snack - teething biscuits & rice rusks/cakes	104	53	5.2	2.3	1.72	Cincinnati, OH	Kroger
HappyBABY	Organic Rice Cakes Puffed Rice Snack - Apple	Snack - teething biscuits & rice rusks/cakes	455	47	1.7	5.4	3.18	Boulder, CO	Whole Foods Market
Meijer	Apple Rice Rusks Baked Rice Snack	Snack - teething biscuits & rice rusks/cakes	50.2	--	3.2 *	3.9	1.99	Detroit, MI	Meijer
Parent's Choice (Walmart)	Organic Strawberry Rice Rusks - Stage 2, 6+ months	Snack - teething biscuits & rice rusks/cakes	108	66	26.9	2.4	2.05	Charlottesville, VA	Walmart
Simple Truth Organic (Kroger)	Mini Rice Cakes Apple - 7+ months	Snack - teething biscuits & rice rusks/cakes	65.9	--	8.7	0.8 *	1.1	Cincinnati, OH	Kroger

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
Cuétara	Animalitos Galleta Crackers (Animal Crackers)***	Snack - teething biscuits & rice rusks/cakes	4.1 *	--	6.4	25.5	< 0.139	San Diego, CA	99 Cents Only Stores
Gerber	Teether Wheels - Apple Harvest - Crawlers	Snack - teething biscuits & rice rusks/cakes	51.5	--	2.1 *	3.8	0.588 *	Washington, DC	Safeway
HappyBABY	Organic Teethers Blueberry & Purple Carrot - Sitting baby	Snack - teething biscuits & rice rusks/cakes	67	--	6	8.2	2.26	Charlottesville, VA	Wegmans
Lil' Dutch Maid	Saltine Crackers***	Snack - teething biscuits & rice rusks/cakes	10.1	--	1.5 *	19.1	< 0.138	San Diego, CA	99 Cents Only Stores
Meijer	True Goodness Organic Teethers Baked Rice Snack - Vegetable	Snack - teething biscuits & rice rusks/cakes	65	36	3.9	6.7	2.41	Detroit, MI	Meijer
Nosh!	Baby Munchables Organic Teething Wafers - Banana & Mango	Snack - teething biscuits & rice rusks/cakes	110	62	6.6	3.1 *	3.44	Detroit, MI	Meijer
Plum Organics	Little Teethers Organic Multigrain Teething Wafers - Banana with Pumpkin - Baby Crawler	Snack - teething biscuits & rice rusks/cakes	49.9	--	1.4 *	6.3	0.726	Columbia, SC	Publix
Snacks - Other (yogurt, biscuits, bars)									
Beech-Nut	Breakfast On-the-Go Yogurt, Banana & Mixed Berry Blend - Stage 4 from about 12 months	Snack - other	< 2.2	--	0.7 *	< 0.5	< 0.139	Charlottesville, VA	Wegmans
Earth's Best	Sesame Street Organic Fruit Yogurt Smoothie - Apple Blueberry	Snack - other	4.4 *	--	2.5	< 0.5	< 0.135	Portland, OR	Fred Meyer
Earth's Best	Sunny Days Snack Bars - Sweet Potato Carrot	Snack - other	13.9	--	3.8	10.5	0.161 *	Boulder, CO	Whole Foods Market
Ella's Kitchen	Organic Nibbly Fingers - Apples and Strawberries, 1+	Snack - other	27	--	3	7.8	0.216 *	Boulder, CO	Whole Foods Market
Gerber	Yogurt Blends Stawberry Snack - Crawler 8+ months	Snack - other	< 2.1	--	1 *	< 0.5	< 0.135	Gambell, AK	ANICA Native Store
Gerber	Fruit & Veggie Melts - Truly Tropical Blend - Freeze-Dried Fruit & Vegetable Snack - Crawler, 8+ months	Snack - other	22.6	--	12.2	26.8	0.455	Albany, NY	buybuyBABY
Gerber	Arrowroot Biscuits - Crawler 10+ months	Snack - other	13.1	--	12.5	25.9	< 0.279	Washington, DC	walmart.com
Little Duck Organics	100% Pressed Fruit Snacks + Probiotics - Pomegranate, Blueberry & Acai	Snack - other	13.6	--	15	1 *	< 0.138	Albany, NY	buybuyBABY
Nostalgia	Marias Cookies Galletas	Snack - other	3.8 *	--	6.6	22	0.14 *	San Diego, CA	99 Cents Only Stores
Parent's Choice (Walmart)	Little Hearts Strawberry Yogurt Cereal Snack - Stage 3, 9+ months	Snack - other	56.1	--	5.2	26.1	0.941	Charlottesville, VA	Walmart
Plum Organics	Mighty Morning Bar - Blueberry Lemon - Tots: 15 months & up	Snack - other	40 ‡	39	3.4	24.3	< 0.137	Cincinnati, OH	Kroger

Brand	Food	Food type	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
SOBISK	Breakfast Biscuits - Golden Oats	Snack - other	9	--	60.1	9.6	0.143 *	Dallas, TX	Dollar Tree
Sprout	Organic Crispy Chews Red Fruit Beet & Berry with Crispy Brown Rice Toddler Fruit Snack	Snack - other	19.2	--	7.7	1.2 *	0.185 *	Charlottesville, VA	Wegmans
Supplement									
Gerber	Soothe Probiotic Colic Drops	Supplement	4.4 *	--	< 0.5	< 0.5	< 0.139	Washington, DC	walmart.com

Notes
The symbol "<" indicates no detection, with a test result less than the indicated limit of detection.
The symbol "*" indicates test results that are estimated, between the limit of detection and the limit of quantitation.
The symbol "--" indicates that no test was performed.
** Total arsenic value is higher than inorganic arsenic value but falls within the allowable and expected analytical error. For example, this ratio of inorganic to total arsenic of 105% falls within the FDA method for arsenic speciation in rice, which allows this ratio to range from 65 – 135%.
*** This food was purchased from a dollar store and is not marketed specifically as a baby food. Because dollar stores carry so few standard baby foods, this food is purchased by parents as an alternative, according to information from HBBF's local partner participating in this study.
† Food is no longer manufactured.
‡ This value is the average of 3 tests of total arsenic (44, 37, and 39 ppb). The original homogenized bar was tested twice, and homogenate of a second, separate bar from the same box was tested once..

APPENDIX B: RECENT SCIENCE ON THE IMPACT OF HEAVY METALS TO CHILDREN'S BRAIN DEVELOPMENT

The table below details 23 recent studies on the impact of arsenic, cadmium, lead and mercury on the development of children's brains. Evidence in the scientific literature spans decades; the studies below are a sampling of publications over the past seven years.

Study number	Study	What did the study find?
Metals combinations: Recent studies of children's exposures to toxic-metal combinations and impacts to the developing brain		
1	Grandjean and Landrigan 2014	In this update to their 2006 systematic review, the authors added six chemicals to their earlier review of the science on the toxicity to the developing brain and nervous system of lead, methylmercury, polychlorinated biphenyls, arsenic, and toluene. The authors provide an estimate of 24 million IQ points lost from combined exposures to lead and mercury.
2	Freire 2018	In a study of the cognitive development of 302 Spanish 4 and 5 year old children, researchers found lower scores on pre-school neurodevelopmental tests among children who had been exposed to higher levels of arsenic and mercury during pregnancy, as measured in the placenta at birth. The study also found a synergistic effect between arsenic and lead indicated by lower general cognitive scores.
3	Kim 2018	A study of 140 Korean 1- and 2-year-olds and their mothers compared the chemicals in pregnant women's blood or urine, or in breast milk after delivery, with standard pre-school tests of neurodevelopmental performance. The mothers' blood lead levels were inversely associated with psychomotor development in their children. Pregnant women with higher levels of a combination of heavy metals in their blood also had children with more behavior problems.
4	Pan 2018	Researchers tested the blood and urine of 530 children ages 9-11 living near an industrialized area and 264 from another town in the same city in South China as a reference. A significant decrease in IQ scores was identified in children from the industrialized town, who had statistically higher geometric mean concentrations of lead, cadmium, and mercury. Blood lead had a significant negative association by itself, and the additive impact of all four metals raised concerns.
5	Lucchini 2019	Scientists studied the effect of co-exposures to socio-economic stressors and arsenic, cadmium, lead, mercury and other metals in schoolchildren in Taranto, Italy. Biomonitoring and an analysis of the distance between the residence of 299 children ages 6 to 12 and point sources of industrial emissions were done along with tests of children's cognitive functions. The researchers found that metal levels in the children's blood and urine had a negative cognitive impact. Lead exposure was shown to have a neurocognitive effect even at very low levels of blood lead concentration for children of low socio-economic status.
Arsenic: Recent studies of children's exposures to arsenic and impacts to the developing brain		
6	Rodríguez-Barranco 2013	This meta-analysis details 13 articles reporting "a significant negative effect on neurodevelopment and behavioural disorders" from arsenic exposure during pregnancy and early childhood.
7	Wasserman 2014	Columbia University researchers report on their assessment of 272 third to fifth graders in Maine who lived in homes with well water. The study found an average loss of 5-6 IQ points among those who drank well water contaminated with arsenic at or above 5 parts per billion. This level is common in some parts of the U.S. and is lower than the legal limit in public water supplies (10 parts per billion).
8	Tsuji 2015	This 2015 literature review identifies 24 studies linking low-level arsenic exposure to neurological harm in children.
9	Signes-Pastor 2019	This study focused on the impact of arsenic exposure from food. The urine of 400 4- and 5-year-olds was tested for arsenic. The children took tests that measure neuropsychological development. Children with higher arsenic levels performed worse on tests of motor function. Boys showed diminished working memory with higher arsenic exposures.
Cadmium: Recent studies of children's exposures to cadmium and impacts to the developing brain		
10	Sanders 2015	This review of recent scientific literature found 16 studies on cadmium's neurotoxic impacts to children. In these studies, lower IQ scores and more learning disorders and special education needs were correlated to higher cadmium levels in children.
11	Gustin 2018	A study of 1500 mother and child pairs in Bangladesh associated prenatal and childhood cadmium exposure with lower intelligence in boys. In girls, there were indications of altered behavior for both prenatal and childhood exposure.
12	Lee 2018	A study of 76 children with ADHD and 46 control children found cadmium levels negatively correlated with Full Scale Intelligence Quotient.
13	Al Osman 2019	This scientific review references studies that link children's cadmium exposure to IQ loss and other health endpoints, including kidney disease, osteoporosis, cardiovascular disease, stunted growth, and pediatric cancer.

Study number	Study	What did the study find?
Lead: Recent studies of children's exposures to lead and impacts to the developing brain		
14	NTP 2012	The National Institutes of Health's National Toxicology Program evaluation of the toxicity of low-level lead exposure concludes that such exposures are responsible for intellectual deficits, diminished academic abilities, attention deficits, and problem behaviors, including impulsivity, aggression, and hyperactivity in children.
15	Zhang 2013	An analysis of the blood lead tests recorded before the age of 6 and the standardized test scores in grades 3, 5 and 8 of 21,281 students in the Detroit Public Schools found that early childhood lead exposure was negatively associated with academic achievement in elementary and junior high school.
16	Evens 2015	The study compared Chicago's birth registry, the blood lead registry and the scores on 3rd grade iSAT tests for 58,650 children. After adjusting for poverty, race/ethnicity, gender, maternal education and very low birth weight or preterm birth, the study concluded "Early childhood lead exposure is associated with poorer achievement on standardized reading and math tests in the third grade, even at very low blood lead levels."
17	Liu 2014	A study of 1341 children in the Jiangsu province of China compared blood lead at ages 3 to 5 with behavioral problems at age 6 and found a significant association. The authors report that the risk of clinical-level behavioral problems increased with blood lead concentration.
18	Lewis 2018	This study's 278 study participants were drawn from a large longitudinal study in Cleveland, Ohio that is examining the developmental effects of prenatal cocaine exposure. The children's blood was tested for lead at age 4, and their language skills were assessed at 4, 6, 10 and 12 years of age. The researchers found that lead exposure harmed both receptive and expressive language skills. Prenatal drug exposure was not related to the effects of lead on language skills.
19	Donzelli 2019	A systematic review of studies on the relationship between lead exposure and the diagnosis of ADHD identified 17 studies reporting an association between lead and ADHD.
Mercury: Recent studies of children's exposures to mercury and impacts to the developing brain		
20	Karagas 2012	A review of the literature on the health effects of low-level exposure to methylmercury concentrated on studies that include measurement of this toxic chemical in blood and hair of pregnant women and their children. The consistent finding in the researchers' review of the science on neurocognitive and behavior outcomes was the connection between prenatal mercury levels and psychomotor function, memory, verbal skills cognition in 7- to 14-year-old children.
21	Jacobson 2015	A 2015 study in Environmental Health Perspectives compared the IQs of 282 school-age children with the levels of mercury in umbilical cord blood taken at birth. The researchers found that prenatal mercury levels were associated with lower scores on school-age IQ tests.
22	Ryu 2017	A study of 458 mother child pairs in Korea found that blood mercury levels during late pregnancy and early childhood were associated with more autistic behaviors in children at 5 years of age, as assessed using the Social Responsiveness Scale.
23	Bellinger 2019	To derive an estimate of the global burden of intellectual disability from prenatal exposure to mercury, scientists conducted a meta-analysis of the available science and determined a dose-effect relationship of IQ reductions to increases in maternal hair mercury levels.

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APPENDIX C: LABORATORY ANALYSIS – SUMMARY OF METHODS FOR HEAVY METALS TESTING

BACKGROUND

HBBF commissioned a national laboratory recognized for its expertise in heavy metals analysis, Brooks Applied Labs (BAL) near Seattle Washington (http://brooksapplied.com/), to test 168 containers of baby food for total recoverable arsenic, lead, cadmium, and mercury; and speciated arsenic for a subset of samples.

BAL is accredited through the National Environmental Accreditation Program (NELAC), the Department of Defense (DOD), and the International Organization for Standardization (ISO). It has also earned state accreditations for a variety of metals analyses, including arsenic and mercury. It uses the most current microwave digestion and ICP-MS technologies, and specializes in heavy metals testing (including arsenic, lead, cadmium, and mercury). BAL's clients include local governments, industry, the federal government, and engineering consulting firms.

BAL specializes in low-level metal analysis, including analysis in food. It has tested a wide range of baby foods. Its sensitive methods can detect heavy metals in a wide range of baby food types, including grains, dairy, fruits and vegetables, and meat.

For the heavy metals analyses used in this study, BAL is accredited according to the ISO 17025 standard. BAL's methods are comparable to FDA methods (FDA 2012,2015), with two notable differences: 1) The extraction acid used by BAL gives optimum results specifically for the food type being analyzed, according to tests of a range of acids and other solvents; and 2) BAL achieves a lower limit of quantification (LOQ) for the analysis of inorganic arsenic than FDA. Other major analytical techniques are comparable: for example, both BAL and FDA rely on chromatography methods to separate arsenic species, and ICP-MS methods to detect heavy metals.

SAMPLE PREPARATION

Baby food receipt and storage: BAL received 168 baby food containers in April and May 2019. BAL logged in samples for the analysis of total recoverable arsenic [As], cadmium [Cd], lead [Pb], and mercury [Hg].

BAL received and stored all samples according to BAL Standard Operating Procedures (SOPs) and EPA methodology. Samples were stored at ambient temperature, maintaining the shipping temperature of the samples. Once containers were opened and aliquots obtained for testing, samples were frozen.

Sample homogenization: Any foods which were heterogeneous (e.g., snack bars) were thoroughly homogenized prior to sample digestion. All equipment used for the homogenization process was pre-cleaned beforehand and subject to routine testing to ensure the accuracy of sample data.

Sample digestion: BAL prepared samples by the addition of hydrogen peroxide (H_2O_2) and concentrated nitric acid (HNO_3) to a microwave digestion vessel, via method AOAC 2015.01, modified. BAL digested samples at a precise pressure and temperature in a controlled microwave digestion program.

TOTAL METALS ANALYSIS BY AOAC 2015.01, MOD.

BAL developed method AOAC 2015.01, Mod (Heavy Metals in Food: Inductively Coupled Plasma-Mass Spectrometry) for analysis of total recoverable metals. The method was accepted as a First Action Method by the consensus standards developing organization AOAC, placing it in AOAC's process leading to formal method adoption.

BAL analyzed total recoverable As, Cd, and Pb according to this method, using inductively coupled plasma triple quadrupole mass spectrometry (ICP-QQQ-MS). The ICPQQQ-MS method uses advanced interference removal techniques to ensure accuracy of the sample results. This technology allows for the removal of polyatomic and doubly-charged ions that can interfere with an isotope. This is a critical step for arsenic analysis, since arsenic is a monoisotopic element. For more information, visit the Interference Reduction Technology section on BAL's website, brooksapplied.com.

TOTAL MERCURY ANALYSIS BY EPA METHOD 1631

BAL prepared samples for Hg analysis using the AOAC 2015.01, modified method, as described above. BAL analyzed sample preparations with stannous chloride ($SnCl_2$) reduction, single gold amalgamation, and cold vapor atomic fluorescence spectroscopy (CVAFS) detection using a Brooks Rand Instruments MERX-T CVAFS Mercury Automated-Analyzer. The laboratory then blank corrected the Hg results as described in the relevant BAL SOP and evaluated results using adjusted reporting limits to account for sample aliquot size.

ARSENIC SPECIATION ANALYSIS

Sample digestion: BAL digested baby food samples for arsenic speciation using a solution of trifluoroacetic acid (TFA). The TFA digestion method typically induces conversion of As(V) to As(III) in the samples and matrix spikes and induces conversion of As(III) to As(V) in the blank spikes. (This is also a characteristic of FDA's method.) Therefore, the accurate measurement resulting from this method is total inorganic arsenic (the sum of As(V) and As(III)), rather than results from individual valence states.

Analysis of arsenic speciation: Extracts from digestion were analyzed for total inorganic arsenic [InorgAs] (sum of As(III) and As(V)), monomethylarsonic acid [MMAs], and dimethylarsinic acid [DMAs] using ion chromatography inductively coupled plasma collision reaction cell mass spectrometry (IC-ICP-CRC-MS). This method uses chromatography to separate the different arsenic species and ICP-CRC-MS to detect the arsenic. The CRC is an interference reduction technology to remove polyatomic ions that can interfere with arsenic.

QA/QC AND CERTIFICATION

Quality Assurance and Quality Control: All analyses were conducted in accordance with BAL's Standard Operating Procedures. Each preparation batch also included four method blanks (BLKs), a laboratory fortified blank (BS), a certified reference material (SRM), a laboratory duplicate (DUP), and a matrix spike/matrix spike duplicate (MS/MSD) set. Post-preparation spikes (PS) were also included in the arsenic speciation batches. The sample results were reviewed and evaluated in relation to the QA/QC samples worked up at the same time. The BS recoveries, SRM recoveries, PS recoveries, and method blanks were evaluated against method criteria to ensure data quality.

BAL certification: BAL is ISO certified for elemental analyses (including arsenic, lead, cadmium, and mercury) and arsenic speciation analysis in food.

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APPENDIX D: LABORATORY TEST RESULTS FOR PERCHLORATE

Results for analysis of perchlorate in a limited number of baby foods are listed below. Testing was commissioned by HBBF and performed by Southwest Research Institute, San Antonio, TX. The detailed laboratory report (SWRI 2019) is provided under “Resources” in HBBF’s online version of this heavy metals study, at healthybabyfood.org.

Twenty-five foods were tested for perchlorate, with containers purchased from supermarkets near Washington DC and from online retailers. These 25 foods were also included in the heavy metals testing described in this report, but perchlorate testing was performed using food samples extracted from a separate container. The table below also lists the number of heavy metals detected in each of these foods, from Appendix A, to provide information on the full range of neurotoxic contaminants covered in this study and detected in the foods chosen for testing. This limited perchlorate testing is intended to spur further testing and research on perchlorate in baby food. It is not necessarily representative of perchlorate levels across the baby food market, but instead provides a snapshot of levels in containers of these 25 foods.

The qualifier “<” indicates that the perchlorate concentration was below the method detection limit, while “(*)” indicates that the arsenic concentration was near the method detection limit and was estimated.

Brand	Food	Food type	Perchlorate (ppb)	Number of heavy metals detected in this food**
Healthy Times	Organic Brown Rice Cereal - 4+ months	Cereal - rice	7.1	4
Gerber	Rice Single Grain Cereal	Cereal - rice	4.6	4
BioKinetics	BioKinetics Brown Rice Organic Sprouted Whole Grain Baby Cereal	Cereal - rice	< 3.2	4
Beech-Nut	Rice Single Grain Baby Cereal - Stage 1, from about 4 months	Cereal - rice	< 3.2	4
Earth’s Best	Whole Grain Rice Cereal	Cereal - rice	< 3.2	4
Gerber	Oatmeal Single Grain Cereal	Cereal - oatmeal	7.7	3
Beech-Nut	Oatmeal Whole Grain Baby Cereal - Stage 1, from about 4 months	Cereal - oatmeal	4.2	3
Earth’s Best	Whole Grain Oatmeal Cereal	Cereal - oatmeal	2.7 *	3
HappyBABY	Oatmeal Baby Cereal, Clearly Crafted - Organic Whole Grains - for sitting baby	Cereal - oatmeal	1.6 *	2
Gerber	MultiGrain Cereal - Sitter 2nd Foods	Cereal - mixed and multi-grain	8.7	4
HappyBABY	Oats & Quinoa Baby Cereal Organic Whole Grains with Iron - Sitting baby	Cereal - mixed and multi-grain	2.4 *	3
Gerber	Whole Wheat Whole Grain Cereal - Sitter 2nd Foods	Cereal - other single-grain	4.2	3
NurturMe	Organic Quinoa Cereals - Quinoa + Sweet Potato + Raisin	Cereal - other single-grain	3.5	4
Gerber	Barley Single Grain Cereal- Supported Sitter 1st Foods	Cereal - other single-grain	3.3	3
Similac	Similac Advance OptiGRO Powder - Milk-Based	Formula	11.4	2
Earth’s Best	Organic Sensitivity - DHR/ARA Infant Formula with Iron Organic Milk-Based Powder	Formula	1.5 *	2
Enfamil	ProSobee Soy Infant Formula, Milk-Free Lactose-Free Powder with Iron	Formula	< 3.2	3
Earth’s Best	Spinach and Potato Organic Baby Food - 2, 6+ months	Veggie - mixed	19.8	3
Beech-Nut	Organics Just Carrots - Stage 1	Veggie - single - carrot	2.3	4
Parent’s Choice (Walmart)	Carrot - Stage 2, 6+ months	Veggie - single - carrot	0.64 *	2
HappyBABY	Simple Combos Apples, Spinach & Kale - 2	Fruit and vegetable - mixed	3.7	4

APPENDIX D: Laboratory Test Results for Perchlorate (continued)

Brand	Food	Food type	Perchlorate (ppb)	Number of heavy metals detected in this food**
Plum Organics	Mighty Morning Bar - Blueberry Lemon - Tots: 15 months & up	Snack - bar	1.8 (J)	3
HappyBABY	Superfood Puffs - Apple & Broccoli Organic Grain Snack - for crawling baby	Snack - puffs	< 3.2	4
Baby Mum-Mum	Banana Rice Rusks	Snack - rice rusks and rice cakes	4.6	4
HappyBABY	Organic Rice Cakes Puffed Rice Snack - Apple	Snack - rice rusks and rice cakes	< 3.2	4

Notes
The symbol "<" indicates no detection, with a test result less than the indicated limit of detection.
The symbol "*" indicates test results that are estimated, between the limit of detection and the limit of quantification.
** Heavy metal test data can be found in Appendix A. Perchlorate and metals tests used food from separate containers for each food, not a single container.

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APPENDIX E: RESULTS OF IQ ANALYSIS: 15 FOODS ACCOUNT FOR OVER HALF OF TOTAL IQ LOSS FROM CHILDREN'S EXPOSURES TO ARSENIC AND LEAD IN BABY FOOD

Healthy Babies Bright Futures (HBBF) commissioned a new study from Abt Associates (Abt) to quantify the health impacts posed by multiple heavy metals in baby food. This work gives first-ever estimates of the population-wide decline in IQ from children's exposures to lead and arsenic in food, from birth to 24 months of age. It also gives the 15 baby foods that collectively account for 55 percent of the total IQ loss from these exposures.

DATA USED IN IQ LOSS ANALYSIS

The analysis relies on two data sources published by the federal government:

Foods babies eat: What We Eat in America (WWEIA) data – 24-hour food recall data collected as part of The National Health and Nutrition Examination Survey (NHANES) – contains dietary intake measurements for the U.S. population, including babies. Dietary data are collected for up to two days for each respondent, including food type and quantity consumed. NHANES is run by the CDC's National Center for Health Statistics (NCHS) and was designed to collect information on the health and nutritional status of the U.S. civilian, non-institutionalized population through in-home interviews and physical examinations. Abt used this data to represent babies' daily food intake in this analysis.

Arsenic and lead levels in baby food: FDA's Total Diet Study (TDS), an ongoing FDA program, collects information on levels of various contaminants, including arsenic and lead, that occur in food and beverages commonly consumed by the U.S. population. FDA buys these foods as a consumer would, prepares them as directed, and then analyzes the prepared foods for levels of the contaminants of interest. This process yields nationally representative estimates of contaminant levels in approximately 280 kinds of food and beverages. Abt used TDS arsenic and lead data to represent contaminant levels in the foods babies eat.

ESTIMATING CHILDREN'S INTAKE OF ARSENIC AND LEAD

Steps and assumptions in estimating children's arsenic and lead intake include:

Mapping the food intake and concentration datasets: A mapping file[1] pairs TDS foods with similar foods included in the WWEIA dataset. The mapping file covers 2014-2016 TDS data cycles; Abt used all three of these years of data to represent the lead and arsenic levels in foods children eat. For WWEIA, FDA's mapping file covers 2003-2014. Abt used a subset of those years, WWEIA data cycles from 2009-2014, to represent the foods children eat. The earlier years of WWEIA data covered in FDA's mapping file (2003-2008) were considered less representative of children's current eating habits than the more recent data, and were therefore excluded from the analysis.

Method used to account for arsenic and lead levels below detection limits: Abt performed the Xue et al. (2010) method for summarizing values of TDS data that fall below the limit of detection (LOD), assigning half the LOD to values below the LOD if there was at least one detection among the many samples taken of each particular food; otherwise a value of 0 was assigned.

1 provided by FDA to Abt (via personal correspondence)

Estimating children's intake of lead and arsenic: Abt matched mean values for each TDS food with each food consumed in the WWEIA dataset according to the mapping file. The intake of arsenic and lead for each food consumed was calculated as the product of the concentration of each metal and the mass of each food consumed during the survey's period of record.

Criteria for inclusion of surveyed children: Abt included in the analysis all children with two days of dietary data from WWEIA, and used the mean lead/arsenic consumption value between the two days to represent each child's average daily lead/arsenic intake.

ESTIMATING INORGANIC ARSENIC CONCENTRATIONS

FDA tests TDS foods for total arsenic, as opposed to inorganic arsenic. Inorganic arsenic is the form considered in studies of arsenic exposure and IQ loss, and for which concentration-response functions have been developed. Studies indicate that inorganic arsenic is more toxic than other forms (Abt 2017). Therefore, it was necessary to scale the total arsenic consumed by children to represent the portion that was inorganic. In the absence of more specific information, Abt assumed that 70 percent of total arsenic consumed in food was comprised of inorganic arsenic, as was done by the European Food Safety Authority in their 2014 report entitled "Dietary exposure to inorganic arsenic in the European population" (EFSA 2014). In certain cases, exceptions to the application of this rule were made using information about the arsenic makeup of particular foods as specified in Cubadda et al. (2017).

Using this information, Abt assumed:

- 95% of total arsenic is inorganic in beverages, and 100% of total arsenic is inorganic in bottled water.
- 80% of total arsenic is inorganic in fruit.
- 60% of total arsenic is inorganic in rice.
- 95% of total arsenic is inorganic in wheat.
- 5% of total arsenic is inorganic in fish and shellfish, including New England clam chowder and tuna casserole.
- 90% of total arsenic is inorganic in vegetables.

In addition, Abt assumed the following inorganic arsenic compositions based on independent testing from data provided by HBBF, from laboratory results presented in HBBF (2017):

- 61% of total arsenic is inorganic in infant rice cereal.
- 53% of total arsenic is inorganic in infant multi-grain and non-rice cereals.

Abt also assumed the following inorganic arsenic compositions based on testing performed by FDA, from analysis of data from FDA (2014) provided by EDF (2018):

- 73% of total arsenic is inorganic in grape juice.
- 59% of total arsenic is inorganic in oat ring cereal.
- 56% of total arsenic is inorganic in teething biscuits.

All other foods not specifically mentioned were assumed to have 70% of total arsenic as inorganic arsenic, per EFSA (2014).

ESTIMATING IQ LOSS FROM LEAD

Abt used the following steps to estimate IQ loss from lead intake:

1. Calculated baseline concurrent childhood lead uptake for each year of age from 0 to 7. Other sources of lead were accounted for by using U.S. Environmental Protection Agency's (EPA's) default levels for air, drinking water, and soil/dust lead exposure, as outlined in the agency's User's Guide for the Integrated Exposure Uptake Biokinetic model for Lead in Children (IEUBK), excluding the contribution from food (EPA 2007). These estimates were input into approximation equations from EPA's IEUBK model that were derived by Zartarian et al. (2017) to convert this baseline lead uptake to blood lead level (without food intake).

2. Estimated the lead consumption from WWEIA's contribution to the child's blood lead level by converting lead consumption to lead uptake (assuming 50% lead uptake from dietary ingestion), and the same estimation equations of EPA's IEUBK model described in Step 1 to convert the baseline lead uptake estimated above plus the additional lead uptake from food to blood lead level (with food intake).

3. Assumed each child's daily lead intake from food was equal to their survey-specific lead intake for the entire year of their age in the WWEIA data, and equal to the population-wide mean lead intake from food for every other year of life.. For example, the estimated mean lead intake for a child when they were one year old (assuming they are not one year old in the WWEIA data) is represented by calculating the mean lead intake of all one-year-olds in the dataset.

4. Calculated lifetime blood lead without food by taking the average of the baseline concurrent blood lead levels for each year of life as estimated by the Zartarian et al. (2017) IEUBK estimation equations (in Step 1). Calculated lifetime blood lead with food by taking the average of the mean value of blood leads with both other sources of lead and food in the data (from step 2) for each year of life, except for the year of each child's age in the WWEIA data, which is represented by their personal blood lead level with the added contribution from food (as described above).

5. Used the Crump et al. (2013) concentration-response function to estimate the lifetime IQ loss due to the difference in lifetime blood lead level based on the contribution of lead in food using the following equation:

$$IQ\ Loss = \beta \times \ln\left(\frac{PbB_1 + 1}{PbB_2 + 1}\right)$$

where:

Beta = -3.25

PbB_1 = Baseline lifetime blood lead level without food

PbB_2 = Baseline lifetime blood lead level including food contribution

ESTIMATING IQ LOSS FROM INORGANIC ARSENIC

Abt used the following steps to estimate IQ loss as a result of inorganic arsenic intake:

1. Assumed each child's inorganic arsenic intake was equal to their personal inorganic arsenic intake for the entire of their current age, and equal to the population-wide mean inorganic arsenic intake for every other year of life specific to that year of life and the study population. For example, the mean inorganic arsenic intake for a child when they were one year old (assuming they are not one year old in the WWEIA data) is represented by calculating the mean inorganic arsenic intake of all one-year-olds in the dataset.

2. Calculated lifetime inorganic arsenic consumption from food by taking the average of the mean inorganic arsenic consumption figures from the dataset for each year of life, except for the year of each child's age in the WWEIA data, which is represented by their personal mean daily inorganic arsenic intake (as described above).

3. Used a concentration-response function based on a study by Wasserman et al. (2004), as described in Abt 2017, to estimate lifetime IQ loss based on arsenic drinking water concentration:

$$IQ\ Loss = \beta \times \Delta AsDW$$

where:

Beta = 0.44

ΔAsDW = Change in arsenic drinking water concentration

4. Converted lifetime inorganic arsenic consumption from food (from Step 2) to an approximate drinking water concentration by assuming that each child in the Wasserman et al. (2004) consumes 1 Liter of water per day, as was done by CalEPA when deriving a chronic Reference Exposure Level for inorganic arsenic consumption in 2008 (CalEPA, 2008). This was necessary to match the concentration-response function in Step 3.

Because the Wasserman et al. (2004) concentration-response function for IQ loss is linear, the approximate equivalent drinking water concentration calculated in Step 4 represents the change in arsenic drinking water concentration used in the equation in Step 3. In other words, the IQ loss for a population with any background level of arsenic exposure using the Wasserman et al. (2004) function will always be equal to the change in arsenic concentration from the calculation in Step 4 multiplied by the beta. This differs from the lead analysis, where the background exposure from other sources matters due to the log transformation of lead in the concentration-response function.

ESTIMATING TOTAL LIFETIME IQ LOSS FROM LEAD AND ARSENIC IN FOODS BABIES EAT

Total IQ loss from food was estimated as the sum of the lifetime IQ loss due to lead consumption from food with the lifetime IQ loss due to inorganic arsenic consumption from food.

DEFINING THE CONTRIBUTION OF EACH FOOD TO IQ LOSS

Total IQ loss was estimated for each food from the TDS based on lead consumption alone, arsenic consumption alone, and lead consumption and arsenic consumption combined. It was necessary to calculate the lifetime IQ loss for each instance that a food was consumed individually, since the method for calculating lead uptake is specific to age. Thus, an instance of food consumption of the same food in the same amount could be responsible for two different magnitudes of IQ loss due to lead if the two children who consumed the food were of different ages.

Lifetime IQ loss from lead was calculated for each instance of food consumption using the IQ Loss equation as above. However, PbB2 was assumed equal to baseline lifetime blood lead level plus the additional blood lead from the consumption of that one food for the current year of their life. All other years of blood lead averaged into the lifetime blood lead equation for PbB2 are assumed equal to the baseline. Each of these incremental IQ losses due to each instance of a particular food being consumed were multiplied by their respective survey weight, and summed to estimate the total IQ loss attributable to each food across the population of children.

Lifetime IQ loss from arsenic was calculated using the concentration response function above for each food consumption instance, but was then multiplied by the survey weight, and summed to estimate the total IQ loss attributable to each food across the population of children.

These two IQ losses for each food were then added together to estimate the total IQ loss from each food due to both lead and arsenic combined.

ESTIMATING POPULATION-WIDE TOTAL LIFETIME IQ LOSS DUE TO LEAD, ARSENIC, AND LEAD AND ARSENIC COMBINED

Total IQ loss due to lead, arsenic, and lead and arsenic combined were calculated by multiplying each child's estimated lifetime IQ loss from each of these sources by the corresponding survey weight, and summed together for all children aged zero to less than two in the survey data.

LIMITATIONS

A baseline level of inorganic arsenic could not be estimated; it was necessary for us to use a linear concentration-response function relating inorganic arsenic to IQ loss. Thus, Abt was unable to provide a range of results related to the many concentration response functions presented in Abt's previous arsenic analysis (Abt 2017). There is a great deal of uncertainty in the inorganic arsenic dose conversions, and it should be noted that Abt is assuming that the linear extrapolation holds for different population and lower doses compared to the original studies. Estimates of IQ loss from lead in food are considered to be lower-bound estimates, from Abt's experience applying a range of accepted concentration-response functions from other studies. HBBF recommends that future work to estimate IQ loss from heavy metals in food include a full range of accepted functions, for a more comprehensive view of potential health impacts for children.

INTERPRETATION OF RESULTS: LIFETIME CONSUMPTION AND IQ LOSS

Results are presented in Abt (2019b) for children under the age of two. The results reflect lifetime consumption / IQ loss, and are focused on the group of children in the WWEIA data who are ages 0 to 2 at the time of the survey.

RESULTS OF THE ANALYSIS

Results are detailed in Abt 2019b. Abt estimates more than 11 million IQ points lost among children ages 0-24 months from exposure to arsenic and lead in food. The table below shows the top 15 foods contributing to IQ loss for those children, from an analysis of all WWEIA foods that are matched to TDS foods.

Food consumed by child age 0 - 24 months	Percent of total harm (fraction of total IQ points lost for children under 2, from lead and arsenic in food)	Primary toxic metal of concern	Of these foods: Rank for potency (considering average IQ points lost per child eating the food; 1=highest, 15=lowest)	Food name from FDA's Total Diet Study (TDS) - source of As/Pb concentration data	Food name(s) from What We Eat in America survey (WWEIA)*, source of data on food types and amounts that children eat
Rice dishes, including with beans & veggies	10.0%	Arsenic	1	Fried rice, meatless, from Chinese carry-out	SPANISH RICE; RICE W/ BEANS; FLAVORED RICE&PASTA MIXTURE (INCL RICE-A-RONI); and other rice dishes
Milk, whole	8.4%	Arsenic	7	Milk, whole, fluid	MILK, COW'S, FLUID, WHOLE
Rice, white and brown	7.0%	Arsenic	6	Rice, white, enriched, cooked	Rice, white, cooked, fat not added in cooking; Rice, white, cooked, fat added in cooking, made with oil; RICE, WHITE, COOKED, REGULAR, NO FAT ADD IN COOKING
Apple juice	6.1%	Arsenic	10	Apple juice, bottled; BF, juice, apple	APPLE JUICE; APPLE JUICE, BABY
Infant formula	5.3%	Lead	4	BF, Infant formula, milk-based, iron fortified RTF	ENFAMIL LIPIL, W/ IRON, INFANT FORMULA, PREP FROM PDR; SIMILAC ADVANCE, W/ IRON, INFANT FORMULA, PREP FROM PDR; Similac Advance, infant formula, prepared from powder, made with baby water; and other infant formulas
Fruit juice blend (100% juice)	4.1%	Arsenic	8	Fruit juice blend (100% juice), canned/bottled	FRUIT JUICE BLEND, 100% JUICE
Infant rice cereal	2.7%	Arsenic	3	BF, cereal, rice, dry, prepared w/ water	RICE CEREAL, BABY, DRY, INSTANT
Grape juice	2.0%	Lead and arsenic	5	Grape juice, frozen conc, reconstituted; BF, juice, grape	GRAPE JUICE
Cheerios and other oat ring cereals	1.6%	Arsenic	12	Oat ring cereal	CHEERIOS; HONEY NUT CHEERIOS
Sweet potato (baby food)	1.6%	Lead and arsenic	2	BF, sweet potatoes	SWEETPOTATOES, BABY, STRAINED; SWEETPOTATOES, BABY, JUNIOR
Soft cereal bars and oatmeal cookies	1.4%	Arsenic	11	Granola bar, w/ raisins	Kellogg's Nutri-Grain Cereal Bar; COOKIE, OATMEAL; COOKIE, OATMEAL, W/ RAISINS OR DATES

Food consumed by child age 0 - 24 months	Percent of total harm (fraction of total IQ points lost for children under 2, from lead and arsenic in food)	Primary toxic metal of concern	Of these foods: Rank for potency (considering average IQ points lost per child eating the food; 1=highest, 15=lowest)	Food name from FDA's Total Diet Study (TDS) - source of As/Pb concentration data	Food name(s) from What We Eat in America survey (WWEIA)*, source of data on food types and amounts that children eat
Macaroni and cheese	1.4%	Lead and arsenic	13	Macaroni and cheese, prepared from box mix	Macaroni or noodles with cheese, made from packaged mix; MACARONI OR NOODLES W/ CHEESE; MACARONI/NOODLES W/ CHEESE, MADE FROM DRY MIX
Puffs and teething biscuits	1.3%	Lead and arsenic	9	BF, teething biscuits	GERBER FINGER FOODS, PUFFS, BABY FOOD; Cookie, teething, baby; Cookie, fruit, baby food; Finger Foods, Puffs, baby food
Bottled drinking water	1.2%	Arsenic	15	Bottled drinking water (mineral/spring), not carbonated or flavored	WATER, BOTTLED, UNSWEETENED; Water, baby, bottled, unsweetened
Fruit yogurt	1.2%	Lead	14	Yogurt, lowfat, fruit-flavored	YOGURT, FRUIT VARIETY, WHOLE MILK; YOGURT, FRUIT VARIETY, LOWFAT MILK

Notes

* What We Eat in America (WWEIA) dataset: Many foods are matched to a single TDS food in Abt's calculation method (per FDA's mapping file). Foods shown above are those most commonly consumed by children 0-24 mo, from among the WWEIA foods matched to each listed TDS food.

Results shown above for IQ loss and potency ranking correspond to children from 0-24 months old

BF = baby food, in TDS food names

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ADDENDUM - REVISIONS TO FDA'S MAPPING FILE

In calculations described above, Abt assumed the following matches that differed from the FDA's original mapping file, to provide more representative concentration estimates where inexact FDA matches yielded inappropriate estimates. In these cases, high arsenic levels in clam chowder from the TDS dataset were inconsistent with arsenic levels typical for the matched foods from WWEIA listed below.

TDS food from FDA mapping file: Clam chowder, New England, canned, cond, prepared w/ whole milk

- **WWEIA matched foods:** CHICKEN NOODLE SOUP, CREAM OF; CHICKEN SOUP, CREAM OF, PREPARED W/ WATER; CHICKEN/TURKEY SOUP, CM OF, CAN, RED SOD, W/ MILK; CHICKEN SOUP, CREAM OF, NS AS TO MILK OR WATER
- **Revised TDS food:** Assume 50/50 mixture of these 2 TDS foods: TDS food #1: Soup, chicken noodle, canned, cond, prepared w/ water; and TDS food #2: Milk, whole, fluid

- **WWEIA matched foods:** POTATO SOUP, CREAM OF, W/ MILK; POTATO SOUP, NS AS TO MADE W/MILK OR WATER; POTATO & CHEESE SOUP
- **Revised TDS food:** Assume 50/50 mixture of these 2 TDS foods: TDS food #1: Potato, boiled (w/out peel); and TDS food #2: Milk, whole, fluid

- **WWEIA matched food:** CORN SOUP, CREAM OF, PREPARED W/ WATER
- **Revised TDS food:** Assume 50/50 mixture of these 2 TDS foods: TDS food #1: Corn, fresh/frozen, boiled); and TDS food #2: Milk, whole, fluid

- **WWEIA matched foods:** MUSHROOM SOUP, CREAM OF, PREP W/ MILK; MUSHROOM SOUP, CREAM OF, PREPARED W/ WATER; MUSHROOM SOUP, NFS
- **Revised TDS food:** Assume 50/50 mixture of these 2 TDS foods: TDS food #1: Mushrooms, raw; and TDS food #2: Milk, whole, fluid

- **WWEIA matched food:** CHEDDAR CHEESE SOUP
- **Revised TDS food:** Assume 50/50 mixture of these 2 TDS foods: TDS food #1: Cheese, cheddar, natural (sharp/ mild); TDS food #2: Milk, whole, fluid

- **WWEIA matched food:** WHITE SAUCE, MILK SAUCE
- **Revised TDS food:** Milk, whole, fluid

APPENDIX F: DATA AND CALCULATIONS—AVERAGE HEAVY METALS LEVELS FOR HIGHER-RISK FOODS AND SAFER ALTERNATIVES

The table below summarizes test results from HBBF and FDA for foods highlighted in this report's charts on higher-risk baby foods and safer alternatives. The tables are the basis of the finding in our study that the safer food choices we list contain 80 percent less arsenic, lead and other toxic heavy metals, on average, than the higher-risk foods. That number is calculated as the average reduction for the 5 food categories shown on the Executive Summary chart entitled "What Parents Can Do." The foods shown on that chart, and the average total heavy metals levels that are the basis of that calculation, are indicated in the table below.

Study	Food	Number of samples	Metal concentration, parts per billion (ppb)						Source of inorganic arsenic level, and average ratio of inorganic to total arsenic		This food's data is shown in safer-choices food charts in this study	Reference for ratio of inorganic to total arsenic
			Lead	Cadmium	Mercury	Arsenic, total	Arsenic, inorganic	Total metals	Measured - ratio of inorganic to total arsenic is shown below	Calculated - Assumed ratio of inorganic to total arsenic is shown below		
Infant rice cereal (dry, white and brown rice)												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Infant rice cereal (dry, white and brown rice)	7	18.44	14.50	2.13	153.19	105.00	140.07	0.77			HBBF 2019 Baby Food study
HBBF 2017 Arsenic in Infant Cereal Study (HBBF 2017)	Infant rice cereal (dry, white and brown rice)	42					85.00		0.61		X	HBBF 2017
FDA testing, 2013 and 2014 (FDA 2016, Abt 2017)	Infant rice cereal (dry, white and brown rice)	76					103.00					
Other cereals (dry)												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Other cereals (non-rice)	11	8.35	20.18	0.14	23.07	12.23	40.91		0.53		HBBF 2017
HBBF 2017 Arsenic in Infant Cereal Study (HBBF 2017)	Other cereals (non-rice)	63					14.00		0.53		X	HBBF 2017
Infant rice cereal (dry, prepared)												
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, cereal, rice, dry, prepared with water	14	0.50	3.10	0.17	26.60	16.83	20.60		0.63	X	HBBF 2017 and this study (see Note 6)
Other cereals (dry, prepared)												
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, cereal, oatmeal, dry, prepared with water	14	0.00	3.20	0.00	3.60	1.91	5.11		0.53		HBBF 2017
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, cereal, mixed, dry, prepared with water	14	0.88	7.30	0.00	6.50	3.45	11.63		0.53		HBBF 2017
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, cereal, oatmeal with fruit, prepared with water	14	0.00	3.30	0.00	4.00	2.12	5.42		0.53		HBBF 2017
FDA's Total Diet Study 2014-2017 (FDA 2019)	Average of the 3 TDS Other Cereals above	14	0.29	4.60	0.00	4.70	2.49	7.38			X	

APPENDIX F: Data and Calculations—Average Heavy Metals Levels for Higher-Risk Foods and Safer Alternatives (continued)

Study	Food	Number of samples	Metal concentration, parts per billion (ppb)						Source of inorganic arsenic level, and average ratio of inorganic to total arsenic		This food's data is shown in safer-choices food charts in this study	Reference for ratio of inorganic to total arsenic
			Lead	Cadmium	Mercury	Arsenic, total	Arsenic, inorganic	Total metals	Measured - ratio of inorganic to total arsenic is shown below	Calculated - Assumed ratio of inorganic to total arsenic is shown below		
Carrot, baby food												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Carrots, baby food	12	7.84	12.62	0.17	2.20	1.98	22.62		0.90		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, carrots	14	8.70	19.00	0.00	1.50	1.35	29.05		0.90		Cubadda 2016
HBBF and FDA studies listed above	Sample-weighted average	26	8.51	17.58	0.04	1.66	1.49	27.62			X	
Sweet potato, baby food												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Sweet potato, baby food	17	10.35	2.62	0.07	5.67	5.10	18.14		0.90		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, sweet	14	13.70	3.60	0.00	1.90	1.71	19.01		0.90		Cubadda 2016
HBBF and FDA studies listed above	Sample-weighted average	31	12.73	3.32	0.02	2.99	2.69	18.76			X	
Other fruits and vegetables, baby food												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Other fruits and vegetables, baby food (excludes carrots and sweet potatoes)	39	2.27	2.41	0.09	3.13	2.66	7.42		0.85	X	Cubadda 2016 (see Note 7)
Fruit juice												
HBBF 2019 Baby Food Study (see Appendix A of this document)		9	2.31	0.36	0.07	3.71	0.83	3.56		0.95		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, juice, apple	14	0.25	0.00	0.00	3.30	3.14	3.39				
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, juice, grape	14	2.70	0.00	0.00	13.60	12.92	15.62				
FDA's Total Diet Study 2014-2017 (FDA 2019)	BF, juice, pear	14	1.30	0.75	0.00	4.70	4.47	6.52				
HBBF and FDA studies listed above	Sample-weighted average	51	1.48	0.26	0.00	6.97	6.44	8.18			X	
Alternative to fruit juice - Tap water												
HBBF's Lead in Water Testing Program (HBBF 2019)	Tap water	743	2.00	0.09	NT	0.50	0.50	2.59		1.00	X	Cubadda 2016 (see Note 8)
Puffs (rice)												
HBBF 2019 Baby Food Study (see Appendix A of this document)		7	12.31	20.90	1.94	201.69	81.00	116.16	0.44			EDF 2018 and HBBF 2019 Baby Food Study (see Note 9)
FDA testing, 2013 and 2014 (EDF 2018)		31	19.10	19.30	0.00	119.00	54.90	93.30	0.58			EDF 2018 (see Note 10)
HBBF and FDA studies listed above	Sample-weighted average	38	17.85	19.59	0.36	134.23	59.71	97.51			X	

APPENDIX F: Data and Calculations—Average Heavy Metals Levels for Higher-Risk Foods and Safer Alternatives (continued)

Study	Food	Number of samples	Metal concentration, parts per billion (ppb)						Source of inorganic arsenic level, and average ratio of inorganic to total arsenic		This food's data is shown in safer-choices food charts in this study	Reference for ratio of inorganic to total arsenic
			Lead	Cadmium	Mercury	Arsenic, total	Arsenic, inorganic	Total metals	Measured - ratio of inorganic to total arsenic is shown below	Calculated - Assumed ratio of inorganic to total arsenic is shown below		
Teething biscuits (rice) and rice rusks												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Teething biscuits and rice rusks	10	6.57	4.29	1.95	68.68	41.80	54.61	0.47			EDF 2018 and HBBF 2019 Baby Food Study (see Note 11)
FDA testing, 2013 and 2014 (EDF 2018)	Teething biscuits and rice rusks	27	12.00	9.20	0.00	84.80	46.40	67.60	0.54			EDF 2018 (see Note 12)
HBBF and FDA studies listed above	Sample-weighted average		10.53	7.87	0.53	80.44	45.16	64.09			X	
Alternatives to teething biscuits												
FDA's Total Diet Study 2014-2017 (FDA 2019)	Banana, raw	14	0.00	0.00	0.00	0.00	0.00	0.00				
FDA's Total Diet Study 2014-2017 (FDA 2019)	Cucumber, peeled, raw	14	0.00	1.23	0.00	11.95	10.76	11.99		0.90		Cubadda 2016
FDA studies listed above	Sample-weighted average	28	0.00	0.62	0.00	5.98	5.38	5.99			X	
Non-rice snacks and teethers												
HBBF 2019 Baby Food Study (see Appendix A of this document)	Non-rice snacks and teethers (biscuits, cookies, teethers)	10	8.90	14.20	0.20	15.30	10.71	34.01		0.70		EFSA 2014
Other snacks recommended as alternatives to rice-based snacks												
FDA's Total Diet Study 2014-2017 (FDA 2019)	Apple (red), raw (with peel)	14	0.53	0.00	0.00	2.10	1.68	2.21		0.80		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	Applesauce: Applesauce, bottled	14	0.00	0.00	0.00	0.59	0.47	0.47		0.80		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	Bananas	14	0.00	0.00	0.00	0.00	0.00	0.00		0.80		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	Barley with diced veggies: No data available											
FDA's Total Diet Study 2014-2017 (FDA 2019)	Beans: White beans, dry, boiled	14	0.00	2.60	0.00	0.97	0.68	3.28		0.70		EFSA 2014
FDA's Total Diet Study 2014-2017 (FDA 2019)	Cheese: Cheese, cheddar, natural (sharp/mild)	14	0.59	0.22	0.00	0.00	0.00	0.81		0.70		EFSA 2014
FDA's Total Diet Study 2014-2017 (FDA 2019)	Grapes: Grapes (red/green), raw	14	2.94	0.47	0.00	3.99	3.19	6.60		0.80		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	Hard-boiled egg	14	0.00	0.00	0.00	0.72	0.50	0.50		0.70		EFSA 2014
FDA's Total Diet Study 2014-2017 (FDA 2019)	Peaches: Peach, raw/frozen	14	0.00	0.54	0.00	4.39	3.51	4.05		0.80		Cubadda 2016
FDA's Total Diet Study 2014-2017 (FDA 2019)	Yogurt: Yogurt, lowfat, fruit-flavored	14	2.65	0.00	0.00	0.00	0.00	2.65		0.70		EFSA 2014

APPENDIX F: Data and Calculations—Average Heavy Metals Levels for Higher-Risk Foods and Safer Alternatives (continued)

Study	Food	Number of samples	Metal concentration, parts per billion (ppb)						Source of inorganic arsenic level, and average ratio of inorganic to total arsenic		This food's data is shown in safer-choices food charts in this study	Reference for ratio of inorganic to total arsenic
			Lead	Cadmium	Mercury	Arsenic, total	Arsenic, inorganic	Total metals	Measured - ratio of inorganic to total arsenic is shown below	Calculated - Assumed ratio of inorganic to total arsenic is shown below		
FDA's Total Diet Study 2014-2017 (FDA 2019)	Average for the snacks listed above	126	0.75	0.43	0.00	1.42	0.00	1.17				
FDA's Total Diet Study 2014-2017 (FDA 2019) and HBBF 2019 Baby Food Study	Average for snacks listed above and the non-rice snacks from this study		1.49	1.68	0.02	2.68	1.89	5.07			X	

Notes

* Sample-weighted averages account for the 3 idividual samples that comprise each TDS composite sample.
1. NT = not tested
2. "HBBF 2019 Baby Food Study" refers to this study; individual sample data are shown in Appendix A.
3. Zero is shown for metals levels from FDA's Total Diet Study for results that fall below the limit of quantitation. For mercury, a zero may also indicate that the test was not conducted.
4. Average inorganic arsenic is calculated from average total arsenic value in cases where HBBF lacked access to data for individual samples.
5. Calculations of average levels for FDA TDS data are calculated using the Xue (2010) method for treatment of results below the quantitation limit.
6. Ratio of inorganic to total arsenic is the sample-weighted average of data from HBBF 2017 and this study.
7. From Cubadda 2017: Inorganic arsenic is 90% total for vegetables, 80% total for fruit. 85% is used here.
8. Metals levels shown are averages from HBBF tap water testing from over 700 homes in 43 states.
9. Inorganic arsenic for one puffs sample was not measured, and was instead calculated from the change FDA 2013-14 study ratio (EDF 2018).
10. Averages are derived from sample data available at EDF 2018.
11. Inorganic arsenic for 4 samples were not measured, and were instead calculated from the FDA 2013-14 study ratio (EDF 2018).
12. Averages are derived from sample data available at EDF 2018.

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Healthy Babies Bright Futures (HBBF) is an alliance of scientists, nonprofit organizations and donors working to create and support initiatives that measurably reduce exposures to neurotoxic chemicals in the first thousand days of development.

Our efforts are inspired and supported by science and data, and designed to help restore the chance for a full life to children who would otherwise face brain-diminishing exposures to toxic chemicals beginning in utero.

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