Is Homemade Baby Food Better?

A new investigation: Tests compare toxic heavy metal contamination in homemade versus store-bought foods for babies

When does the baby food aisle pay off?
When do homemade foods take the cake?
We tested 288 foods to find out.

Report includes a data-driven guide to better baby food for parents seeking healthy choices for infants and toddlers

Healthy Babies Bright Futures

Jane Houlihan, Research Director and Charlotte Brody, National Director | Healthy Babies Bright Futures | August 2022

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HBBF is responsible for any errors of fact or interpretation contained in this report.

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Executive Summary

A Healthy Babies Bright Futures (HBBF) 2019 study found that 95% of baby foods tested were contaminated with toxic heavy metals, sparking national conversations about homemade baby food as a safer alternative. Questions about baby food safety continued when a 2021 Congressional investigation found baby foods to be tainted with "dangerous levels" of toxic heavy metals like lead and arsenic, giving parents one more reason to steer clear of the baby food aisle.

We wanted to know if the DIY work-around *actually works.* Our new study sought to determine if homemade purees and foods purchased outside the baby food aisle have lower heavy metal levels than pre-made, store-bought baby food. To find the answer, HBBF tested 288 foods and examined 7,000+ additional food testing data from published studies.

We found no evidence to suggest that homemade baby food has lower heavy metal levels than store-bought brands. Heavy metal levels varied widely by **food type**, not by who made the food.

Our top findings were:

- 94% of all food samples we tested contained detectable amounts of toxic heavy metals: 94% of store-bought baby food and 94% of homemade purees and family brand foods.
- Rice cakes and crisped rice cereal are **heavily contaminated** with arsenic. They contain higher levels of inorganic arsenic (the toxic form of arsenic than any other foods tested. Both stand out as foods to avoid for children and adults alike.
- Lead, arsenic, and cadmium levels are high in some fresh carrots and sweet potatoes. We recommend that parents vary the source by choosing from different brands, varieties, or stores each week to avoid accidentally serving a high-metal source often.
- The 10 most heavily contaminated foods consumed by babies, beginning with the highest, are: rice cakes, crisped rice cereal, rice-based puffs, brown rice, rice-based teething biscuits and rusks, white rice, raisins, teething crackers (non-rice), granola bar with raisins, and oat-ring cereal.[1]
- The 10 least contaminated foods consumed by babies, beginning with the lowest, are: bananas, grits, baby food brand meats, butternut squash, lamb, apples, pork, eggs, oranges, and watermelon.[1]

1 From HBBF analysis of 7,900 tests of foods commonly consumed in the U.S., from studies by FDA and HBBF (see Section 2). The 10 most heavily contaminated foods are foods consumed by babies with the highest levels of lead and inorganic arsenic combined, the two metals of greatest concern given their ubiquity in baby food and their confirmed ability to harm the developing brain. The 10 least contaminated foods are foods consumed by babies with the lowest level of all four toxic heavy metals considered in this study, lead, cadmium, mercury, and inorganic arsenic combined. The rankings consider heavy metals only, not pesticides, pathogens, and other contaminants.

Our analysis of 7,000+ food tests revealed 40 popular baby foods and food groups to serve, limit and avoid.

See page 9 for the full list.

SKIP 4 foods heavily contaminated with heavy metals

- Crisped rice cereal
- Puffs (rice-based)
- Brown rice with no extra cooking water used
- Rice cakes

SERVE 13 foods with very low heavy metal contamination

FRUIT:

- Fresh and frozen fruit (not canned)
- Baby food brand fruits

VEGGIES - BABY FOOD, FRESH, OR FROZEN:

- Green beans
- Peas
- Butternut squash

TEETHING FOODS:

- Peeled and chilled cucumber
- Frozen bananas

OTHER FOODS:

- Baby food brand meat
- Soft or pureed home-cooked meat
- Beans
- Eggs
- Infant formula
- Healthy low-metals snacks (see page 9)

OTHER HEALTHY CHOICES:

Grains, sweet potatoes, carrots, and other nutritious foods are also part of a healthy diet. See page 9 for tips on how to serve these important but moderately contaminated foods in a varied diet.

Source: HBBF analysis of 7,900 tests of foods commonly consumed in the U.S., from studies by FDA and HBBF (see Section 2).

The fundamental problem and the two-pronged solution

Parents should not have to worry about the safety of their babies' meals and snacks. They shouldn't need to wonder if they have served carrots or spinach too many days in a row, or guess if nutrient loss from boiling and peeling is an acceptable price for heavy metal reduction. This is a complex problem and will require a multi-pronged solution for both our **kitchens** and our **country**.

The Kitchen Solution: Until foods with reliably low heavy metal levels are widely available, parents can choose and prepare foods in ways that significantly reduce babies' exposures by following HBBF's one-page guide on fruits and vegetables, proteins, grains, snacks, and drinks (page 9). The most important step: **introduce and serve a variety of healthy foods**, whether baby food brands or homemade foods. Serving the same food every day for a long time can accidentally concentrate one or more contaminants in a child's diet. A varied diet avoids this and ensures a healthy mix of nutrients too.

The Country's Solution: To date, FDA has set limits for heavy metals in only two baby foods—infant rice cereal and juice—leaving the burden on parents to navigate the risks for all other foods. FDA should establish and enforce protective limits for heavy metals in all foods consumed by babies and young children. Heavy metal contamination spans all the food aisles of the grocery store; FDA's safety standards must as well. Standards extending beyond the baby food aisle would encompass foods eaten during pregnancy as well, a crucial time for lowering toxic metal exposures. FDA should require companies and growers to follow best practices to lower heavy metals in crops and processed ingredients.

Food-by-food swaps to lower heavy metal levels

Teething foods

95% ↓

To relieve teething pain, offer a **frozen banana** instead of **rice-based teething biscuits and rice rusks** for a 95% reduction in total heavy metals.

Fruits

30x ↓

Offer **fresh or frozen (thawed) fruit** (including homemade purees) instead of **canned fruit** for less lead. Tests find lead 30 times more often in canned fruit than in fresh and frozen fruit. **Baby food brand fruit purees** are also recommended.

Vegetables

43% ↓

Offer a **variety of vegetables** instead of **carrots, potatoes, and sweet potatoes every day** for a 43% reduction in total heavy metals.

Meat, beans, eggs, nuts, seeds and their butters

69% ↓

Baby food pureed meats have 69% less lead and inorganic arsenic than peanut butter, on average, and significantly less cadmium as well. But nut butters are nutritious and should remain in the diets of allergy-free children, in rotation with a variety of other protein-rich foods.

Cereal and grains

75% ↓

Offer **infant oatmeal cereal** instead of **infant rice cereal** for a 75% reduction in total heavy metals.

Drinks

39% ↓

Offering **tap water** instead of **apple juice** provides a 39% reduction in total heavy metals (assuming national average levels of metals in unfiltered tap water[2]).

Snacks

95% ↓

Offer **healthy low-metal snacks** instead of **baby food puffs** (rice-based) for a 95% reduction in total heavy metals. Try applesauce, beans, and yogurt (see page 9 for more).

2 HBBF analysis of results from nearly 3,000 tap water tests from homes nationwide. From HBBF's tap water testing initiative (HBBF 2022): "Protect yourself and your family from toxic lead in tap water with a simple kit that provides customized action steps" https://leadkit.hbbf.org/.

SECTION 1.

Overview

Are you making baby food at home to avoid toxic heavy metals in commercial baby food? Our investigation reveals when it helps, when it doesn't, and when even more action is needed.

Many parents skip store-bought baby foods and make baby food from fresh ingredients at home instead. They enjoy the perks—cutting costs and controlling ingredients for a variety of flavors and family favorites. But another motivation emerged last year when Congressional investigations capped a decade of research, finding baby foods to be tainted with "dangerous levels"[1] of toxic heavy metals like lead and arsenic, giving parents one more reason to steer clear of the baby food aisle.

But does this work-around *actually work*? Do homemade purees and family brands purchased outside the baby food aisle have lower heavy metal levels than store-bought baby food?

Published studies have uncovered contamination in nearly all foods tested but have not compared homemade and store-bought brands to spotlight the safest choices. To find the answers, Healthy Babies Bright Futures (HBBF) commissioned tests of 288 foods and assessed more than 7,000 additional tests from published studies. **We found that lowering babies' exposures to toxic heavy metals depends far less on who makes the food — parents or baby food companies — than it does on choosing the right mix of foods each day.**

In this study, we:

- Share results from our head-to-head testing of baby food brands versus homemade purees and family brands, bolstering our findings with results from 27 additional studies on the impact of peeling and cooking and choosing one variety of food over another.
- Describe results from our own simple kitchen experiments to estimate the benefits of peeling carrots and sweet potatoes.
- Condense all this information into a practical guide parents can use to reduce babies' exposures to toxic heavy metals.
- Present a two-pronged "Kitchen and Country" solution to the problem of heavy metals in baby food, spanning steps each parent can take in the kitchen to reduce children's exposures to toxic heavy metals, and actions the federal government must take to reduce exposures for all children nationwide.

1 "Baby Foods Are Tainted with Dangerous Levels of Arsenic, Lead, Cadmium, and Mercury." Staff Report, Subcommittee on Economic and Consumer Policy. Committee on Oversight and Reform. U.S. House of Representatives. February 4, 2021. https://oversight.house.gov/sites/democrats.oversight.house.gov/files/2021-02-04%20ECP%20Baby%20Food%20Staff%20Report.pdf

Key findings

- 94% of all food samples we tested contained detectable amounts of toxic heavy metals: 94% of store-bought baby food, and 94% of homemade purees and family brand foods.

- **We found no evidence to suggest that homemade baby food has lower heavy metal levels than store-bought brands.** Heavy metal levels varied widely by food type, not by who made the food.[2]

- Rice cakes and crisped rice cereal are heavily contaminated with arsenic. They contain higher levels of arsenic than any other foods tested. Both stand out as foods to avoid for children and adults alike.

- The top 10 most heavily contaminated foods consumed by babies, beginning with the highest, are:
  - rice cakes
  - crisped rice cereal
  - puffs (rice-based)
  - brown rice
  - teething biscuits and rusks (rice-based)
  - white rice
  - raisins
  - teething crackers (non-rice)
  - granola bar with raisins
  - oat-ring cereal

- The 10 least contaminated foods, beginning with the lowest, are:
  - bananas
  - grits
  - baby food brand meats
  - butternut squash
  - lamb
  - apples
  - pork
  - eggs
  - oranges
  - watermelon

- Lead, arsenic, and cadmium levels are high in some individual fresh carrots and sweet potatoes. We recommend that parents vary the source by choosing from different varieties or stores each week to avoid accidentally serving a high-metals source often.

- Four popular foods consumed by babies are so heavily contaminated by heavy metals that we recommend **avoiding them altogether** (page 9).

- Fourteen foods or food groups have little contamination and can be served freely (page 9).

- Twenty-two foods have moderate to relatively high amounts of heavy metals, to be eaten rarely or in rotation with other foods. For some of these foods, preparation matters — peeling and cooking can lower the heavy metal content (page 9).

ESSENTIAL TERMS

Baby food brand and **store-bought baby food:** Pre-packaged foods marketed for babies and toddlers, such as those made by Gerber, Beech-Nut, and Earth's Best.

Homemade baby food: Baby food prepared at home from basic ingredients, including purees and diced forms of fruits, vegetables, and meats.

Family brand: Pre-packaged foods appropriate for the family, not marketed only for babies and toddlers, like Cheerios cereal and Quaker rice cakes.

Family food and Family-style food: Foods appropriate for the whole family, homemade or pre-packaged.

OMB: United States Office of Management and Budget, the agency that reviews all significant regulatory proposals from FDA and all other federal agencies.

2 The term "total heavy metals" or "heavy metal levels" in this report refers to the sum of lead, cadmium, mercury, and inorganic arsenic. In the context of food groups or groups of samples, it refers to the average total heavy metal concentration for all available samples. See Appendix C for test results.

The fundamental problem and the two-pronged solution

The levels of heavy metal contamination in the foods babies eat are far from ideal. Research continues to confirm widespread exposures and troubling risks for babies, including 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.

To date, the U.S. Food and Drug Administration (FDA) has set or proposed limits for heavy metals in only two baby foods—infant rice cereal and juice—leaving the burden on parents to navigate the risks for all other foods. The powerful government agency that reviews agency proposals, the White House's Office of Management and Budget (OMB), has slow-tracked progress even more, holding FDA's proposed limits hostage for months before approving them for release.

Parents should not have to worry about the safety of their babies' meals and snacks. They shouldn't need to wonder if they have served carrots or spinach too many days in a row, or guess if nutrient loss from boiling and peeling is an acceptable price for heavy metal reduction. This is a complex problem and will require a multi-pronged solution for both our **kitchens** and our **country**.

The Kitchen Solution

Until foods with reliably low heavy metal levels are widely available, parents can choose and prepare foods in ways that significantly reduce babies' exposures by following HBBF's guide on fruits and vegetables, proteins, grains, snacks, and drinks (page 9). The most important step: **introduce and serve a variety of healthy foods**, whether baby food brands or homemade foods. Serving the same food every day for a long time can accidentally concentrate one or more contaminants in a child's diet. A varied diet avoids this and ensures a healthy mix of nutrients too.

Who bears the greatest risk from heavy metals in baby food?

For low-income families and families of color, the problem of heavy metals in baby food is urgent. They are more likely to eat rice-based foods high in heavy metals and are more likely to be exposed to heavy metals found in old lead paint and in contaminated air and water (Jones 2022, Geron 2022).

- Hispanic infants and toddlers are 2.5 times more likely than other children to eat rice on a given day (EPA 2008). Asian Americans eat nearly 10 times more rice than the national average (Potera 2007).

- Black babies are more likely to be exposed to lead in formula. Early in life infants can receive formula as their sole food, making it a uniquely concentrated source for heavy metal exposure when it is made with lead-contaminated tap water. Twenty-six percent of black infants never receive breastmilk and are exclusively formula fed, compared to only 17% of Hispanic babies and 13% of non-Hispanic white babies (CDC 2018, Beauregard 2019).

The Country's Solution

FDA should establish and enforce protective limits for heavy metals in all foods consumed by babies and young children. Heavy metal contamination spans all the food aisles of the grocery store; FDA's safety standards must as well. Standards extending beyond the baby food aisle would encompass foods eaten during pregnancy as well, a crucial time for lowering toxic metal exposures. FDA should require companies and growers to follow best practices to lower heavy metals in crops and processed ingredients.

Solutions must accelerate to protect babies

Heavy metals occur naturally in soil and water and are also found at elevated levels in fields polluted by pesticides, contaminated fertilizer, airborne contaminants, and industrial operations. Food crops pick up these metals that are ultimately found in the foods babies eat, whether organic or conventionally grown. Our new analysis reinforces years of published research showing that babies are exposed to toxic heavy metals like lead and arsenic from an array of foods that span every food aisle of the grocery store. Babies ingest trace amounts of heavy metals every day with every meal they eat with health consequences that may include lifelong deficits in intelligence.

In April 2021, FDA responded to the problem by announcing its Closer to Zero action plan "to reduce exposure to arsenic, lead, cadmium, and mercury from foods eaten by babies and young children — to as low as possible" (FDA 2021a,b). More than a year later, the agency has proposed new limits for only one food: fruit juice. FDA remains years out from delivering fully on its promise.

When FDA drags its feet, infants pay the price. Earlier this year, the agency sat for months on a whistleblower's complaint alleging lax cleaning practices and falsified records at an Abbott infant formula factory responsible for producing one-quarter of the U.S. formula supply. By the time FDA alerted parents, two infants had died, seven more deaths were under investigation, and up to dozens of additional infants had been sickened by the disease-causing contaminant (Reiley 2022). Many more suffered from formula shortages as the weeks wore on without a government plan to keep shelves stocked during the factory's closure.

FDA's multi-year initiative to limit lead, arsenic and other heavy metals in baby food also has significant repercussions for infants. Nearly 10,000 babies in the U.S. begin eating solid food every day. Each day that passes has an impact, as children ingest metals that harm neurological development.

The 2022 infant formula crisis can be an opportunity for FDA to get serious about protecting babies, including accelerating its multi-year timeline to get heavy metals out of the food babies and young children eat. HBBF has urged the agency to pick up the pace and to strengthen its lax rice and juice limits, which were set at caps the industry was already largely achieving and which will do little to nudge the baby-food market closer to the goal of

zero heavy metals. We have also called on baby food companies to get out ahead of FDA, by establishing a goal of no measurable amounts of heavy metals in baby food in recognition of the absence of a known safe level of exposure, and by achieving steady progress toward that goal.

Recent years have been marked by signs of progress. FDA launched its Closer to Zero initiative, established guidance to restrict heavy metals in two baby foods, and lowered its benchmark for lead exposure from food (the Interim Reference Level, or IRL) for children and females of childbearing age. Arsenic contamination in rice cereal and juice is 45 and 61 percent lower, respectively, than amounts measured a decade ago because of companies' success in complying with FDA guidance, based on HBBF's analysis of FDA's most recent data (FDA 2020a). Congress introduced the Baby Food Safety Act of 2021, and USDA is funneling much-needed funding to researchers investigating growing practices and crop varieties that can drive down or bypass heavy metals in baby food ingredients. Baby food companies took infant brown rice cereal off the market (see Appendix D). Three states have taken infant rice cereal off the list of approved foods for the Women, Infants and Children (WIC) supplemental food program, Oregon, Hawaii, and Alaska (Bettin 2020, Hawaii WIC 2019, Alaska WIC 2020). Babies are better off as a result.

But despite the advances, heavy metals remain unregulated in nearly every baby food, too many foods are contaminated, and babies' daily exposures continue. Until FDA's pace accelerates and OMB's roadblocks end, parents will continue to shoulder the burden of kitchen-focused solutions.

Fortunately, simple changes can help limit babies' exposures to toxic heavy metals in food. HBBF created a menu of 40 foods to serve, limit, serve rarely, and avoid that can significantly reduce babies' dietary exposures to metals (page 9). In fact, foods with higher metal levels ("Serve rarely") have 8.1 times more heavy metal contamination than foods with the lowest levels ("Serve, eat freely"), on average.[3] See page 9 for the complete list of foods, designed to help parents choose lower-metal foods in each major food group.

3 *This calculation omits protein-rich foods because sunflower seeds' uniquely high cadmium level drives a 63-fold difference in total heavy metal concentrations for the Eat Rarely versus Eat Freely food categories, an outlier compared to the other food categories considered.*

Figure 1. The 40 Baby Foods Menu: What to serve, limit, and avoid to lower babies' exposures to toxic heavy metals

Serve Lowest heavy metals - Eat freely	Limit or Rotate Moderate heavy metals - Eat each food less than daily ★ = Nutritious food: keep it on the menu, rotate with other foods.	Serve rarely High heavy metals	Avoid Highest heavy metals
FRUIT			
Fresh & frozen fruit **Baby food fruits**	★ **Cantaloupe** - Keep in the diet but less than daily **Canned fruit** - Better choice: fresh, frozen, or baby food	**Dried fruit**	None
VEGETABLES			
Baby food, fresh, or frozen: Green beans, peas, butternut squash	Rotate - Serve a variety of these, not the same one every day: ★ **Sweet potato, potato, carrot, and other root and tuber veggies** (baby food or fresh/frozen, peeled) ★ **Leafy greens, baby spinach**	**Full-size spinach** (Better choice: baby spinach)	None
PROTEIN-RICH FOODS			
Baby food brand meats, eggs, soft or pureed meats & beans	**Peanut butter** - Avoid serving every day	**Sunflower seed butter**	None
CEREALS & GRAINS			
None	★ **A variety of non-rice grains** like oatmeal, barley, millet, and farro, not the same grain every day: **Infant cereal - Iron-fortified oatmeal & multi-grain** **Rice** - limit, and use these varieties and cooking methods: • Rice cooked like pasta, in extra water and then drained • Basmati rice grown in California, India, Pakistan • Sushi rice grown in the U.S. • White rice, not brown	**Infant rice cereal** **Rice -** avoid these varieties and cooking methods: • Rice with no extra cooking water used • Rice grown in Arkansas, Louisiana, Texas or "U.S." • Brown rice	**Crisped rice cereal** **Brown rice with no extra cooking water used**
DRINKS			
Infant formula - Ready-to-feed or made with lead-free tap water **Tap water tested for lead**[4]	**100% fruit juice (not grape)** - Better choices: fresh fruit and water	**Grape juice**	None
SNACKS			
The "Serve" fruits & veggies above, and applesauce (unsweetened), beans, cheese, grapes (cut lengthwise), hard-boiled eggs, yogurt	**The "Limit or rotate" fruits and veggies above**	**Oat ring cereal**	**Puffs (rice)** **Rice cakes**
TEETHING FOODS			
Peeled & chilled cucumber **Frozen banana**	**Non-rice teething biscuits & crackers**	**Rice-based teething biscuits & rusks** **Arrowroot teething crackers**	**Rice cakes**

Source: HBBF analysis of 7,863 tests of arsenic, lead, cadmium, and mercury from: 1) 288 tests commissioned for this study, 2) FDA tests of heavy metals in national market basket studies (FDA 2017a, FDA 2020a), 3) HBBF study of arsenic in infant rice cereal (HBBF 2017), 4) HBBF study of heavy metal contamination in a broad range of baby foods (HBBF 2019), 5) tests of lead in canned pears (HBBF-EDF 2022), 6) FDA tests of lead in juice (FDA 2022a). See Appendix F for methodology.

4 Tap water tested for lead. Learn how to test your water for lead: https://hbbf.org/sites/default/files/documents/2020-10/HBBF_LeadInWater_ParentTipsSheet_R3.pdf

6 Essential Tips for Baby's Healthiest Plate

A healthy mix

1 Is there a food you serve day after day? Add variety instead.

Serving the same food every day for a long time can concentrate one or more contaminants in a child's diet. Rotate it with other healthy foods. **A varied diet of wholesome food** ensures a healthy mix of nutrients, too.

2 Are meals ever skipped? Serve regular meals and snacks.

Meal skipping and fasting is linked to higher blood lead levels in children and greater lead absorption for adults. Serve **regular meals** to help reduce exposure.

3 Next time at the doctor: Ask about iron. *Many babies don't get enough.*

Babies 6-12 months old need extra iron, from formula, iron-fortified cereal (oatmeal or multi-grain), or other foods. Along with **calcium**, **zinc**, and **vitamin C**, **iron** can help reduce the toxic metals absorbed into the body. Among the many foods rich in these nutrients are beans and lentils, lean red meat, iron-fortified cereal, yogurt and cheese, leafy greens, citrus fruit, strawberries, kiwi, and peppers.

Foods to skip, swap, and serve

4 Skip: 4 rice-based foods contaminated with arsenic

Avoid serving **rice cakes**, **baby food puff snacks**, **brown rice with no extra cooking water used**, and **crisped rice cereal.**

5 Swap: Safer picks.

- **Iron-fortified oatmeal and multi-grain infant cereal** over **rice cereal**, for less arsenic.
- **Frozen banana** or **chilled, peeled cucumber** over **rice-based teething biscuits**, for less arsenic.
- **Whole fruit and purees** over **fruit juice**, for fiber and nutrient upsides.
- **Healthy low-metal snacks** over **puffs and rice cakes**. Recommended: Soft-cooked, diced, or mashed to fit a child's age — Apples, applesauce (unsweetened), bananas, barley with diced vegetables, beans, cheese, grapes (cut lengthwise), hard-boiled eggs, peaches, and yogurt.
- **A variety of grains** and **white rice cooked in extra water**, over **rice cooked in just enough water**, for less arsenic.

  Tip: Cook rice like pasta, in extra water you pour off before eating to remove over half of the arsenic. Choose basmati rice from California and white over brown for lower metals. Rotate rice with other grains—try amaranth, quinoa, buckwheat, millet, and polenta (all gluten-free), or bulgur, barley, and farro (these contain gluten, a problem for those with celiac disease or gluten sensitivity).

6 Serve: Fruits and vegetables, either baby food brands or homemade, with these tips:

The fruits we tested are low in heavy metals. Vegetables are a daily essential, but some of the most nutritious like carrots and sweet potatoes have more metals.

- To remove surface metals as well as dirt and bacteria, wash all produce under cold running water for 20 seconds, scrubbing tough skins using a vegetable brush or your hands.
- **Carrots and sweet potatoes**: Eat each less than daily; rotate with other vegetables. For homemade purees vary what you buy, choosing different brands or varieties or shopping from different stores each week to avoid accidentally eating a high-metals source often. Peel before serving.
- **Spinach**: Eat less than daily, rotate with other greens, choose **baby spinach**.
- **Squash**: Choose **butternut squash** over **acorn or Hubbard squash** for less cadmium and arsenic.
- And of course, wash hands before eating. It makes a difference. Contaminated dust sticks to babies' hands and ends up in their mouths.

The approach behind HBBF's food recommendations

HBBF's food recommendations are summarized in the menu and tips on pages 9 and 10. They are grounded in the fact that parents can lower babies' exposures by consistently choosing lower-metals foods within each food group, and by avoiding regularly serving foods high in heavy metals. This fact drives the approach behind the food recommendations in this report.

HBBF's approach underlying the food recommendations in this study:

- Empowers parents to reduce babies' exposures through these dual actions: serving a variety of healthy foods, and emphasizing lower-metals foods within each food group (fruit, vegetables, proteins, grains, drinks, snacks, teething foods). For instance, babies' average exposure levels will be lowered by the choice of baby spinach over full-grown spinach, rice cooked in extra water and drained over rice that absorbs all cooking water, fresh pears over canned pears, and a variety of vegetables over sweet potatoes every day.
- Allows for flexible category limits in the menu on page 9 (avoid, serve rarely, limit, serve). These categories are defined by successively lower total metal concentrations within each food group, not by an absolute concentration across all food groups. This accommodates the way parents plan children's menus, by food group, and provides lower-metals choices within each group.
- Allows for the average total heavy metal concentration to be a key factor behind the menu in lieu of serving size calculations. This approach allows parents to easily spot foods with higher metal levels in each food group and avoid serving those in large portions or often. In contrast, a menu organized by metal amounts in an average serving might give a green light to a higher-metals food usually served in smaller amounts but leave at risk babies and toddlers who eat that food in larger amounts or more often than other children (common among picky eaters).
- Accounts for high variability in metal levels in certain foods through recommendations to vary the source when purchasing, to avoid unintentionally selecting a high-metal source repeatedly.
- Assigns a lower category of concern for foods for which cadmium is the dominant metal, reflecting the likelihood of lower absorption and the less extensive weight of evidence for neurotoxicity compared to the other metals considered in this study. For example, a food containing more than 100 ppb cadmium is placed in the "Serve rarely" category instead of "Avoid" as is the case for other metals of concern. This placement is consistent with the need for caution regarding a metal with a growing but limited body of evidence on neurotoxicity and with significant data gaps with respect to the safety of exposures during infancy.
- Empowers parents to serve a wide variety of foods. The "Avoid" category contains only 4 foods. These can be skipped with no nutritional downsides for babies when alternate healthy foods are served.

Parents can use common sense in their choices. Serving a few raisins to a toddler (a food relatively high in arsenic and lead) is very different from serving a large handful of raisins every day. Mixing a teaspoon of peanut butter into a puree is different from spreading much more than that on crackers for a daily snack. "Serve rarely" foods can be occasionally included in a baby's diet. Following the #1 tip to "serve a variety of healthy foods" averts the chance that a particular contaminant will be concentrated in a baby's diet.

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 shopping with attention to the recommended menu and tips on pages 9 and 10.

SECTION 2.

Results — New tests of heavy metals in foods eaten by babies

Are there more heavy metals in baby food brands than in homemade purees and family foods?

The food babies eat can be a major exposure source for toxic heavy metals like lead, arsenic, and cadmium that cause cancer and harm brain development. Ten years of sustained research includes investigations finding six times more arsenic in infant rice cereal than other types of infant cereal and detecting heavy metals in 95 percent of all baby foods tested (HBBF 2017, 2019). Other published studies have highlighted arsenic and lead in fruit juice (CR 2011,2019), arsenic in grains and cereals (CR 2012), and heavy metals in a range of baby foods (e.g., CR 2018, CR 2022, EDF 2017, Gardener 2019).

Children in the U.S. lose an estimated 11 million IQ points from birth to 24 months of age from dietary sources of lead and arsenic, according to an HBBF-commissioned study (HBBF 2019). Impacts from heavy metal exposures are lifelong and span learning, behavior, and productivity. Despite the risks, with few exceptions, there are no specific limits for toxic heavy metals in baby food.

Some parents have turned to homemade baby food to mitigate dietary exposures to the metal contamination reported in commercial baby food. Proponents of homemade baby foods range from pediatricians to mommy bloggers. A Congressional investigation uncovered high metal levels tainting some vitamins and other additives used in commercial baby food, and FDA found high heavy metal levels in a common food thickener (carrageenan), additives that are absent from homemade food (HR 2021a,b, EDF 2018). A food industry publication includes homemade baby food on a list of ways to "avoid processed baby foods and accompanying heavy metals" (Shell 2022). A Mom Blogger's Club post advises parents that "organic or homemade food is another remedy to avoid heavy metals" (mombloggersclub.com 2022). Among other important steps, the American Academy of Pediatrics recommends serving a varied diet to lower heavy metal exposures, and adds that homemade baby food could further reduce levels by averting heavy metal contamination from processing and packaging, a potential secondary source of metals that could add to amounts accumulated by crops in the field (AAP 2021).

Our study explores whether making baby food at home makes a measurable difference. To find out, we commissioned tests of 288 foods and assessed more than 7,000 additional tests from other published studies to learn how the levels of lead, arsenic, and other heavy metals in homemade purees or packaged family brands compare to amounts found in baby food brands.

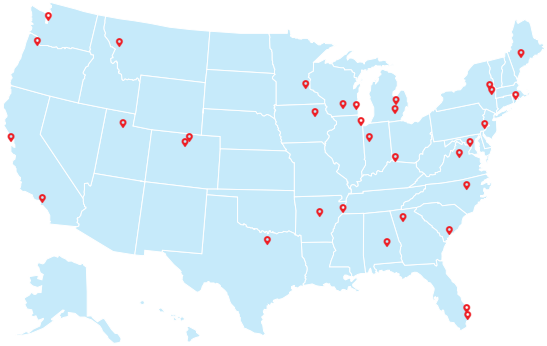
New tests of heavy metals in baby food and family food

Forty-five shoppers in 26 states (Figure 2) purchased 288 foods from grocery stores, big-box retailers, and farmers' markets, choosing from 14 types of baby foods paired with an equivalent homemade ingredient or packaged family brand (Figure 3). HBBF commissioned Brooks Applied Labs of Bothell WA, a nationally recognized laboratory with expertise in heavy metal analysis, to test the samples for the top four heavy metals of concern in food: lead, arsenic, cadmium, and mercury. We also commissioned this lab to test 30 of those foods, those with the highest arsenic levels, for the specific form of arsenic most toxic to people, inorganic arsenic.

Our tests included between 8 and 12 pairs for each food type, providing a snapshot of shoppers' choices on a particular day rather than a statistically robust analysis of the market. Nevertheless, our findings line up with FDA's national testing program and other published studies: every food type tested had some amount of heavy metal contamination. Results support a troubling conclusion — **babies are exposed every day through every meal they eat, whether store-bought or homemade.**

Test results, specific samples and brands purchased, analytical methods, and quality control procedures are in Appendices A, B, and C.

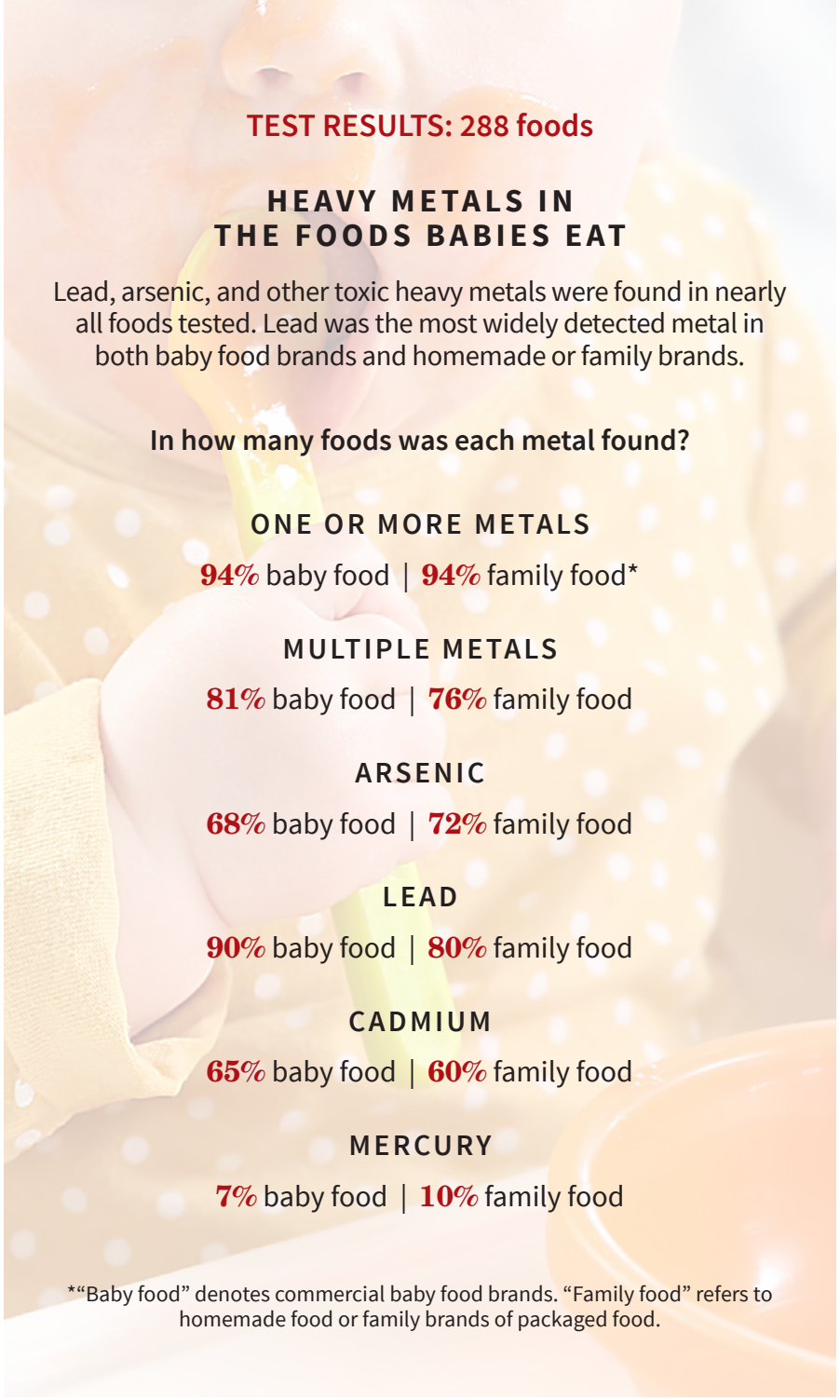
Figure 2. Shoppers from across the country shopped for the foods we tested.



Albany, NY
Ann Arbor, MI
Atlanta, GA
Boulder, CO
Cedar Falls, IA
Charleston, SC
Charlottesville, VA
Chicago, IL
Cincinnati, OH
Dallas, TX
Flint, MI
Fort Collins, CO
Fort Lauderdale, FL
Little Rock, AR
Los Angeles, CA
Madison, WI
Memphis TN
Miami, FL
Milwaukee, WI
Minneapolis, MN
Missoula, MT
Montgomery, AL
Philadelphia, PA
Portland, OR
Providence, RI
Raleigh, NC
Salt Lake City, UT
San Francisco, CA
Schenectady, NY
Seattle, WA
Washington, DC
Waterville, ME
West Lafayette, IN

Figure 3. Fourteen pairs of foods purchased by shoppers

BABY FOOD BRAND	FRESH FOODS AND FAMILY BRANDS
FRUIT	
Apple or applesauce puree	Apple — fresh, any variety
Banana puree	Banana — fresh, any variety
Pear puree	Pear — fresh, any variety
VEGETABLES	
Sweet potato puree	Sweet potato — fresh, any variety
Carrot puree	Carrot — fresh, any variety
Squash puree	Squash — fresh, type matching baby food ingredient
Pea puree	Peas — frozen
Green bean puree	Green beans — frozen
CEREAL AND GRAINS	
Infant rice cereal	Rice — any brand/type
Infant oatmeal cereal	Instant or steel-cut oatmeal — any brand/type
FRUIT JUICE	
Apple juice — 100% juice	Apple juice — 100% juice
Grape or pear juice — 100% juice	Juice that matches the baby food juice — 100% juice
SNACKS AND TEETHING FOODS	
Puffs	Oat ring cereal (like Cheerios) — any brand/type
Teething biscuits or rusks	Rice cakes — any brand/type



TEST RESULTS: 288 foods

HEAVY METALS IN THE FOODS BABIES EAT

Lead, arsenic, and other toxic heavy metals were found in nearly all foods tested. Lead was the most widely detected metal in both baby food brands and homemade or family brands.

In how many foods was each metal found?

ONE OR MORE METALS

94% baby food | **94%** family food*

MULTIPLE METALS

81% baby food | **76%** family food

ARSENIC

68% baby food | **72%** family food

LEAD

90% baby food | **80%** family food

CADMIUM

65% baby food | **60%** family food

MERCURY

7% baby food | **10%** family food

*"Baby food" denotes commercial baby food brands. "Family food" refers to homemade food or family brands of packaged food.

Toxic heavy metals were found in nearly every food tested and were just as likely to be detected in family brands and homemade purees as in store-bought baby food brands.

Ninety-four percent of both baby foods and family-style foods tested were contaminated with one or more of four toxic heavy metals—arsenic, lead, cadmium, and mercury. More than three-fourths of the foods tested were contaminated with multiple metals, including 81 percent of baby foods and 76 percent of family-style foods.

Lead and cadmium were more prevalent in baby food brands than in homemade purees and family brands; arsenic and mercury were less prevalent. We found no evidence to suggest that homemade purees and family brands are generally safer, with lower metal levels, than store-bought baby food.

We found no evidence to suggest that homemade purees and family brands are generally safer, with lower metal levels, than store-bought baby food.

Our results are consistent with FDA's findings in national market basket testing. The agency detected one or more of these four heavy metals in recent tests of the same types of foods (FDA 2017a, 2020a and Appendix C) and detected heavy metals in both baby foods and comparable fresh foods or family brands. **The ubiquity of metals across all baby food brands, fresh produce, and packaged family brands signals the need for FDA to go beyond the baby food aisle in setting standards for these contaminants.**

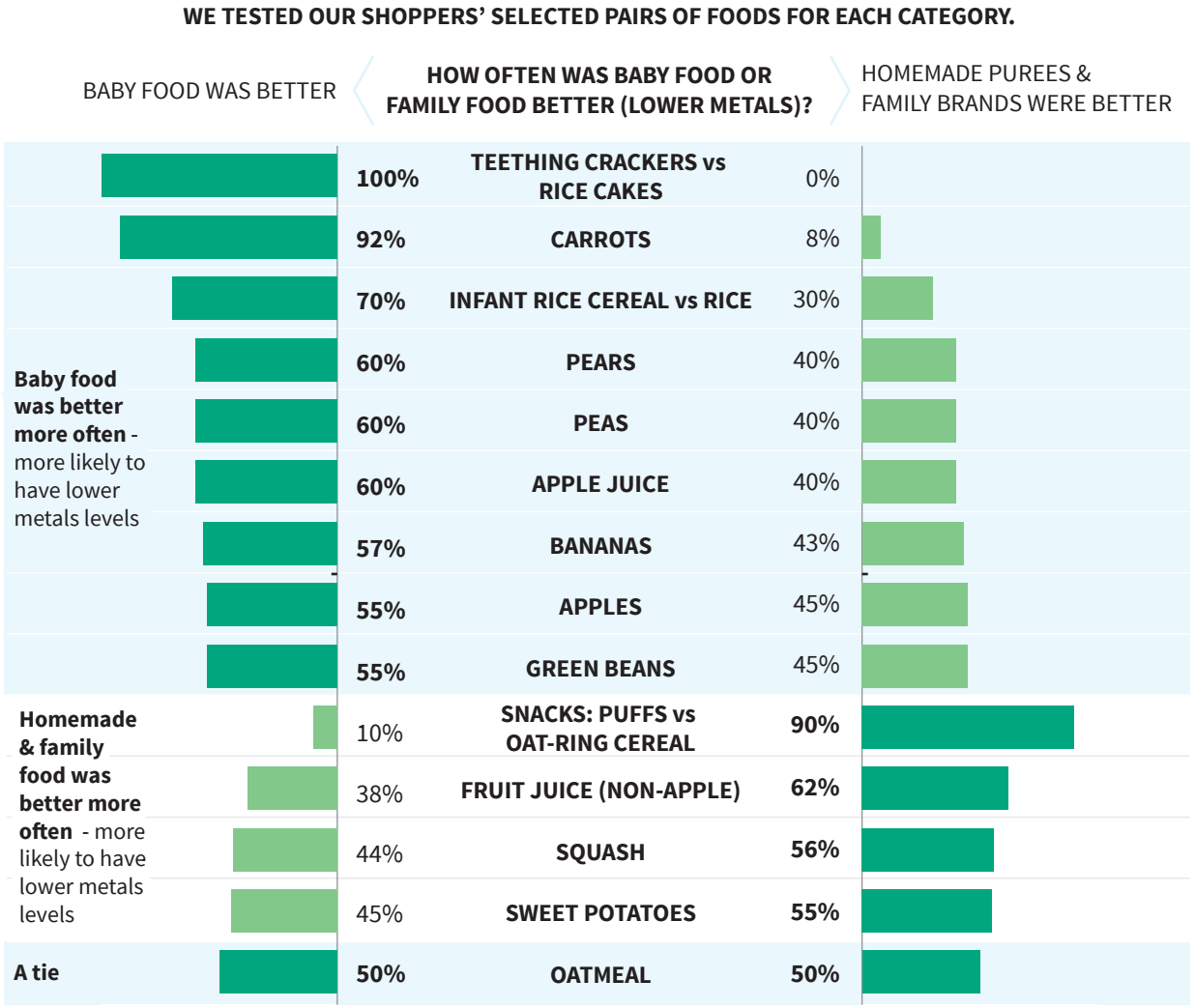
For our shoppers, differences in metal contamination between baby food brands and comparable homemade/family foods reflected rice content and cooking methods.

For 9 of 14 food types tested, baby food was more likely to have a lower total metal level than family food for the pairs of foods tested (Figure 4). Differences were usually small, exceeding 5 ppb in fewer than half of the 144 food pairs tested.

Results for rice cakes and rice-based snacks stood out — their high heavy metal levels were dominated by arsenic, and led to our recommendations for healthier snacks (page 9):

- Rice cakes had higher total heavy metal levels than any other food tested by HBBF. Among the pairs of foods we tested, every rice cake had a higher metal amount than rice-based teething biscuits.
- In 9 of 10 pairs of foods purchased, oat-ring cereal (the rice-free family brand snack) had a far lower total heavy metal amount than baby food puff snacks made from rice flour, an ingredient naturally high in arsenic. Far lower still are the heavy metal levels in our recommended snacks, including beans, fresh fruits, and yogurt (page 9).
- Food prep steps in the kitchen could make foods like carrots and rice (where baby food was more likely to have lower amounts of heavy metals) safer:
  - Seven of 10 infant rice cereals tested had lower metal levels than family-brand rice, with lower arsenic concentrations driving the difference. The gap would be closed by

Figure 4. Safer picks from our shopper's 144 pairs of food purchased



Source: HBBF analysis of 288 samples of baby food and family-style food tested by Brooks Applied Labs, Bothell Washington, with analysis of total arsenic, lead, cadmium, and mercury, and inorganic arsenic for a subset of samples.. Statistics shown reflect comparison of total heavy metal concentrations (the sum of all 4 metals tested) for each of the 144 pairs of foods purchased (baby food and its comparable homemade or family-style food).

- Fruit juice - non-apple: Tests include baby-food and family brands of grape and pear juice.

cooking rice in extra water that is poured off before eating, which can remove over half of the arsenic.

- Baby food carrots bested pureed fresh carrots for 11 of 12 pairs of food our shoppers purchased, with lower total heavy metal levels driven mostly by reduced cadmium. The gap could be narrowed or even reversed by boiling the fresh carrots, which leaches out heavy metals (but leaches nutrients as well - see Appendix D).

Parents have no way to know if they are bringing home a food with high metal levels.

With few limits for heavy metals in place for the foods tested, some shoppers brought home samples with strikingly high levels. High or low metals were based on chance. A Walmart shopper in Raleigh, NC purchased a sweet potato with 60.7 ppb lead, **10 times more lead** than was detected in the baby food sweet potato container she chose. A shopper from Memphis, TN, on the other hand, brought home a fresh sweet potato with one-twelfth the lead of the baby food sweet potato brand she purchased. A shopper in Chicago bought a fresh carrot containing 15.1 ppb arsenic, 8 times more arsenic than was found in the baby food carrot container she selected. A California shopper found the opposite, purchasing a fresh carrot from a local farmers' market with one-third the arsenic of the baby food brand she bought.

Our results show that unless FDA rapidly advances its Closer to Zero initiative, every parent will continue to risk bringing home one or more foods laden with significant amounts of heavy metals, whether in commercial baby food, family brands, or ingredients for homemade baby food.

A deeper dive into thousands of additional tests reveals the need for a two-pronged Kitchen and Country-Wide Solution.

We bolstered our new test results with more than 7,000 additional tests from FDA and HBBF studies, assessing heavy metals in 190 types of food altogether. Results for the 14 foods highlighted in this study and for other popular baby foods featured in this study are shown in Figure 5 and Appendix C.

Foods with relatively high heavy metal concentrations include some nutritious and essential staples like carrots, sweet potatoes, greens, and grains. Our research shows that parents can reduce amounts to some extent in the kitchen, by cooking, peeling, and serving a varied diet (see Appendix D for details). **But an FDA-led solution is ultimately essential for bringing levels down nationally.**

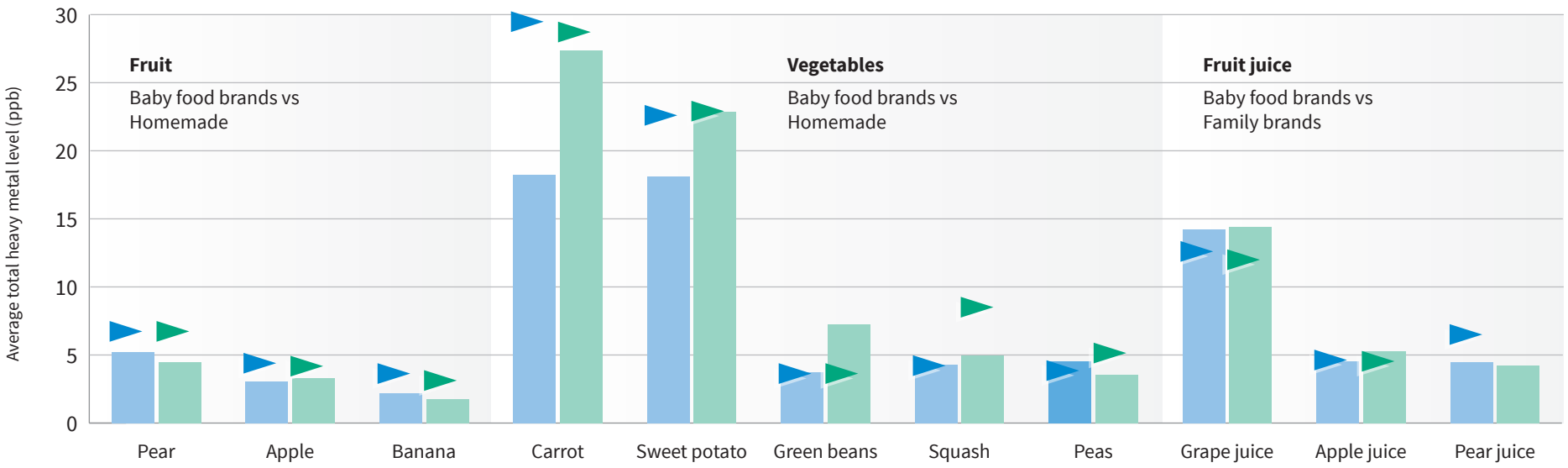
Other foods with the highest metal levels can be skipped in a baby's diet with no nutritional downside. Whole pureed fruit over juice, healthy snacks over rice-based puffs, a frozen banana over teething crackers, and iron-fortified oatmeal and multigrain infant cereal over infant rice cereal are parent-led solutions with immediate benefits for babies. But not all parents will hear this news. FDA must establish protective limits to drive exposures down nationally.

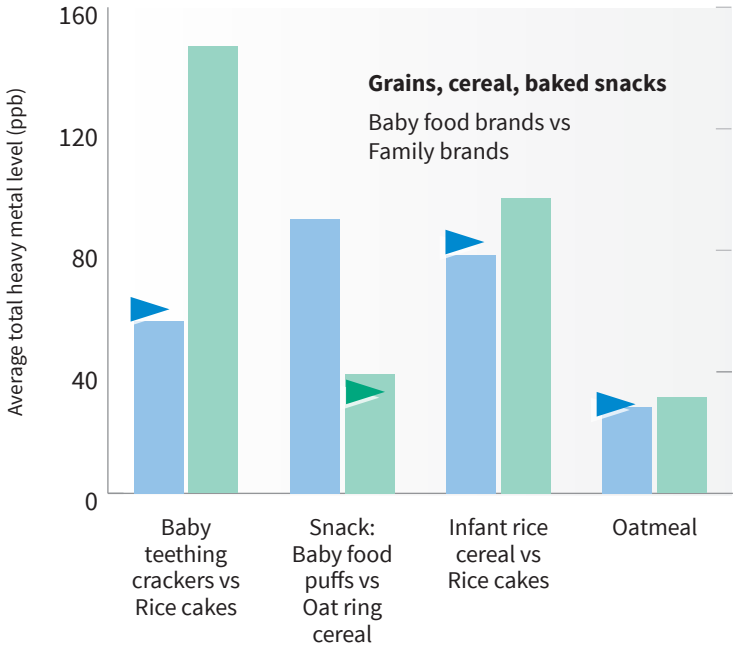
TEST RESULTS: 288 foods

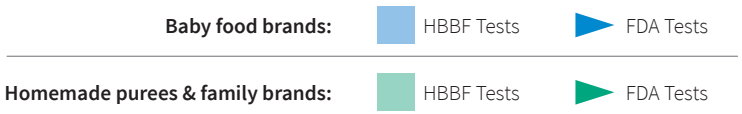
HOW DID THE TESTED FOODS COMPARE?

- Differences between store-bought baby foods and comparable homemade or family brands were often small, exceeding 5 parts per billion (5 ppb) for only four foods in HBBF's tests: carrots, sweet potatoes, rice cereal vs rice, and teething crackers (see Figure 5).
- At the extreme high and low ends of contamination were rice cakes and fresh bananas, with a 82-fold difference in average level of total heavy metals between the two (147 vs 1.8 ppb).
- Generally, in order of contamination from high to low were rice-based foods; other grains; carrots, sweet potatoes, and grape juice; followed by other juices; low-metals vegetables (green beans, peas, squash); and fruit.

Figure 5. Heavy metals contaminate every type of food tested: baby food brands, homemade purees, and family brands







Source: FDA Total Diet Study national market basket tests, 2014-2020 (FDA 2017a, 2020a), and HBBF analysis of 779 samples of baby food and family-style food tested by Brooks Applied Labs, Bothell Washington, for total arsenic, lead, cadmium, mercury, and total solids, 2016-2021. For HBBF tests of fresh and frozen produce, metals levels are adjusted to reflect the impact of pureeing food at home. The adjustment equalizes the moisture content of each pair of foods, mimicking the addition of water to achieve a smoother blend for homemade purees. See Appendix F for details. FDA results are analyzed separately from HBBF tests because FDA's tests are often less sensitive than the analyses from HBBF's commissioned laboratory, with generally higher detection limits that can miss some heavy metal occurrences.

About the 4 toxic heavy metals found in baby food

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. Although many baby foods are contaminated with arsenic, rice-based foods have the highest levels; the grain naturally accumulates arsenic from contaminated soil and irrigation water. Arsenic's most toxic form, inorganic arsenic, is the dominant form in baby food. Studies find lasting impacts when children are exposed to arsenic early in life, including persistent IQ deficits in children exposed to contaminated drinking water and cognitive deficits among school-age children exposed early in life.

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 in 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 impairment still accounts for an estimated 23 million IQ points lost among children under five. Even very low exposure levels cause lower academic achievement, attention deficits, and behavior problems. No safe level of exposure has been identified. HBBF's new tests found lead in 85% of foods tested. FDA's national food testing program finds the highest levels in sweet potatoes, teething biscuits, and cookies.

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 it deserves attention from parents, companies, and regulators, since available published studies show that it also displays a troubling ability to cause harm at low levels of exposure. A 2019 review found convincing evidence that exposures during pregnancy impact children's neurodevelopment, including impaired language development, performance ability, and general cognitive development for children exposed in utero. FDA's national food testing program finds the highest levels in sunflower seeds, spinach, potato chips, and leaf lettuce.

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. Mercury is also found in some other foods babies eat, including infant rice cereal and other grains.

See Appendix G for references and more information.

Food-by-food results and advice for parents

HBBF based our food-by-food recommendations below on an analysis of heavy metal levels in 7,863 samples of baby food and homemade or family-style foods, including 779 foods tested by HBBF and 7,084 samples tested by the U.S. Food and Drug Administration (HBBF 2017, 2019; HBBF-EDF 2022; FDA 2017a, 2020a, 2022a). See Appendix C for a summary of test results. We also considered information from 27 published studies on the impact of washing, cooking, peeling, and crop variety (Appendix E).

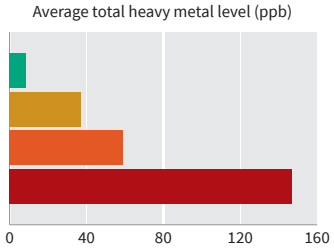
A summary of HBBF's findings for each food group is below. For further information see page 9 (a complete list of foods to eat freely, limit, serve rarely, and avoid for each food group), and Appendix D, which gives details of our analysis.

Teething foods

95% ↓

To relieve teething pain, offer a **frozen banana** instead of **rice-based teething biscuits and rice rusks** for a 95% reduction in total heavy metals.

HBBF tested a variety of teething foods — rice-based teething biscuits, rice cakes, and fresh bananas. Rice cakes stood out as a food to avoid for both children and adults, with higher amounts of inorganic arsenic, the most toxic form of arsenic, than any other food we tested. Baby food teething biscuits had lower metal amounts, but still contain significant levels of arsenic, lead, and cadmium. We recommend avoiding rice-based teething foods altogether and offering a **frozen banana** or a **peeled and chilled cucumber** instead, both of which have far lower metal levels. Parents can also offer a clean, cold wet washcloth or spoon. Healthcare professionals advise parents to stay with their baby regardless of the food or object, to watch for choking.



- Serve: Frozen banana, Peeled chilled cucumber
- Limit: Non-rice teething crackers
- Serve rarely: Rice teething crackers
- Avoid: Rice cakes

TEETHING TIPS:

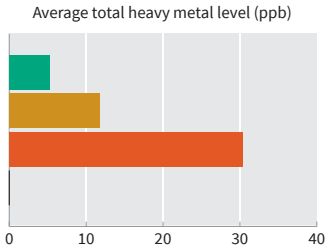
- Offer a peeled, chilled cucumber or frozen banana.
- Try a clean cold wet washcloth or spoon.
- Stay with your baby to watch for any choking.

Fruits

30x ↓

Offer **fresh or frozen (thawed) fruit** (including homemade purees) instead of **canned fruit** for less lead. Tests find lead 30 times more often in canned fruit than in fresh and frozen fruit. **Baby food brand fruit purees** are also recommended.

We tested baby food brands and fresh apples, pears, and bananas, and reviewed FDA data for a wide variety of fruits. Levels in store-bought baby food, homemade purees, and fresh fruit are all low. Higher amounts are found in raisins and canned fruits. Levels in raisins are more than four times the amounts found in grapes. FDA has not tested other dried fruits, but it is expected that the drying process would concentrate heavy metals. Therefore, we recommend serving dried fruit only rarely, for children old enough to handle the tough texture. FDA found lead 30 times more often in canned fruit than in fresh and frozen fruit (HBBF-EDF 2022). We recommend that parents choose fresh fruit over canned. Cantaloupe is rich in nutrients but has more arsenic than other fresh fruits and nearly four times the total heavy metal levels of our recommended, low-metal fruits. Serving it less than daily in rotation with other fruits is our advice. FDA has tested only one other melon, watermelon, which is low in heavy metals.

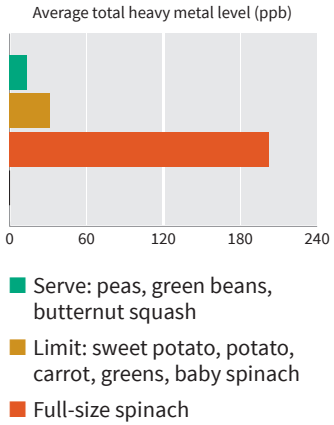


- Serve: baby food, fresh, and frozen fruit
- Limit: canned fruit, cantaloupe
- Serve rarely: dried fruit

■ **Lowest metals**: Serve, eat freely ■ **Moderate metals**: Limit or rotate ■ **High metals**: Serve rarely ■ **Highest metals**: Avoid

Vegetables

43% ↓ Offer a **variety of vegetables** instead of **carrots, potatoes, and sweet potatoes every day** for a 43% reduction in total heavy metals.



HBBF tested baby food purees and homemade purees for five types of vegetables — green beans, peas, squash, carrots, and sweet potatoes. We analyzed FDA's tests for those and many additional vegetables, including potatoes, summer squash, and four types of greens. We reviewed 27 peer-reviewed studies to assess if cooking, washing, and peeling help lower heavy metal levels (Appendix E). And finally, we conducted our own simple kitchen experiments to estimate the benefits of peeling carrots and sweet potatoes (Appendix F). Our review found that at-home actions like peeling and cooking remove heavy metals, with as much as a 17% and 39% reduction in heavy metals for peeling and cooking, respectively, among studies reviewed. But these actions remove nutrients as well, including water-soluble B and C vitamins and up to half of the phytonutrients.

Nearly all peeling studies we identified were conducted outside the U.S. with vegetables grown in unusually contaminated soil. U.S.-based teams at agricultural research centers have only recently launched research to identify low-metal varieties and to understand the impact of peeling on vegetables available in the U.S. (USDA 2022, Villordon 2022). The studies hold promise to inform growers, baby food companies, and consumers on preferred varieties and preparation methods specific to the U.S. market.

Our recommendations for parents: baby food brands, homemade purees, and fresh or frozen vegetables are all recommended. Peas, green beans, and butternut squash are reliably low in heavy metals, in baby food and fresh/frozen forms. We advise that parents choose butternut squash over other squash varieties for both baby food and fresh produce, and baby spinach over regular spinach, for lower metal amounts. Metal levels in carrots, potatoes, and sweet potatoes are relatively high compared to other vegetables; we recommend keeping these nutritious foods in the diet but serving each one less than daily. Because of high spikes in some of the carrots and sweet potatoes tested, we suggest varying the type that you purchase if possible, choosing a different brand or variety or from a different store each week, to avoid serving a high-metals source often. Also because of high spikes, we recommend peeling until U.S.-based research is available to reassess.

SOLUTIONS FOR HEAVY METALS IN CARROTS AND SWEET POTATOES:

Higher heavy metal levels are found in carrots, sweet potatoes, and other root and tuber veggies, compared to most other veggies. Keep these nutritious foods in the diet, but take these steps:

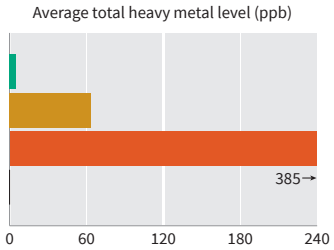
- **Scrub** under tap water to remove soil, which contains metals.
- **Vary what you eat.** Eat each veggie type less than daily; rotate with other vegetables.
- **Vary what you buy** for each of these veggies. Choose from different varieties, brands, or stores from week to week to avoid accidentally eating a high-metals source often.
- **Peeling?** Yes, peel before serving to remove metals that concentrate in the peel.

■ **Lowest metals**: Serve, eat freely ■ **Moderate metals**: Limit or rotate ■ **High metals**: Serve rarely ■ **Highest metals**: Avoid

Meat, beans, eggs, nuts, seeds, and their butters

69% ↓ **Baby food pureed meats** have 69% less lead and inorganic arsenic than peanut butter, on average, and significantly less cadmium as well. But nut butters are nutritious and should remain in the diets of allergy-free children, in rotation with a variety of other protein-rich foods.

Eggs, beans, and baby food brand meat purees tested by HBBF and FDA are low in heavy metals. The nut- and seed-based foods tested, on the other hand (peanuts, peanut butter, and sunflower seeds), are surprisingly high in cadmium, giving them a much higher total heavy metal level than other protein sources. Peanuts and peanut butters are also high in arsenic and lead compared to baby food pureed meats.



- Serve: Baby food brand meats, eggs, home-cooked meat, beans
- Limit: Peanut butter
- Serve rarely: sunflower seed butter

Available research indicates that limited amounts of cadmium absorb into the body after a meal, about 5% for men and 10% for women. Laboratory experiments suggest that absorption may be higher in infancy (Eklund 2003, CDC, 2015), but studies in people have not confirmed this finding. Also absent are studies showing how much more cadmium would be absorbed by an infant deficient in nutrients known to block cadmium.

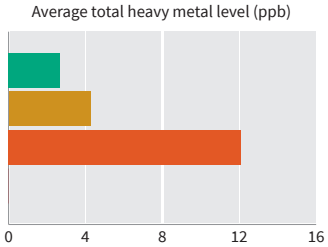
Even marginal deficiencies of certain nutrients can enhance cadmium absorption as much as 10 times (Reeves 2008). Additionally, some studies find absorption rates in adults well above the average, especially among those with a subsistence rice diet (Schaefer 2020, Vesey 2010, Reeves 2008). These uncertainties and data gaps prompted HBBF to advise limiting consumption of high-cadmium foods for now.

Evidence of cadmium's toxicity to the developing brain is compelling but less extensive than that for lead. FDA is undertaking a comprehensive review of cadmium absorption and toxicity in its Closer to Zero program. Until research gaps are filled, we urge caution when it comes to peanut and sunflower seed butters, keeping them in the diet but not as an everyday staple. Walnuts have significantly lower metals levels than peanuts. FDA has tested three or fewer samples of almonds, cashews, tofu, and veggie burgers, and has not tested other forms of non-meat proteins, including other popular seeds and nuts. In choosing protein sources for their children, parents can also take environmental impacts in account. Meat production causes twice the greenhouse gas emissions of plant-based foods, and beef is by far the top contributor (Xu 2021).

Drinks

39% ↓ Offering **tap water** instead of **apple juice** provides a 39% reduction in total heavy metals (assuming national average levels of metals in unfiltered tap water[5]).

Juices are an avoidable source of heavy metals. Apple, pear, and grape juices contain traces of lead and arsenic. Grape juice has notably high levels of both, and pear juice also contains cadmium. Levels in juice aren't as high as in some other foods, but toddlers drink juice often, so it's a top exposure source. Juices are high in calories and sugar and lack fiber and some nutrients found in whole fruit.



- Serve: Infant formula, Tap water tested for lead
- Limit: 100% fruit juice (not grape)
- Serve rarely: Grape juice

The American Academy of Pediatrics recommends no juice for children under 1 and limited amounts of 100% fruit juice after that (AAP 2017a,b). Tap water (for older babies) and whole fruit or fruit purees are better choices. We suggest testing tap water for lead and filtering it if lead is detected, especially during pregnancy or if using it to make infant formula. Testing kits available at leadkit.hbbf.org.

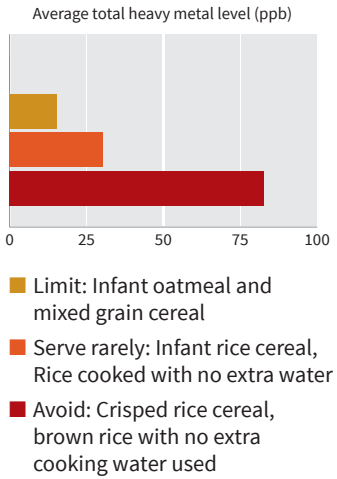
5 HBBF analysis of results from nearly 3,000 tap water tests from homes nationwide. From HBBF's tap water testing initiative (HBBF 2022): "Protect yourself and your family from toxic lead in tap water with a simple kit that provides customized action steps" https://leadkit.hbbf.org/.

■ **Lowest metals**: Serve, eat freely ■ **Moderate metals**: Limit or rotate ■ **High metals**: Serve rarely ■ **Highest metals**: Avoid

Cereal and grains

75% ↓ Offer **infant oatmeal cereal** instead of **infant rice cereal** for a 75% reduction in total heavy metals.

Rice can be grown in ways that cut arsenic uptake in half, but our tests show that this shift hasn't been made. Rice-based foods still have more inorganic arsenic than any other food we have tested. Rice rises to the top as a grain with relatively high heavy metal levels. For babies, we suggest serving oatmeal and multi-grain cereals instead of infant rice cereal. For the family, serving a variety of grains helps reduce metal exposures. Rice should be cooked it in extra water poured off before eating to remove up to 60% of the arsenic (FDA 2022b).



HBBF has called on FDA to reduce the current action level of 100 ppb inorganic arsenic in infant rice cereal to protect babies' neurological development. In setting the current limit 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. Companies have taken infant brown rice cereal off the market and three states have removed infant rice cereal from the Women, Infants, and Children supplemental food program (Oregon, Alaska, and Hawaii) (Bettin 2020, Hawaii WIC 2019, Alaska WIC 2020). The U.S. House Committee on Oversight and Reform has urged USDA to remove infant rice cereal from the WIC program nationally, an action that would encompass all U.S. states and territories and that would protect the more than half of U.S. infants who rely on WIC foods (Krishnamoorthi 2021).

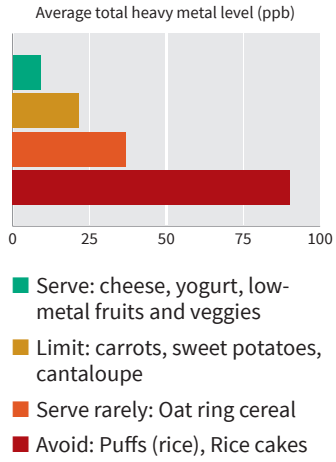
RICE IS HIGH IN ARSENIC: HERE'S HOW TO REDUCE IT.

- **Cook rice in extra water** that you pour off before eating to reduce arsenic levels by up to 60%.
- **Buy lower-arsenic rice**: basmati rice from California, India, and Pakistan. Sushi rice from the U.S. White rice instead of brown.
- **Avoid high-arsenic varieties**: rice from Arkansas, Louisiana, Texas, or simply "U.S."
- **Eat other grains**. Try amaranth, quinoa, buckwheat, millet, and polenta (all gluten-free), or bulgur, barley, and farro (these contain gluten).

Snacks

95% ↓ Offer **healthy low-metal snacks** instead of **baby food puffs** (rice-based) for a 95% reduction in total heavy metals. See page 10 for the list.

Baby-food puffs have 18 times more heavy metals than other baby-friendly snacks, on average. Baby-friendly snacks that are low in metals include apples, unsweetened applesauce, bananas, beans, cheese, grapes (cut in half), hard-boiled eggs, peaches, and yogurt.



Lowest metals: Serve, eat freely **Moderate metals**: Limit or rotate **High metals**: Serve rarely **Highest metals**: Avoid

SECTION 3.

What companies can do about toxic heavy metals in the foods babies eat

Food companies can make changes to significantly lower levels of heavy metals in their products. Effective steps include:

Require growers to follow accepted best practices.

Growers applying best agricultural practices can reduce levels of heavy metals in vegetables, fruits, and grains. Basic steps including testing soil and water for heavy metals and avoiding fields with high levels or with a history of metals contamination, including fields with a history of flooding, which can leave behind contaminated sediment. Growers can use irrigation water with low metal levels. They can also optimize soil pH, mineral levels, and soil organic content to reduce heavy metal uptake by plants.

Best practices vary by crop. To minimize cadmium uptake by spinach, for example, the crop can be grown in soils with less than 1 ppm cadmium, using zinc fertilizer (when zinc is plentiful, the plants absorb it instead of cadmium), and with lime and compost applied, which decrease cadmium mobility in soil (USDA 2022).

When agricultural researchers at Louisiana State University follow best practices for growing sweet potatoes, metal levels are so low they meet bottled water standards (C&EN 2021). Heavy metal concentrations in sweet potatoes tested by HBBF were far higher, with lead and arsenic amounts up to 6 times higher than water limits, suggesting that growers do not always follow best practices.

There is no legal limit for heavy metals in sweet potatoes, and it is not mandatory to follow known best practices. But baby food companies and other food manufacturers and retailers could certainly require it of suppliers.

Require suppliers to test crops.

Heavy metal levels can vary widely based on the crop variety, a field's soil and water chemistry, and other growing conditions. As a result, levels will vary widely by supplier. Gerber reported a 7.5-fold difference in cadmium content of carrot ingredients, on average, between suppliers with high cadmium carrots (two suppliers) versus amounts reported for the remaining four suppliers (Gerber 2019). All levels reported are legal — cadmium is not yet regulated in carrots — but Gerber and other companies could choose to buy from suppliers that regularly report lower amounts of cadmium and other heavy metals.

Reduce arsenic in rice by changing field flooding cycles.

Ten years of sustained research shows that rice absorbs less arsenic when growers alternately wet and dry the field or use raised beds separated by furrows, instead of maintaining a constant flooded state (e.g., Somenahally 2011). These changes can reduce total arsenic concentrations in the rice grain as much as 50%, depending on the amount of time the field remains dry (Das 2016).

Growing rice varieties in excessively dry conditions drives arsenic concentrations down even further. A two-year trial of brown rice in Texas found a 20-fold arsenic reduction for extremely dry versus flooded conditions, with a substantial reduction in arsenic for all 1,763 rice varieties tested and with total arsenic for all but 3 varieties averaging below 100 ppb (Pinson 2015), FDA's action level for inorganic arsenic in infant rice cereal (FDA 2020b).

These studies show that yield drops along with arsenic as periods of dryness are extended. Growers

are nevertheless finding a workable balance between the competing goals of high yield and low arsenic. From 2016 to 2020, Arkansas growers doubled the acreage using reduced flooding times from 1 in every 12 acres to 1 in every 6 (8 to 16%) (USDA 2022). Progress will continue as even more farms shift to growing current U.S. rice varieties with these production systems that reduce flood times, reducing grain arsenic with the added benefit of saving water. Food companies can create incentives for more rapid change by setting field conversion as a condition for suppliers and growers.

Buy ingredients grown in locations known to produce less contaminated crops.

Food companies can avoid buying crops grown in areas with a history of metal contamination or with naturally occurring higher metal levels in soil or irrigation water. For example, companies can avoid areas with cadmium-rich soils like California's Salinas Valley for crops like spinach known to accumulate cadmium (USDA 2022). Former orchards where now-banned lead arsenate pesticides were used can also be avoided, to prevent issues like lead-contaminated carrots grown in former orchards in Michigan and Washington where toxic heavy metals still contaminate the soil (Codling 2014). In 2012, Gerber began sourcing lower arsenic rice based on availability in the market. Since then, Gerber has developed a sourcing strategy to procure lower arsenic rice and is working with suppliers to implement alternate growing and irrigation practices (Gerber 2012, Watson 2022).

HBBF's tests suggest that some growers may be ignoring background contamination problems. For example, although we tested only 11 fresh sweet potatoes, we found a 19-fold difference in average lead levels between two groups of these vegetables, 4 that stood out with far higher lead levels than the 7 remaining samples, which had quite low levels (50.5 ppb versus 2.7 ppb, on average) (Appendix A). High-metals sweet potatoes increase health risks for consumers and suggest that growers are not optimizing the location and growing conditions of their crops.

Choose varieties known to uptake lower amounts of heavy metals.

Available research shows variability in the amounts of metals that different cultivars or varieties of crops absorb from soil and water. Significant research efforts are underway to identify existing low-metal varieties and to develop new variants with optimum traits to exclude metals.

Researchers are developing wheat varieties that accumulate less cadmium, relying on advanced genomic and phenotyping technologies (Liu 2019a). UC Davis scientists are breeding spinach that uptakes less cadmium (Melotto 2020). USDA and academic research teams are testing 726 types of carrots and 90 spinach cultivars to find metal-excluding varieties. The carrot research uncovered a 10-fold variation in arsenic uptake and effective off-the-shelf varieties currently available to growers. The research team found a 30-fold variation in cadmium uptake, but will need time to breed the best performers, which aren't yet commercially available. The spinach research showed a 3-fold variation in cadmium uptake among varieties tested and far lower cadmium levels in younger spinach (USDA 2022). New studies are also uncovering differences in metal uptake among sweet potato cultivars, with further study planned (Villordon 2022).

Research on genetic variations in rice also promises change. Researchers found a 13-fold difference in arsenic uptake among 1,763 rice varieties tested in a trial that revealed numerous high-performing varieties (Pinson 2015). Among the better performers are so-called "excluders" that preferentially sequester arsenic in leaves over the grain, resulting in lower amounts in rice (Heuschele 2017). All 10 main rice varieties grown in the U.S. are among these excluder varieties, but gains are possible for rice grown in other countries: 11 genes in U.S. rice are now known to be linked to low grain arsenic and can power further improvement worldwide (USDA 2022).

To the extent that these diverse investigations reveal low-metal varieties already commercially available, growers can put the findings into action right away to increase the availability of fruits, vegetables, and grains that are lower in heavy metals.

Invest in research needed to identify and evaluate methods to reduce heavy metals in products and ingredients.

Companies should not wait for federally funded research to reveal solutions. They should invest in their own initiatives to accelerate the development of solutions and best practices.

SECTION 4.

What the federal government should do about toxic heavy metals in the foods babies eat

In April 2021, FDA responded to the problem by announcing its Closer to Zero action plan "to reduce exposure to arsenic, lead, cadmium, and mercury from foods eaten by babies and young children — to as low as possible" (FDA 2021a).

HBBF celebrated FDA's response to the attention that Congress, Consumer Reports, HBBF and other organizations have all brought to this issue. We appreciated the FDA's stated commitment to continuous progress towards zero because toxic heavy metals like lead and arsenic don't have a safe threshold — another way of stating that there is no safe level of exposure. Every agricultural research finding on safer cultivars, growing locations, and growing and processing practices can be adopted by the food industry to lower the levels in food and better protect babies' developing brains.

> *"No safe level of lead exposure has yet been identified for children's health."*
>
> U.S. Food and Drug Administration (Flannery 2020)

But now, more than a year later, FDA missed its first Closer to Zero commitment. April 2022 has come and gone, and we do not have the proposed action levels for lead in the foods babies eat. And the proposed draft action levels for lead in juices that FDA released in April 2022 (FDA 2022c) are not tight enough to make juice less contaminated.

To make the promise of Closer to Zero a reality, FDA must:

Accelerate Closer to Zero's timeline and meet each deadline.

For every day that passes, nearly 10,000 more babies in the U.S. begin eating solid food. For lead and arsenic, the timeline proposes final standards two or more years from now. For cadmium and mercury no date has been specified. Closer to Zero has already missed its first promised deadline: instead of proposing action levels for lead in baby food in April 2022 as promised (FDA 2021a), FDA instead sent its proposal to the White House OMB in April, to comply with a required review that can take many months. FDA's internal workplan must be revised to meet a new, more aggressive timeline to protect babies. OMB must work with FDA to meet the timeline.

Account for additive impacts of multiple toxic metals.

To date, FDA has proposed only four standards for single metals in single foods — arsenic in infant rice cereal, lead and arsenic in apple juice, and lead in other juices. But HBBF's 2019 study shows that one-fourth of all baby foods contain all four toxic heavy metals — arsenic lead cadmium and mercury (HBBF 2019). FDA's own recent developmental neurotoxicity research confirms additive impacts of these metals (e.g., Hunt 2018). Even a single food can drive excess exposure for a young child.

Take into account risks for children with the highest exposures to heavy metals, including exposures from non-food sources.

Ensuring equity is crucial to FDA's Closer to Zero mission to "reduce exposure to toxic elements from foods eaten by babies and young children to as low as possible" (FDA 2021a). Closer to Zero action levels need to be low enough to protect children with prenatal and early life exposures from all sources. The lead in juice action level must be revised to protect children with the highest levels of lead exposure.

Issue standards driven by what is necessary to protect children's neurodevelopment.

FDA's first metals limits for baby food (for juice and infant rice cereal) did not account for the harm to children's neurological development. Instead, the agency appeared to "cater to the needs of the industry" (CSPI 2022, HBBF 2016). Current sourcing, farming, and processing practices have all failed to protect children and should not drive safety standards for baby food. History shows that when FDA acts, the food industry can respond to reduce levels. FDA's Total Diet Study shows that in recent years arsenic levels have dropped in the two foods for which FDA has issued action levels, falling 45% in infant rice cereal and 61% in apple juice, simply through changes in sourcing and farming practices (HBBF 2019, FDA 2017, 2020).

Issue standards driven by what is needed to protect babies' brains, not by conjectures of supply issues or nutritional deficits.

Experience shows that when new standards go into place, the market adapts. When the State of Oregon removed infant rice cereal from its Women, Infants and Children program in 2016 — a program available to about half of the babies in the state — fortified alternate cereals remained readily available, at an equivalent price point. There were no reported supply issues or gaps in nutrition for babies (Bettin 2021). This experience shows that manufacturers and vendors can adapt to new standards with nutritious, cost-effective alternatives.

Strengthen the three action levels issued thus far in the Closer to Zero program.

FDA must provide a strong precedent for action levels still to come. All four action levels are weak, largely reflecting limits companies are already meeting instead of advancing change. Between 90 and 97% of foods tested already complied when the levels were issued:

- Over 90% of infant rice cereals HBBF has tested since 2019 meet FDA's 2022 guidance level of 100 ppb inorganic arsenic, suggesting that lower-arsenic sources are available.
- 97% of apple juice samples FDA has tested since 2014 are below the newly proposed 10 ppb cap for lead, again suggesting the widespread availability of low-lead sources that would allow for a far more protective limit.
- 96% of samples of other (non-apple) juices FDA has tested since 2014 fall below FDA's newly proposed lead limit of 20 ppb, a clear signal that the limit is far higher than is currently feasible.

If FDA continues to set limits that the industry is already achieving, it will never meet its goal of reducing exposures to as low as possible. We recommend establishing limits at the amount that 80% of samples currently meet, to spur companies to identify the cleanest sources and develop best practices across their supply chains that drive levels down. This, combined with FDA regularly updating limits as improvements are made, would continually nudge market-wide levels closer to zero.

Lastly, the White House's Office of Management and Budget should expedite review of FDA proposals that emerge from the Closer to Zero program. OMB must comply with the mandatory maximum review window of 90 days required under Executive Order 13563 (OMB 2022). Holding up FDA's work for months has a consequence — babies face continuing high exposures to heavy metals for the duration of OMB's delay.

Rapid action by FDA and OMB will go a long way toward protecting children from toxic heavy metals in the foods they consume.

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APPENDIX A:

Laboratory test results for heavy metals

Results for analysis of heavy metals in a variety of packaged baby foods, fresh produce, and family-brand 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. Attachment B 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.

Shoppers participating in this study purchased pairs of food, a baby food brand and the corresponding family brand or fresh/frozen/canned food. Each food pair is shown together below, with a sample number ending in "A" for the baby food brand and "F" for the corresponding "family" food.

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 "*" 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.

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H1-01A	Gerber	Apple - Organic, Supported Sitter 1st Foods	Apple - baby food	13.35	1.4*	--	2.4	<0.6	<0.8	Philadelphia, PA	ACME Markets
H1-01F	Not available	Apple - Red Delicious	Apple- fresh produce	12.98	<1	--	<0.4	<0.6	<0.8	Philadelphia, PA	ACME Markets
H1-03A	HappyBABY	Sweet Potatoes - Organic, Clearly Crafted, Stage 1	Sweet potato - baby food	11.35	5.9	--	1.3*	0.6*	<0.8	Philadelphia, PA	ACME Markets
H1-03F	Not available	Yam - Sweet Golden, USA	Sweet potato / Yam - fresh produce	17.56	1.3*	--	55.4	6.9	<0.8	Philadelphia, PA	ACME Markets
H1-05A	Gerber	Rice Cereal - Organic Single-Grain, Supported Sitter 1st Foods	Infant rice cereal	--	57.2	--	5.9	4.8	<1.6	Philadelphia, PA	ACME Markets
H1-05F	Signature Select	Enriched Long Grain Rice	White rice - family brand	--	163	81.5	<0.9	16.2	3.5*	Philadelphia, PA	ACME Markets
H11-01A	Gerber	Apple - Organic, Supported Sitter 1st Foods	Apple - baby food	12.79	2.4*	--	0.9*	<0.6	<0.8	Little Rock, AR	Kroger
H11-01F	Not available	Apple - Gala	Apple- fresh produce	13.9	<1.1	--	<0.5	<0.6	<0.9	Little Rock, AR	Kroger
H11-03A	Beech-Nut	Sweet Peas - Stage 2	Peas - baby food	13.47	<1.1	--	1.8	0.9*	<0.8	Little Rock, AR	Kroger
H11-03F	Simple Truth Organic	Green Peas - Organic, Frozen	Peas - frozen	22.85	<1.1	--	1.8	<0.6	<0.9	Little Rock, AR	Kroger
H11-05A	Gerber	100% Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.5	--	1.3	<0.3	<0.4	Little Rock, AR	Kroger
H11-05F	Kroger	100% Apple Juice from Concentrate	Apple juice - family brand	--	1.2*	--	5.5	<0.3	<0.4	Little Rock, AR	Kroger
H12-01A	Gerber	Apple with Vitamin C - Natural, Supported Sitter 1st Foods	Apple - baby food	12.32	<1.1	--	<0.5	<0.6	<0.9	Miami, FL	Winn-Dixie
H12-01F	Not available	Apple - Gala	Apple- fresh produce	12.42	<1.1	--	<0.5	<0.6	<0.8	Miami, FL	Winn-Dixie
H12-03A	Gerber	Pea - Organic, Support Sitter 1st Foods	Peas - baby food	16	<1.1	--	1.9	0.7*	<0.9	Miami, FL	Winn-Dixie

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H12-03F	SE Grocers	Green Peas - Frozen	Peas - frozen	23.4	<1.1	--	3.5	2.1	<0.8	Miami, FL	Winn-Dixie
H12-05A	Gerber	100% Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.9	--	1.2	<0.3	<0.3	Miami, FL	Winn-Dixie
H12-05F	Mott's	100% Apple Juice from Concentrate with Added Vitamin C	Apple juice - family brand	--	4	--	0.6*	<0.3	<0.3	Miami, FL	Winn-Dixie
H13-01A	Gerber	Banana with Vitamin C - Natural, Supported Sitter 1st Foods	Banana - baby food	21.6	<1.1	--	<0.5	<0.6	<0.8	Washington, DC	Harris Teeter
H13-01F	Chiquita	Banana - Organic, Ecuador	Banana- fresh produce	24.58	<1.1	--	0.9*	<0.6	<0.9	Washington, DC	Giant Food
H13-04A	Beech-Nut	Green Beans - Naturals Stage 1	Green beans - baby food	6.82	<1	--	1.8	0.7*	<0.8	Washington, DC	Harris Teeter
H13-04F	Simple Truth Organic	Green Beans - Organic, Frozen	Green beans - frozen	7.06	<1	--	1.2*	<0.6	<0.8	Washington, DC	Harris Teeter
H13-06A	Gerber	Pear Juice from Concentrate - Toddler	Pear juice - baby food	--	2.7	--	0.5*	0.6*	<0.4	Washington, DC	Harris Teeter
H13-06F	Looza	Pear Juice Drink from Concentrate	Pear juice - family brand	--	0.5*	--	0.7	0.4*	<0.3	Washington, DC	Harris Teeter
H14-01A	Gerber	Banana - Natural for Baby, Sitter 2nd Food	Banana - baby food	22.12	<1.1	--	<0.5	<0.6	<0.9	Cincinnati, OH	Kroger
H14-01F	Chiquita	Banana - Panama	Banana- fresh produce	22.24	<1.1	--	<0.5	<0.6	<0.9	Cincinnati, OH	Kroger
H14-04A	Gerber	Green Bean - Natural for Baby, Supported Sitter 1st Foods	Green beans - baby food	10.07	1.1*	--	1.2*	1.7	<0.8	Cincinnati, OH	Kroger
H14-04F	Birds Eye	Green Beans - Steamfresh Cut, Frozen	Green beans - frozen	8.29	9	--	22.4	<0.6	<0.9	Cincinnati, OH	Kroger
H14-06A	Gerber	White Grape Juice - 100% Juice Variety Pack, Toddler	Grape juice - baby food	--	12.5	9.15	5.6	<0.2	<0.3	Cincinnati, OH	Kroger
H14-06F	Kroger	100% White Grape Juice from Concentrate - No Sugar Added	Grape juice - family brand	--	7.3	--	5.9	<0.2	<0.3	Cincinnati, OH	Kroger
H15-08A	Gerber	Pear - Natural for Baby, Supported Sitter 1st Foods	Pear - baby food	14.85	6.4	--	1.1*	0.7*	<0.9	Charlottesville, VA	Wegmans
H15-08F	Not available	Pear - Bartlett, California	Pear- fresh produce	14.94	<1.1	--	<0.5	0.8*	<0.8	Charlottesville, VA	Wegmans
H15-09A	Earth's Best	Winter Squash - Organic Stage 2, 6+ months	Squash - baby food	8.79	<1.1	--	1*	0.6*	<0.8	Charlottesville, VA	Wegmans
H15-09F	Not available	Acorn Squash - Pennsylvania	Squash- fresh produce	12.09	<1.1	--	2.7	4.7	<0.9	Charlottesville, VA	Wegmans
H15-11A	Beech-Nut	Oatmeal - Whole Grain Cereal	Oatmeal - baby food	--	18.6	--	1.7*	10.5	<1.7	Charlottesville, VA	Wegmans
H15-11F	Simple Truth Organic	Oatmeal - Original Instant, Organic	Oatmeal - family brand	--	6.9*	--	<1	12.8	<1.8	Charlottesville, VA	Wegmans
H15-13A	Gerber	Pear Juice from Concentrate - Toddler	Pear juice - baby food	--	2.6	--	0.6*	1.1	<0.4	Charlottesville, VA	Wegmans
H15-13F	R.W. Knudsen	Pear Juice - Organic	Pear juice - family brand	--	8.5	--	0.8	<0.3	<0.4	Charlottesville, VA	Wegmans
H15-15A	Gerber	Teethers - Banana Peach, 7+ Months	Teething biscuit/rusk - baby food	--	73.7	--	3.7	10.7	2.3*	Charlottesville, VA	Wegmans
H15-15F	Quaker	Rice Cakes - Lightly Salted	Rice cake - family brand	--	187	--	1.9*	18.9	3.8*	Charlottesville, VA	Wegmans
H17-01A	Beech-Nut	Apple - Organics Stage 1	Apple - baby food	13.73	1.5*	--	0.5*	<0.6	<0.9	Milwaukee, WI	Pick 'n Save
H17-01F	GMI Orchards	Gala - USA	Apple- fresh produce	11.95	2*	--	<0.5	<0.6	<0.9	Milwaukee, WI	Pick 'n Save
H17-03A	Plum Organics	Just Sweet Potato - Stage 1, 4 months & up	Sweet potato - baby food	11.86	3.4*	--	18.2	2.7	<0.9	Milwaukee, WI	Pick 'n Save
H17-03F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	17.56	<1.1	--	2.7	4.3	<0.9	Milwaukee, WI	Pick 'n Save
H17-05A	Gerber	Puffs	Puff snack - baby food	--	49.7	--	1.5*	19.7	<1.6	Milwaukee, WI	Pick 'n Save
H17-05F	General Mills	Cheerios - 100% Whole Grain Oats	Oat-ring cereal - family brand	--	34.1	20	4.7	20.8	<1.8	Milwaukee, WI	Pick 'n Save
H19-01A	Gerber	Carrot - Organic, Supported Sitter 1st Foods	Carrot - baby food	9.31	2.4*	--	1.1*	1.9	<0.8	Atlanta, GA	Kroger
H19-01F	Simple Truth Organic	Whole Carrots	Carrot- fresh produce	10.4	1.8*	--	1.6	29.3	<0.8	Atlanta, GA	Kroger

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H19-02A	Beech-Nut	Butternut Squash - Naturals Stage 1	Squash - baby food	6.36	<1.1	--	0.7*	<0.6	<0.9	Atlanta, GA	Kroger
H19-02F	Not available	Butternut Squash	Squash- fresh produce	12.08	1.3*	--	1.3*	0.7*	<0.9	Atlanta, GA	Kroger
H19-06A	Gerber	Arrowroot Biscuits - Crawler	Teether crackers non-rice - baby food/- family food	--	<2.1	--	2.3*	13.2	<1.7	Atlanta, GA	Kroger
H19-06F	Quaker	Rice Cakes - Lightly Salted, 100% Whole Grain	Rice cake - family brand	--	196	--	2.1*	14.7	3.4*	Atlanta, GA	Kroger
H20-01A	Gerber	Carrot - Natural for Baby, Sitter 2nd Foods	Carrot - baby food	8.33	<1.1	--	8.8	25.8	<0.9	Providence, RI	Price Rite
H20-01F	Vegco	Carrots - Canada	Carrot- fresh produce	8.5	3.8*	--	11.8	30.6	<0.8	Providence, RI	Price Rite
H20-03A	Gerber	Peas - Natural for Baby, Sitter 2nd Food	Peas - baby food	10.7	<1	--	<0.4	1*	<0.8	Providence, RI	Price Rite
H20-03F	Shop Rite	Sweet Green Peas - Frozen	Peas - frozen	22.32	<1	--	1.8	1.1*	<0.8	Providence, RI	Price Rite
H20-06A	HappyBABY	Teethers - Organic, Sweet Potatoes and Bananas	Teething biscuit/rusk - baby food	--	95	53	2.4*	12.6	<1.8	Providence, RI	Price Rite
H20-06F	Shop Rite	Rice Cakes - Lightly Salted, 10g Whole Grain - Fat Free	Rice cake - family brand	--	193	--	3.2	10.3	2.5*	Providence, RI	Price Rite
H23-01A	Gerber	Sweet Potato - Supported Sitter 1st Foods	Sweet potato - baby food	15.38	2.5*	--	19.6	4.3	<0.8	Salt Lake City, UT	WalMart
H23-01F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	11.82	1.3*	--	3.3	12.8	<0.8	Salt Lake City, UT	WalMart
H23-04A	Gerber	Green Beans - Supported Sitter 1st Foods	Green beans - baby food	8.86	<1	--	2.2	1.2*	<0.8	Salt Lake City, UT	WalMart
H23-04F	Marketside	Green Beans - Fresh	Green beans - fresh produce	7.36	1.4*	--	2.3	<0.6	<0.8	Salt Lake City, UT	WalMart
H24-01A	Beech-Nut	Sweet Potato - Organics Stage 1	Sweet potato - baby food	14.17	6.2	--	8.4	2.9	<0.9	Charleston, SC	Food Lion
H24-01F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	18.79	30.8	--	44.3	6.9	<0.9	Charleston, SC	Food Lion
H24-03A	Gerber	Pea - Supported Sitter 1st Foods	Peas - baby food	11.08	<1.1	--	1.6	<0.6	<0.8	Charleston, SC	Food Lion
H24-03F	Food Lion	Tiny Green Peas - Frozen	Peas - frozen	20.93	1.1*	--	1.9	3.7	<0.8	Charleston, SC	Food Lion
H24-05A	Gerber	Rice Cereal - Single Grain, Supported Sitter 1st Foods	Infant rice cereal	--	122	64.8	4.9	6.3	1.7*	Charleston, SC	Food Lion
H24-05F	Nature's Promise	Long Grain White Rice	White rice - family brand	--	19.5	--	3.3	4.4	<1.4	Charleston, SC	Food Lion
H25-02A	Beech-Nut	Carrots - Naturals Stage 1	Carrot - baby food	7.63	<1.1	--	1.7	9.2	<0.9	Washington, DC	Safeway
H25-02F	Not available	Carrots - Organic	Carrot- fresh produce	12.39	9	--	2.5	11.7	<0.8	Washington, DC	Safeway
H25-04A	Beech-Nut	Green Beans - Naturals Stage 1	Green beans - baby food	5.95	1.3*	--	2.6	0.7*	<0.8	Washington, DC	Safeway
H25-04F	Hanover	Green Beans - Whole, Frozen	Green beans - frozen	7.67	<1.1	--	1.6	<0.6	<0.9	Washington, DC	Safeway
H25-05A	Gerber	Oatmeal - Single Grain, Supported Sitter 1st Foods	Oatmeal - baby food	--	13.8	--	4.4	15.3	<1.8	Washington, DC	Safeway
H25-05F	O Organics	Oats - Organic Steel Cut	Oatmeal - family brand	--	7*	--	1.1*	8.9	<1.5	Washington, DC	Safeway
H26-02A	Gerber	Carrot - Organic, Supported Sitter 1st Foods	Carrot - baby food	9.19	2.5*	--	1.8	3	<0.8	Fort Collins, CO	King Soopers
H26-02F	Not available	Carrots	Carrot- fresh produce	9.83	3.1*	--	7	12.6	<0.9	Fort Collins, CO	King Soopers
H26-04A	Beech-Nut	Green Beans - Naturals Stage 1	Green beans - baby food	6.5	<1	--	1*	<0.6	<0.8	Fort Collins, CO	King Soopers
H26-04F	Best Choice	Green Beans - Cut, Frozen, USA	Green beans - frozen	6.09	<1	--	0.8*	<0.6	<0.8	Fort Collins, CO	Hay's Market
H26-05A	Gerber	Oatmeal - Single Grain, Supported Sitter 1st Foods	Oatmeal - baby food	--	12.2	--	4.3	15	<1.8	Fort Collins, CO	King Soopers
H26-05F	Kroger	Oats - 100% Whole Grain, Quick 1 minute	Oatmeal - family brand	--	21.8	--	<0.7	19.6	<1.3	Fort Collins, CO	King Soopers
H27-02A	Earth's Best	Carrots - Organic, 6+ Months	Carrot - baby food	8.13	4.9	--	2.1	12.8	<0.7	Portland, OR	Fred Meyer
H27-02F	Not available	Carrots - Organic	Carrot- fresh produce	14.12	7	--	1.5	63.7	<0.9	Portland, OR	Fred Meyer
H27-04A	HappyBABY	Green Beans - Organic Stage 1	Green beans - baby food	6.85	<1.1	--	1.5	1*	<0.8	Portland, OR	Fred Meyer

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H27-04F	Kroger	Green Beans - Italian Cut, Frozen	Green beans - frozen	8.34	<1.1	--	4.5	1.1*	<0.9	Portland, OR	Fred Meyer
H27-05A	Earth's Best	Oatmeal Cereal - Organic Whole Grain	Oatmeal - baby food	--	8.4*	--	28.9	6.8	<1.8	Portland, OR	Fred Meyer
H27-05F	Kroger	Original Oats Instant Oatmeal	Oatmeal - family brand	--	30.9	25.2	2.7*	37.8	<1.7	Portland, OR	Fred Meyer
H28-01A	Wild Harvest	Applesauce - Organic	Apple - baby food	14.18	4.5*	--	1.6	<0.6	<0.8	Minneapolis, MN	Cub Foods
H28-01F	Not available	Apple - Honeycrisp	Apple- fresh produce	11.79	1.5*	--	<0.5	<0.6	<0.9	Minneapolis, MN	Cub Foods
H28-03A	Wild Harvest	Squash - Organic, 6 months and up	Squash - baby food	5.9	3.8*	--	3	<0.6	<0.9	Minneapolis, MN	Cub Foods
H28-03F	Not available	Butternut Squash	Squash- fresh produce	17.81	<1.1	--	0.6*	<0.6	<0.8	Minneapolis, MN	Cub Foods
H28-05A	Gerber	Rice Cereal - Single-Grain, Supported Sitter 1st Foods	Infant rice cereal	--	103	--	5.6	10.2	2.5*	Minneapolis, MN	Cub Foods
H28-05F	Essential Everyday	White Rice	White rice - family brand	--	182	84.7	2.1*	20.2	3.7*	Minneapolis, MN	Cub Foods
H28-08A	Gerber	Pear - Supported Sitter 1st Foods	Pear - baby food	15.24	3.4*	--	0.8*	1.9	<0.9	Minneapolis, MN	Cub Foods
H28-08F	Not available	Pear - Bartlett	Pear- fresh produce	14.17	<1	--	0.5*	<0.6	<0.8	Minneapolis, MN	Cub Foods
H28-09A	Tippy Toes	Squash - Stage 2, 6 months and up	Squash - baby food	7.89	<1.1	--	<0.5	1.1*	<0.9	Minneapolis, MN	Cub Foods
H28-09F	Not available	Butternut Squash - Organic	Squash- fresh produce	9.88	<1	--	0.8*	1.2*	<0.8	Minneapolis, MN	Cub Foods
H28-11A	Gerber	Oatmeal - Single Grain, Supported Sitter 1st Foods	Oatmeal - baby food	--	12.6	--	4.1	12.7	<1.7	Minneapolis, MN	Cub Foods
H28-11F	Hyvee	Steel Cut Oats - 100% Whole Grain Cereal	Oatmeal - family brand	--	8.4*	--	1.2*	8.5	<1.8	Minneapolis, MN	Cub Foods
H28-13A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.4	--	1.1	<0.3	<0.3	Minneapolis, MN	Cub Foods
H28-13F	Hyvee	Apple Juice - 100% Premium, Fresh Pressed, Not from Concentrate	Apple juice - family brand	--	5.4	--	6.5	<0.3	<0.4	Minneapolis, MN	Cub Foods
H28-15A	HappyBABY	Teethers - Organic, Blueberries and Purple Carrot	Teething biscuit/rusk - baby food	--	51.5	--	9.1	14.3	<1.5	Minneapolis, MN	Cub Foods
H28-15F	Full Circle Market	Multigrain Rice Cakes - Organic	Rice cake - family brand	--	355	155	1.7*	11	<1.7	Minneapolis, MN	Cub Foods
H3-01A	Beech-Nut	Apple - Naturals Stage 1	Apple - baby food	14.73	<1	--	1.2*	<0.6	<0.8	Washington, DC	Wegmans
H3-01F	Not available	Apple - Granny Smith	Apple- fresh produce	11.66	3.1*	--	1*	<0.6	<0.9	Washington, DC	Wegmans
H3-05A	Gerber	Rice Cereal - Single-Grain, Supported Sitter 1st Foods	Infant rice cereal	--	94.2	--	3.1	9.5	<1.7	Washington, DC	Wegmans
H3-05F	Wegmans	White Rice - Jasmine, Organic	White rice - family brand	--	139	--	1.6*	11.9	4.1*	Washington, DC	Wegmans
H32-01A	Gerber	Banana - Natural, Supported Sitter 1st Foods	Banana - baby food	21.4	<1	--	<0.4	<0.5	<0.8	Chicago, IL	Jewel (Albertson's)
H32-01F	Del Monte	Banana	Banana- fresh produce	18.3	<1.1	--	0.8*	<0.6	<0.9	Chicago, IL	Jewel (Albertson's)
H32-03A	Gerber	Carrot - Natural, Supported Sitter 1st Food	Carrot - baby food	9.21	1.9*	--	0.7*	1.8	<0.8	Chicago, IL	Jewel (Albertson's)
H32-03F	Signature Select	Carrots - Baby-Cut, Peeled	Carrot- fresh produce	7.67	15.1	11.8	4.8	6.2	<0.9	Chicago, IL	Jewel (Albertson's)
H32-05A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.8	--	1.2	<0.3	<0.3	Chicago, IL	Jewel (Albertson's)
H32-05F	Mott's	100% Apple Juice from Concentrate with Added Vitamin C	Apple juice - family brand	--	3.5	--	1.5	<0.3	<0.3	Chicago, IL	Jewel (Albertson's)
H33-01A	Gerber	Banana with Vitamin C - Natural, Sitter 2nd Foods	Banana - baby food	21.69	<1	--	<0.5	<0.6	<0.8	San Francisco, CA	Andronico's Community Market/ owned by Safeway
H33-01F	Dell Corp	Banana - Equador	Banana- fresh produce	23.37	<1.1	--	<0.5	<0.6	<0.9	San Francisco, CA	Sunday Inner Sunset Farmers Market
H33-03A	HappyBABY	Carrots - Stage 1	Carrot - baby food	7.75	3.2*	--	3.4	5.9	<0.8	San Francisco, CA	Andronico's Community Market/ owned by Safeway

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H33-03F	Fifth Crow (organic grower)	Carrots - Organic	Carrot- fresh produce	13.52	1.1*	--	1.1*	16.8	<0.9	San Francisco, CA	Sunday Inner Sunset Farmers Market
H34-02A	Beech-Nut	Pear - Organics Stage 1	Pear - baby food	15.1	2.6*	--	2.2	0.9*	<0.9	Schenectady, NY	Price Chopper
H34-02F	Not available	Pear - Bartlett	Pear- fresh produce	12.4	<1	--	<0.4	2	<0.8	Schenectady, NY	Price Chopper
H34-04A	Beech-Nut	Green Beans - Naturals Stage 1	Green beans - baby food	6.24	<1.1	--	2	<0.6	<0.8	Schenectady, NY	Price Chopper
H34-04F	Full Circle Market	Green Beans - Organic, Frozen	Green beans - frozen	7.77	<1.1	--	4.1	<0.6	<0.9	Schenectady, NY	Price Chopper
H34-06A	Gerber	100% White Grape Juice from Concentrate - Unsweetened	Grape juice - baby food	--	11.1	--	4.8	<0.2	<0.3	Schenectady, NY	Price Chopper
H34-06F	Welch's	100% Grape Juice - No Sugar Added	Grape juice - family brand	--	11	--	10.5	0.4*	<0.3	Schenectady, NY	Price Chopper
H35-05A	Gerber	Apple Juice - 100% Juice Variety Pack - Toddler	Apple juice - baby food	--	3.7	--	1.4	<0.3	<0.4	Madison, WI	Festival Foods
H35-05F	Simply Apple	Apple Juice not from Concentrate	Apple juice - family brand	--	1.1*	--	<0.2	<0.3	<0.4	Madison, WI	Festival Foods
H38-01A	Beech-Nut	Sweet Potato - Naturals Stage 1	Sweet potato - baby food	15.39	2.1*	--	7.5	3.1	<0.9	Boulder, CO	Safeway
H38-01F	Not available	Sweet Potato - USA	Sweet potato / Yam - fresh produce	25.45	4.8*	--	1.7	0.7*	<0.9	Boulder, CO	Safeway
H38-03A	Beech-Nut	Butternut Squash - Naturals Stage 1	Squash - baby food	7.88	<1.1	--	0.6*	0.9*	<0.9	Boulder, CO	Safeway
H38-03F	Not available	Butternut Squash - USA	Squash- fresh produce	6.38	<1.1	--	<0.5	<0.6	<0.9	Boulder, CO	Safeway
H38-05A	Organics	Puffs - Purple Carrot and Blueberry	Puff snack - baby food	--	118	41.6	22.8	88.3	<1.7	Boulder, CO	Safeway
H38-05F	General Mills	Cheerios - 100% Whole Grain Oats	Oat-ring cereal - family brand	--	30	--	4	21.9	<1.8	Boulder, CO	Safeway
H38-07A	Beech-Nut	Banana - Nothing Artificial Added, Stage 2	Banana - baby food	19.35	<1	--	0.9*	<0.6	<0.8	Boulder, CO	Safeway
H38-07F	Dole	Banana - Guatemala	Banana- fresh produce	18.35	<1	--	1.3*	<0.6	<0.8	Boulder, CO	Safeway
H38-08A	HappyBABY	Pears - Organic Clearly Crafted Stage 1	Pear - baby food	14.36	<1.1	--	0.8*	0.7*	<0.9	Boulder, CO	Safeway
H38-08F	Not available	Pear - Bartlett Organic	Pear- fresh produce	13.51	4.3*	--	<0.4	<0.6	<0.8	Boulder, CO	Safeway
H38-11A	HappyBABY	Oatmeal Baby Cereal - Clearly Crafted Organic	Oatmeal - baby food	--	5.4*	--	1*	9.7	<1.6	Boulder, CO	Safeway
H38-11F	O Organics	Steel Cut Oats	Oatmeal - family brand	--	4.6*	--	<0.9	7.7	<1.6	Boulder, CO	Safeway
H38-13A	Gerber	White Grape Juice - 100% Juice Variety Pack - Toddler	Grape juice - baby food	--	10.2	--	4.9	<0.2	<0.3	Boulder, CO	Safeway
H38-13F	Welch's	100% White Grape Juice from Concentrate - No Sugar Added	Grape juice - family brand	--	10	--	10	0.3*	<0.3	Boulder, CO	Safeway
H38-14A	O Organics	Puffs - Purple Carrot and Blueberry	Puff snack - baby food	--	78.7	--	18.9	96	<1.7	Boulder, CO	Safeway
H38-14F	O Organics	Toasted O's Cereal	Oat-ring cereal - family brand	--	6*	--	2.1*	16.9	<1.8	Boulder, CO	Safeway
H38-15A	O Organics	Teething Wafers - Baked Rice Snack, Banana Flavored	Teething biscuit/rusk - baby food	--	43.9	--	14.4	11.4	<1.8	Boulder, CO	Safeway
H38-15F	O Organics	Rice Cakes - Unsalted	Rice cake - family brand	--	251	125	1.8*	14.7	3.5*	Boulder, CO	Safeway
H39-01A	Gerber	Sweet Potato - Supported Sitter Stage 1	Sweet potato - baby food	14.3	2.4*	--	19.6	4.8	<0.9	Memphis TN	Kroger
H39-01F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	16.47	<1.1	--	1.6	3	<0.9	Memphis TN	Kroger
H39-05A	Gerber	Apple Sweet Potato Lil' Crunchies - Crawler+ months	Puff snack - baby food (non-rice)	--	<2.1	--	3.1	1.3*	<1.7	Memphis TN	Kroger
H39-05F	General Mills	Cheerios - 100% Whole Grain Oats	Oat-ring cereal - family brand	--	28	--	3.9	24.4	<1.7	Memphis TN	Kroger
H40-01A	HappyBABY	Carrots - Clearly Crafted Stage 1	Carrot - baby food	7.58	3.1*	--	6.8	5.1	<0.9	San Francisco, CA	Whole Foods
H40-01F	Not available	Carrots - Organic	Carrot- fresh produce	14.39	10.7	--	2.1	90.6	<0.8	San Francisco, CA	Whole Foods
H40-03A	Earth's Best	Peas - Organic, Stage 2, 6+ Months	Peas - baby food	12.48	5.3	--	9.2	<0.6	<0.9	San Francisco, CA	Whole Foods

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H40-03F	365 Whole Foods Market	Green Peas - Frozen	Peas - frozen	19.5	<1	--	1*	6.2	<0.8	San Francisco, CA	Whole Foods
H40-06A	HappyBABY	Teether Crackers - Organic, Mango & Pumpkin	Teething biscuit/rusk - baby food	--	52.3	--	4.9	13.9	1.8*	San Francisco, CA	Whole Foods
H40-06F	Lundberg	Rice Cake - Whole Grain, Brown Rice Lightly Salted	Rice cake - family brand	--	208	142	<0.9	13.5	2*	San Francisco, CA	Whole Foods
H41-06A	HappyBABY	Teether Crackers - Organic, Strawberry & Beet	Teething biscuit/rusk - baby food	--	55.2	--	13.4	14.2	<1.7	San Francisco, CA	Whole Foods
H41-06F	Lundberg	Rice Cake - Whole Grain, Brown Rice No Salt	Rice cake - family brand	--	201	141	1.3*	7.7	<1.6	San Francisco, CA	Whole Foods
H42-01A	Gerber	Carrot - Natural Supported Sitter 1st Food	Carrot - baby food	8.81	1.9*	--	1*	1.5	<0.8	Washington, DC	Giant Food
H42-01F	Not available	Carrots	Carrot- fresh produce	9.65	8.7	--	1.3*	14.7	<0.9	Washington, DC	Giant Food
H42-03A	Beech-Nut	Sweet Peas - Stage 2	Peas - baby food	13.37	<1	--	1.2*	1.1*	<0.8	Washington, DC	Giant Food
H42-03F	Not available	Green Peas - Frozen	Peas - frozen	20.01	<1.1	--	6.1	1*	<0.8	Washington, DC	Giant Food
H42-06A	Nature's Promise Organic	Rice Rusks - Organic, Apple	Teething biscuit/rusk - baby food	--	86.9	48.7	6.9	12.5	2.2*	Washington, DC	Giant Food
H42-06F	Lieber's	Rice Cakes with Sea Salt	Rice cake - family brand	--	196	--	2.9	8.3	2.2*	Washington, DC	Giant Food
H43-01A	Beech-Nut	Banana - Naturals Stage 1	Banana - baby food	21.91	<1	--	<0.4	<0.6	<0.8	Raleigh, NC	Walmart
H43-01F	Not available	Banana	Banana- fresh produce	19.09	<1.1	--	<0.5	<0.6	<0.8	Raleigh, NC	Walmart
H43-03A	Beech-Nut	Sweet Potato - Naturals Stage 1	Sweet potato - baby food	15.2	6.8	--	5.9	2.7	<0.8	Raleigh, NC	Walmart
H43-03F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	18.74	<1.1	--	60.7	9.1	<0.8	Raleigh, NC	Walmart
H44-01A	Gerber	Banana - Organic, Supported Sitter 1st Foods	Banana - baby food	22.64	1.3*	--	<0.5	<0.6	<0.9	San Francisco, CA	Safeway
H44-01F	Not available	Banana - Guatemala	Banana- fresh produce	19.2	<1.1	--	<0.5	<0.6	<0.9	San Francisco, CA	Safeway
H44-03A	Beech-Nut	Sweet Potato - Naturals Stage 1	Sweet potato - baby food	15.46	<1.1	--	3.1	3.5	<0.9	San Francisco, CA	Safeway
H44-03F	Not available	Yam - Sweet Red	Sweet potato / Yam - fresh produce	14.12	2.8*	--	0.7*	3.9	<0.9	San Francisco, CA	Safeway
H44-05A	Gerber	Puffs Sweet Potato - Crawler	Puff snack - baby food	--	41.4	--	3.4	11.6	<1.7	San Francisco, CA	Safeway
H44-05F	General Mills	Cheerios - 100% Whole Grain Oats	Oat-ring cereal - family brand	--	28.2	--	3.9	18.3	<1.7	San Francisco, CA	Safeway
H45-03A	HappyBABY	Sweet Potatoes - Clearly Crafted Stage 1	Sweet potato - baby food	9.68	6.2	--	3.5	<0.6	<0.8	Providence, RI	Stop & Shop
H45-03F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	16.76	<1.1	--	7.8	3.6	<0.8	Providence, RI	Stop & Shop
H45-05A	Gerber	Puffs Blueberry - Crawler	Puff snack - baby food	--	48.8	--	3.2	14.4	<1.8	Providence, RI	Stop & Shop
H45-05F	Giant	Oats & O's - Toasted Whole Grain Oat Cereal	Oat-ring cereal - family brand	--	17.4	--	5.6	13.6	<1.8	Providence, RI	Stop & Shop
H46-01A	Gerber	Apple - Natural, Supported Sitter 1st Foods	Apple - baby food	12.04	<1.1	--	0.5*	<0.6	<0.9	Atlanta, GA	Target
H46-01F	Good & Gather	Apple - Gala, Organic	Apple- fresh produce	15.86	<1.1	--	0.5*	<0.6	<0.8	Atlanta, GA	Target
H46-03A	Plum Organics	Just Sweet Potato - Stage 1, 4 months & up	Sweet potato - baby food	12.19	3.3*	--	28	2.7	<0.8	Atlanta, GA	Target
H46-03F	Not available	Sweet Potato	Sweet potato / Yam - fresh produce	16.38	7.2	--	41.7	10.6	<0.8	Atlanta, GA	Target
H46-05A	Gerber	Rice Cereal - Single Grain, Supported Sitter 1st Foods	Infant rice cereal	--	116	--	7.1	9.2	2.2*	Atlanta, GA	Target
H46-05F	Good & Gather	Long Grain Brown Rice	Brown Rice - family brand	--	138	--	2.5*	107	2*	Atlanta, GA	Target
H47-01A	Sprouts	Apple Sauce - Organic No Sugar Added	Apple - baby food	13.36	1.3*	--	<0.5	<0.6	<0.9	Dallas, TX	Sprouts Farmers Market

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H47-01F	Not available	Apple - Honeycrisp	Apple- fresh produce	11.61	<1	--	0.6*	<0.6	<0.8	Dallas, TX	Sprouts Farmers Market
H47-04A	HappyBABY	Green Beans - Organic Clearly Crafted, Stage 1	Green beans - baby food	8.23	<1.1	--	2.1	0.8*	<0.9	Dallas, TX	Sprouts Farmers Market
H47-04F	Sprouts	Green Beans - Frozen	Green beans - frozen	9.04	<1.1	--	1.8	1.3*	<0.9	Dallas, TX	Sprouts Farmers Market
H47-05A	Earth's Best	Rice Cereal - Organic, Iron Fortified	Infant rice cereal	--	109	--	16.4	44	1.5*	Dallas, TX	Sprouts Farmers Market
H47-05F	Lundberg	White Rice - Basmati	White rice - family brand	--	84.9	--	<0.9	5.4	<1.7	Dallas, TX	Sprouts Farmers Market
H50-01A	Gerber	Apple with Vitamin C - Natural, Supported Sitter 1st Foods	Apple - baby food	13.82	<1	--	0.5*	<0.5	<0.8	Chicago, IL	Jewel-Osco
H50-01F	Not available	Apple - Gala	Apple- fresh produce	14.33	1.7*	--	0.5*	<0.6	<0.8	Chicago, IL	Jewel-Osco
H50-03A	Gerber	Carrot - Natural, Supported Sitter 1st Food	Carrot - baby food	9.38	1.9*	--	1.1*	2.5	<0.9	Chicago, IL	Jewel-Osco
H50-03F	Not available	Carrots	Carrot- fresh produce	13.63	2.8*	--	1.3*	6	<0.8	Chicago, IL	Jewel-Osco
H51-03A	Beech-Nut	Sweet Carrots - Stage 2	Carrot - baby food	5.99	<1	--	3.4	6.3	<0.8	West Lafayette, IN	WalMart
H51-03F	Bolthouse Farms	Carrots	Carrot- fresh produce	11.8	3.1*	--	1.5	22.3	<0.8	West Lafayette, IN	WalMart
H51-06A	Gerber	Oatmeal - Single Grain Organic, Supported Sitter 1st Foods	Oatmeal - baby food	--	14.1	--	8.3	12.2	<1.8	West Lafayette, IN	WalMart
H51-06F	Great Value	Old Fashioned Oats - 100% Whole Grain	Oatmeal - family brand	--	27	19.8	<0.9	21.8	<1.6	West Lafayette, IN	WalMart
H52-02A	Gerber	Butternut Squash - Natural for Baby, Sitter 2nd Foods	Squash - baby food	11.47	<0.8	--	2.1	1.4*	<0.9	Flint, MI	Krogers
H52-02F	Not available	Butternut Squash	Squash- fresh produce	11.48	5.4	--	1.2*	<0.6	<0.9	Flint, MI	Krogers
H52-03A	Gerber	Pea - Sitter 2nd Foods	Peas - baby food	10.34	<1.1	--	1*	0.8*	<0.8	Flint, MI	Krogers
H52-03F	Kroger	Green Peas - Frozen	Peas - frozen	19.21	<1.1	--	2.2	<0.6	<0.8	Flint, MI	Krogers
H52-05A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.6	--	1.2	<0.3	<0.3	Flint, MI	Krogers
H52-05F	Mott's	100% Apple Juice from Concentrate	Apple juice - family brand	--	2.1	--	2.2	<0.3	<0.3	Flint, MI	Krogers
H54-01A	Beech-Nut	Sweet Potato - Organic Stage 1	Sweet potato - baby food	14.78	2.1*	--	7.5	2.9	<0.8	Los Angeles, CA	Ralphs
H54-01F	Not available	Sweet Potato - Organic	Sweet potato / Yam - fresh produce	12.82	<1.1	--	1.2*	<0.6	<0.9	Los Angeles, CA	Pavillions
H54-03A	Gerber	Pea - Sitter 2nd Foods	Peas - baby food	10.51	<1.1	--	0.6*	0.7*	<0.8	Los Angeles, CA	Ralphs
H54-03F	Organics	Peas - Organic, Frozen	Peas - frozen	23.05	1.1*	--	2.8	1.1*	<0.9	Los Angeles, CA	Pavillions
H54-05A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.7	--	1.2	<0.3	<0.3	Los Angeles, CA	Ralphs
H54-05F	Mott's	100% Apple Juice from Concentrate	Apple juice - family brand	--	4.1	--	1.3	<0.3	<0.3	Los Angeles, CA	Ralphs
H55-02A	Gerber	Green Beans - Supported Sitter 1st Foods	Green beans - baby food	8.35	1.1*	--	2.9	1.2*	<0.8	Missoula, MT	Winco Foods
H55-02F	Not available	Green Beans - Fresh, Organic	Green beans - fresh produce	12.92	2.4*	--	25.8	1.1*	<0.8	Missoula, MT	Farm Stand - Clark Fork Organics
H55-05A	HappyBABY	Puffs Organic Grain Snack - Sweet Potato & Carrot	Puff snack - baby food	--	318	59.4	8.2	11.8	<1.7	Missoula, MT	Winco Foods
H55-05F	General Mills	Cheerios - 100% Whole Grain Oats	Oat-ring cereal - family brand	--	28.3	--	5	18	<1.8	Missoula, MT	Winco Foods
H56-02A	HappyBABY	Green Beans - Organic Stage 1	Green beans - baby food	7.56	<1.1	--	1*	0.8*	<0.9	Waterville, ME	Hannaford
H56-02F	Nature's Promise	Green Beans - Cut, Organic, Frozen	Green beans - frozen	11.15	<1.1	--	3.9	<0.6	<0.9	Waterville, ME	Hannaford
H56-03A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.7	--	1.3	<0.3	<0.3	Waterville, ME	Hannaford
H56-03F	Mott's	100% Apple Juice from Concentrate	Apple juice - family brand	--	2.1	--	2.8	<0.3	<0.4	Waterville, ME	Hannaford

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H56-05A	Gerber	Puffs Banana - Crawler	Puff snack - baby food	--	43.7	--	1.5*	19.9	<1.6	Waterville, ME	Hannaford
H56-05F	General Mills	Cheerios - 100% Whole Grain Oats	Oat-ring cereal - family brand	--	34.3	23.5	6	22.7	<1.7	Waterville, ME	Hannaford
H57-01A	Beech-Nut	Sweet Peas - Stage 2	Peas - baby food	13.54	<1.1	--	0.7*	<0.6	<0.9	Salt Lake City, UT	Smith's Grocers
H57-01F	Kroger	Green Peas - Frozen	Peas - frozen	21.9	2*	--	4.1	<0.6	<0.8	Salt Lake City, UT	Smith's Grocers
H57-02A	Beech-Nut	Green Beans - Naturals Stage 1	Green beans - baby food	5.8	1.3*	--	2.4	<0.6	<0.8	Salt Lake City, UT	Smith's Grocers
H57-02F	Simple Truth Organic	Green Beans - Frozen	Green beans - frozen	9.73	<1.1	--	1.8	<0.6	<0.9	Salt Lake City, UT	Smith's Grocers
H57-03A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.3	--	1.2	<0.2	<0.3	Salt Lake City, UT	Smith's Grocers
H57-03F	Simple Truth Organic	Apple Juice from Concentrate - 100% Juice	Apple juice - family brand	--	4	--	0.7	<0.2	<0.3	Salt Lake City, UT	Smith's Grocers
H57-04A	Gerber	White Grape Juice from Concentrate - Toddler	Grape juice - baby food	--	9.6	--	4	<0.2	<0.3	Salt Lake City, UT	Smith's Grocers
H57-04F	Simple Truth Organic	White Grape from Concentrate - 100% Juice	Grape juice - family brand	--	9.2	--	2	<0.2	<0.3	Salt Lake City, UT	Smith's Grocers
H57-05A	Gerber	Puffs - Strawberry Apple, Crawler	Puff snack - baby food	--	46.2	--	2.2*	12.1	<1.8	Salt Lake City, UT	Smith's Grocers
H57-05F	Kashi	Oat Cereal - Organic, Honey Toasted	Oat-ring cereal - family brand	--	15.3	--	7.4	9.3	<1.7	Salt Lake City, UT	Smith's Grocers
H58-01A	Gerber	Apple - Natural for Baby, Supported Sitter 1st Foods	Apple - baby food	12.68	<1.1	--	0.7*	<0.6	<0.8	Montgomery, AL	Piggly Wiggly
H58-01F	Not available	Apple - Gala	Apple- fresh produce	14.16	1.7*	--	0.8*	<0.6	<0.9	Montgomery, AL	Piggly Wiggly
H59-01A	Gerber	Apple - Natural for Baby, Supported Sitter 1st Foods	Apple - baby food	14.13	<1.1	--	0.6*	<0.6	<0.8	Seattle, WA	Fred Meyer
H59-01F	Not available	Apple - Pink Lady	Apple- fresh produce	15.14	8.5	--	<0.4	<0.6	<0.8	Seattle, WA	Fred Meyer
H59-03A	Gerber	Rice Cereal - Single Grain, Supported Sitter 1st Foods	Infant rice cereal	--	119	73.5	3.2	9.2	<1.7	Seattle, WA	Fred Meyer
H59-03F	Kroger	Long-Grain Rice - Enriched	White rice - family brand	--	87.9	--	<1	3.6	<1.8	Seattle, WA	Fred Meyer
H60-01A	Gerber	Apple - Supported Sitter 1st Foods	Apple - baby food	12.09	1.1*	--	<0.4	<0.6	<0.8	Cedar Falls, IA	Hy-Vee
H60-01F	Not available	Apple - Red Delicious	Apple- fresh produce	12.15	13.6	10.5	0.6*	<0.6	<0.8	Cedar Falls, IA	Hy-Vee
H60-03A	Gerber	Rice Cereal - Single Grain, Supported Sitter 1st Foods	Infant rice cereal	--	112	--	3.7	10.3	2*	Cedar Falls, IA	Hy-Vee
H60-03F	WaterMaid	Rice - Medium Grain Enriched	White rice - family brand	--	278	125	1.9*	10.3	3.7*	Cedar Falls, IA	Hy-Vee
H60-06A	Gerber	Teethers - Strawberry Apple Spinach	Teething biscuit/rusk - baby food	--	89.1	44.6	4.1	11.8	2.1*	Cedar Falls, IA	Hy-Vee
H60-06F	Hyvee	Rice Cakes - Whole Grain Lightly Salted	Rice cake - family brand	--	302	127	1.5*	11.5	4.8*	Cedar Falls, IA	Hy-Vee
H61-07A	Beech-Nut	Bananas - Naturals Stage 1	Banana - baby food	19.92	1.6*	--	<0.5	<0.6	<0.9	Washington, DC	Safeway
H61-07F	Dole	Banana	Banana- fresh produce	20.25	<0.9	--	0.8*	<0.5	<0.7	Washington, DC	Safeway
H61-08A	HappyBABY	Pears - Clearly Crafted Stage 1	Pear - baby food	14.46	<1.1	--	1.1*	0.6*	<0.8	Washington, DC	Safeway
H61-08F	Not available	Pear - Bosc Organic	Pear- fresh produce	13.63	4.9	--	<0.4	1.3	<0.7	Washington, DC	Safeway
H61-11A	Beech-Nut	Oatmeal - Whole Grain Baby Cereal	Oatmeal - baby food	--	19.3	14.5	1.8*	15.3	<1.7	Washington, DC	Safeway
H61-11F	Signature Select	Oatmeal - Instant Organic, 100% Whole Grain Oat Cereal	Oatmeal - family brand	--	18.2	--	14.3	10.6	<1.7	Washington, DC	Safeway
H61-12A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	2.9	--	0.6*	<0.3	<0.4	Washington, DC	Safeway
H61-12F	Minute Maid	100% Apple Juice from Concentrate with Vitamin C	Apple juice - family brand	--	2.7	--	1	<0.3	<0.4	Washington, DC	Safeway
H62-07A	Beech-Nut	Bananas - Naturals Stage 1	Banana - baby food	22.26	8.5	--	1.5	0.9*	<0.9	Washington, DC	Giant

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H62-07F	Nature's Promise / Chiquita	Banana - Organic, Ecuador	Banana- fresh produce	22.01	1.6*	--	<0.4	<0.6	<0.8	Washington, DC	Giant
H62-08A	Gerber	Pear - Natural for Baby, Supported Sitter 1st Foods	Pear - baby food	15.46	3.6*	--	1.5	2	<0.8	Washington, DC	Giant
H62-08F	Stimilt Rushing Rivers	Pear - Red, USA	Pear- fresh produce	16.79	12.2	8.19	0.9*	0.7*	<0.8	Washington, DC	Giant
H62-08-2A	Beech-Nut	Pear - Organics Stage 1	Pear - baby food	15.66	<1.1	--	0.6*	<0.6	<0.9	Washington, DC	Giant
H62-08-2F	Not available	Pear - Bosc	Pear- fresh produce	16.69	1.4*	--	0.7*	1.5	<0.8	Washington, DC	Giant
H62-08-3A	HappyBABY	Pears - Clearly Crafted Stage 1	Pear - baby food	14.2	1.7*	--	1.6	1.1*	<0.8	Washington, DC	Giant
H62-08-3F	Not available	Pear - Bartlett, USA	Pear- fresh produce	15.11	1.8*	--	2.9	<0.6	<0.8	Washington, DC	Giant
H62-09A	Gerber	Butternut Squash - Natural for Baby, Sitter 2nd Foods	Squash - baby food	8.83	<1.1	--	1*	0.7*	<0.9	Washington, DC	Giant
H62-09F	Not available	Butternut Squash - USA	Squash- fresh produce	10.63	<1.1	--	1.6	<0.6	<0.9	Washington, DC	Giant
H62-10A	Gerber	Rice - Organic, Single Grain Cereal, Supported Sitter 1st Foods	Infant rice cereal	--	118	76.5	5.4	3.9	<1.7	Washington, DC	Giant
H62-10F	Mahatma	Rice - Whole Grain Brown	Brown Rice - family brand	--	203	123	1.2*	19.4	3.7*	Washington, DC	Giant
H62-11A	Earth's Best	Oatmeal Whole Grain Cereal - Organic, Iron Fortified	Oatmeal - baby food	--	15.8	--	1.8*	13.8	<1.6	Washington, DC	Giant
H62-11F	John McCann	Oatmeal - Steel Cut	Oatmeal - family brand	--	6.7*	--	1.2*	42.3	<1.5	Washington, DC	Giant
H62-12A	Gerber	Apple Juice from Concentrate - Toddler	Apple juice - baby food	--	3.1	--	0.7	<0.3	<0.3	Washington, DC	Giant
H62-12F	Apple & Eve	100% Apple Juice from Concentrate	Apple juice - family brand	--	1.6*	--	2.2	<0.3	<0.4	Washington, DC	Giant
H62-13A	Gerber	White Grape Juice from Concentrate - Toddler	Grape juice - baby food	--	12.4	8.88	5.5	<0.2	<0.3	Washington, DC	Safeway
H62-13F	Signature Select	White Grape from Concentrate - 100% Juice	Grape juice - family brand	--	10.6	--	6.9	<0.2	<0.3	Washington, DC	Safeway
H62-13A-2A	Gerber	Pear Juice from Concentrate - Toddler	Pear juice - baby food	--	2.5	--	0.5*	0.7	<0.4	Washington, DC	Safeway
H62-13F-2F	Looza	Pear Juice Drink from Concentrate - Belgium	Pear juice - family brand	--	0.6*	--	0.6*	0.4*	<0.4	Washington, DC	Safeway
H62-14A	Nature's Promise Organic	Puffs - Broccoli & Spinach Whole Grain	Puff snack - baby food	--	372	81.5	11.3	18.6	<1.8	Washington, DC	Giant
H62-14F	Giant	Oats & O's - Multigrain Cereal	Oat-ring cereal - family brand	--	27.4	--	11.5	14.2	<1.8	Washington, DC	Giant
H62-15A	Nature's Promise Organic	Rice Rusks - Organic, Apple	Teething biscuit/rusk - baby food	--	79.4	--	5.9	12	1.8*	Washington, DC	Giant
H62-15F	Quaker	Rice Cakes - Butter Popcorn	Rice cake - family brand	--	110	--	1.8*	6.4	3.6*	Washington, DC	Giant
H7-02A	Beech-Nut	Pear - Organics Stage 1	Pear - baby food	13.95	2.4*	--	1.4	<0.6	<0.8	Ann Arbor, MI	Kroger
H7-02F	Not available	Pear - Bartlett	Pear- fresh produce	12.49	1.2*	--	<0.5	1.6	<0.9	Ann Arbor, MI	Kroger
H7-03A	Gerber	Butternut Squash - Organic Supported Sitter 1st Foods	Squash - baby food	6.51	<1.1	--	<0.5	<0.6	<0.9	Ann Arbor, MI	Kroger
H7-03F	Not available	Butternut Squash	Squash- fresh produce	9.86	1.7*	--	2.4	1*	<0.9	Ann Arbor, MI	Kroger
H7-05A	Gerber	Rice Cereal - Single Grain, Supported Sitter 1st Foods	Infant rice cereal	--	102	--	3.2	8	<1.8	Ann Arbor, MI	Kroger
H7-05F	Kroger	Rice - Long Grain Enriched	White rice - family brand	--	80	--	0.8*	139	<1.3	Ann Arbor, MI	Kroger
H8-01A	Gerber	Banana - Natural for Baby, Sitter 2nd Foods	Banana - baby food	21.53	<1.1	--	<0.5	<0.6	<0.9	Fort Lauderdale, FL	Publix
H8-01F	Not available	Banana	Banana- fresh produce	22.81	1.4*	--	<0.4	<0.5	<0.8	Fort Lauderdale, FL	Publix
H8-03A	Gerber	Carrot - Sitter 2nd Foods	Carrot - baby food	8.58	<1	--	7.8	24.7	<0.8	Fort Lauderdale, FL	Publix
H8-03F	Publix	Carrots - Baby-Cut, Peeled	Carrot- fresh produce	8.6	3.2*	--	2.4	39.7	<0.9	Fort Lauderdale, FL	Publix
H8-04A	Gerber	Pea - Sitter 2nd Foods	Peas - baby food	10.16	<1.1	--	0.8*	<0.6	<0.9	Fort Lauderdale, FL	Publix

Sample number	Brand	Food	Food type	Percent solids	Arsenic (total, ppb)	Arsenic (inorganic, ppb)	Lead (ppb)	Cadmium (ppb)	Mercury (total, ppb)	Metro area where purchased	Retailer
H8-04F	La Sueur	Sweet Peas - Canned	Peas - canned	13.68	1.5*	--	3.6	1.5	<0.9	Fort Lauderdale, FL	Publix
H9-02A	Beech-Nut	Pear - Organics Stage 1	Pear - baby food	13.55	3.5*	--	2	<0.6	<0.9	Albany, NY	buybuy BABY
H9-02F	Not available	Pear - Bosc Organic, Argentina	Pear- fresh produce	17.92	10.1	--	<0.5	1.1*	<0.8	Albany, NY	Honest Weight Food Coop
H9-03A	Earth's Best	Winter Squash - Organic Stage 2, 6+ months	Squash - baby food	8.63	4.3*	--	6.8	0.7*	<0.8	Albany, NY	buybuy BABY
H9-03F	Not available	Acorn Squash - Organic, Mexico	Squash- fresh produce	7.5	13.3	10.6	8.4	<0.6	<0.8	Albany, NY	Honest Weight Food Coop
H9-05A	Gerber	Oatmeal - Single Grain, Supported Sitter 1st Foods	Oatmeal - baby food	--	39.7	28.5	3.5	9.2	<1.6	Albany, NY	buybuy BABY
H9-05F	Nature's Path Organic	Oatmeal - Organic, Original Instant	Oatmeal - family brand	--	8.8*	--	<1.1	11.9	<2	Albany, NY	Honest Weight Food Coop

APPENDIX B:

Laboratory analysis – Method for testing baby food and family-style food

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 288 foods, including packaged foods and fresh and frozen produce, for total recoverable arsenic, lead, cadmium, and mercury; and speciated arsenic for a subset of samples.

BAL is accredited through the National Environmental Laboratory Accreditation Program (NELAP) 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

Food receipt and storage: BAL received 288 food containers and individual produce samples from July through September 2021, including 14 food types (see Table 1 in main report). 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. Non-perishable samples were stored at ambient temperature, maintaining the shipping temperature of the samples. Perishable samples were refrigerated upon receipt but then frozen after preparation to maintain sample integrity:

- Apples and Pears – peeled, core removed, then homogenized
- Squash – peeled, halved, seeds removed, then homogenized
- Bananas, Sweet Potatoes, Carrots – peeled and then homogenized
- Frozen/Canned Peas and Green Beans – liquid drained as needed, then homogenized.

Sample homogenization: Produce and any heterogeneous packaged foods 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.

Total solids content: To account for differences in the moisture content of prepacked foods and raw produce (considered in comparisons of baby food brands and homemade purees, see Appendix F), the total solids content of each sample was determined as follows: A known mass of each sample was dried to constant weight in a laboratory oven, and the solids content was then calculated as the ratio of the mass remaining after drying to that originally weighed before drying.

Sample digestion: BAL prepared samples by the addition of hydrogen peroxide (H2O2) and concentrated nitric acid (HNO3) 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, Hg, 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.

Arsenic speciation analysis

Sample digestion: BAL digested baby food samples for arsenic speciation using a dilute acid solution. The digestion method typically induces conversion of As(III) to As(V). (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. 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, MS/MSD 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.

References

FDA 2015 (U.S. Food and Drug Administration). Elemental Analysis Manual (EAM) for Food and Related Products, EAM 4.7. Inductively Coupled PlasmaMass Spectrometric Determination of Arsenic, Cadmium, Chromium, Lead, Mercury, and Other Elements in Food Using Microwave Assisted Digestion. https://www.fda.gov/food/laboratory-methods-food/elemental-analysis-manual-eam-food-and-related-products.

FDA 2012 (U.S. Food and Drug Administration). Elemental Analysis Manual (EAM) for Food and Related Products, EAM 4.11. Arsenic Speciation in Rice and Rice Products Using High Performance Liquid Chromatography Inductively Coupled Plasma-Mass Spectrometric Determination. https://www.fda.gov/food/laboratory-methods-food/elemental-analysis-manual-eam-food-and-related-products.

APPENDIX C:

Summary of test results for heavy metals from seven HBBF and FDA studies

The following table reflects analysis of data in seven investigations of heavy metals in baby food brands and foods eaten by all family members, including raw and cooked samples and family brands. Samples were tested between 2014 and 2021 (HBBF 2017, 2019, HBBF-EDF 2022, current study; FDA 2017,2020,2022).

The table includes a subset of the hundreds of foods covered in these seven studies and assessed in the current investigation, those that are commonly consumed by babies or that are otherwise featured in HBBF's study. The qualifier "ND" indicates that the metal was reported as not detected. The qualifiers "NT" and "--" indicate that the analysis was not performed or was not published, in the case of FDA tests. The phrase "As only" within a food name denotes a food that was tested for arsenic only.

HBBF-commissioned tests are generally more sensitive (lower detection and/or reporting limits) than FDA tests, driving the higher "Percent detect" reported for many HBBF-tested foods compared to FDA's results.

Inorganic arsenic was tested for only a subset of foods, and generally for only a subset of samples within each food type, often the samples with the highest total arsenic levels. Therefore, average inorganic arsenic shown below do not necessarily reflect the average across all samples.

"Total metals" in this table is the average of the sum for each sample of lead, cadmium, mercury, and total arsenic. In developing the food recommendations shown in this report, HBBF relied on "Total metals" for each food that incorporated inorganic arsenic (the more toxic form), not total arsenic. When not available from laboratory testing, inorganic arsenic was estimated from the measured total arsenic level using the method described in Appendix F.

Non-detect values were assumed to equal half of the detection limit for the purposes of this table. Particularly for FDA's 2020 study, which has higher detection limits for lead and arsenic than other studies considered, this assumption may have the effect of overestimating actual total metal levels. Analyses in this report rely on results from studies with higher rates of detection, for foods for which detection limits (and detection rates) vary widely among studies.

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Almonds, shelled (FDA)	3	26.20	100%	ND	0%	15.00	100%	ND	0%	8.70	100%	--	NT	FDA 2017,2020
Apple - baby food (FDA)	14	4.86	21%	1.75	7%	ND	0%	--	NT	2.61	21%	--	NT	FDA 2017
Apple - baby food (HBBF)	17	3.43	82%	1.00	71%	0.31	6%	ND	0%	1.80	47%	--	NT	HBBF 2019,2022
Apple - homemade baby food (HBBF)	12	3.92	75%	0.43	50%	ND	0%	ND	0%	2.81	58%	10.45	100%	HBBF 2022
Apple - raw with peel (FDA)	15	4.77	47%	1.67	7%	ND	0%	ND	0%	2.57	40%	--	NT	FDA 2017
Apple - raw, peeled (HBBF)	12	4.07	75%	0.45	50%	ND	0%	ND	0%	2.90	58%	10.50	100%	HBBF 2022
Apple juice - baby food (FDA)	22	4.80	95%	0.90	27%	ND	0%	ND	0%	3.34	95%	--	NT	FDA 2017,2020
Apple juice - baby food (HBBF)	15	4.69	100%	1.12	100%	ND	0%	ND	0%	3.26	93%	--	NT	HBBF 2019,2022
Apple juice (FDA)	282	--	NT	2.31	57%	--	NT	--	NT	--	NT	--	NT	FDA 2022
Apple juice (HBBF)	11	5.43	100%	2.22	91%	ND	0%	ND	0%	2.89	100%	--	NT	HBBF 2019,2022

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Apple juice, bottled (FDA)	17	4.75	82%	1.07	53%	ND	0%	ND	0%	3.26	82%	--	NT	FDA 2017,2020
Applesauce, bottled (FDA)	14	3.82	7%	ND	0%	ND	0%	ND	0%	1.75	7%	--	NT	FDA 2017
Apricots, canned in heavy/light syrup (FDA)	14	11.32	100%	9.21	100%	ND	0%	--	NT	1.61	7%	--	NT	FDA 2017
Arrowroot cookies - baby food (FDA)	14	64.00	100%	24.43	100%	25.79	100%	--	NT	13.79	100%	--	NT	FDA 2017
Asparagus, fresh/frozen, boiled (FDA)	42	24.27	100%	1.93	5%	18.84	100%	ND	0%	3.16	57%	--	NT	FDA 2017,2020
Avocado, raw (FDA)	42	19.33	100%	2.06	2%	9.88	100%	0.56	10%	6.83	26%	--	NT	FDA 2017,2020
Bagel, plain, toasted (FDA)	42	33.50	100%	2.69	24%	24.17	100%	ND	0%	6.32	98%	--	NT	FDA 2017,2020
Banana - baby food (FDA)	14	4.04	7%	ND	0%	ND	0%	0.54	7%	ND	0%	--	NT	FDA 2017
Banana - baby food (HBBF)	13	2.47	31%	0.39	15%	0.33	8%	ND	0%	1.40	23%	--	NT	HBBF 2019,2022
Banana - homemade baby food (HBBF)	10	1.90	60%	0.50	40%	ND	0%	ND	0%	0.71	20%	--	NT	HBBF 2022
Banana - raw (HBBF)	10	1.96	60%	0.52	40%	ND	0%	ND	0%	0.73	20%	--	NT	HBBF 2022
Banana, raw (FDA)	15	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2017
Barley cereal - dry, As only, baby food (HBBF)	3	NT	67%	ND	0%	ND	0%	--	NT	ND	0%	6.50	67%	HBBF 2017
Barley cereal - dry, baby food (HBBF)	1	27.44	100%	3.00	100%	13.70	100%	ND	0%	10.60	100%	--	NT	HBBF 2019
Beans, black, canned, drained solids (FDA)	3	9.50	100%	ND	0%	5.50	100%	ND	0%	ND	0%	--	NT	FDA 2020
Beans, kidney, canned, drained solids (FDA)	3	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2020
Beans, pinto, canned, drained solids (FDA)	3	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2020
Beans, pinto, dry, boiled (FDA)	14	6.04	100%	1.61	7%	2.71	100%	--	NT	1.71	14%	--	NT	FDA 2017
Beans, white, canned, drained solids (FDA)	3	5.97	100%	ND	0%	1.97	100%	ND	0%	ND	0%	--	NT	FDA 2020
Beans, white, dry, boiled (FDA)	14	5.89	93%	ND	0%	2.68	93%	--	NT	1.71	14%	--	NT	FDA 2017
Beef and broth/gravy - baby food (FDA)	14	3.79	14%	1.79	14%	ND	0%	--	NT	ND	0%	--	NT	FDA 2017
Beef steak, loin/sirloin, oven-roasted (FDA)	27	8.67	93%	ND	0%	ND	0%	ND	0%	5.67	93%	--	NT	FDA 2020
Beef, ground, pan-cooked (FDA)	42	7.14	90%	ND	0%	0.54	2%	ND	0%	4.45	90%	--	NT	FDA 2017,2020
Beverage, almond (non-dairy) (FDA)	3	5.93	67%	1.43	67%	1.13	67%	ND	0%	2.87	67%	--	NT	FDA 2020
Beverage, soy (non-dairy) (FDA)	3	6.70	100%	0.87	67%	2.77	100%	ND	0%	2.57	67%	--	NT	FDA 2020
BF, infant formula, milk-based, powdered (FDA)	2	10.50	100%	6.00	50%	1.45	100%	ND	0%	2.55	50%	--	NT	FDA 2020
Blueberries, raw (FDA)	28	8.99	64%	2.45	11%	0.58	7%	ND	0%	5.45	57%	--	NT	FDA 2017,2020
Bread, multigrain (FDA)	10	43.50	100%	6.30	100%	26.10	100%	--	NT	11.10	100%	--	NT	FDA 2017
Bread, white, enriched (FDA)	42	36.75	100%	3.75	38%	26.90	100%	ND	0%	5.60	98%	--	NT	FDA 2017,2020
Bread, whole wheat (FDA)	42	45.09	100%	5.00	79%	29.62	100%	ND	0%	10.14	100%	--	NT	FDA 2017,2020
Broccoli, fresh/frozen, boiled (FDA)	42	18.68	98%	ND	0%	14.92	98%	ND	0%	1.61	2%	--	NT	FDA 2017,2020
Brown rice - dry (HBBF)	2	238.40	100%	1.85	100%	63.20	100%	2.85	100%	170.50	100%	123.00	100%	HBBF 2022
Brown rice cereal - dry, As only, baby food (HBBF)	22	NT	100%	ND	0%	ND	0%	--	NT	177.24	77%	95.73	100%	HBBF 2017
Brown rice cereal - dry, baby food (HBBF)	4	240.29	100%	27.70	100%	17.98	100%	2.11	100%	192.50	100%	124.25	100%	HBBF 2019
Buckwheat cereal - dry, As only, baby food (HBBF)	3	NT	33%	ND	0%	ND	0%	--	NT	9.00	33%	2.67	33%	HBBF 2017
Cabbage, raw (FDA)	27	9.77	100%	ND	0%	5.51	100%	ND	0%	1.77	7%	--	NT	FDA 2020

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Cantaloupe, raw/frozen (FDA)	42	20.83	98%	ND	0%	9.18	98%	ND	0%	9.50	86%	--	NT	FDA 2017,2020
Carrot - baby food (FDA)	28	29.69	100%	8.18	82%	19.46	100%	ND	0%	1.80	18%	--	NT	FDA 2017,2020
Carrot - baby food (HBBF)	24	18.46	100%	5.58	100%	10.50	96%	0.29	38%	2.10	54%	--	NT	HBBF 2019,2022
Carrot - homemade baby food (HBBF)	12	27.95	100%	2.81	100%	20.33	100%	ND	0%	4.48	100%	11.80	100%	HBBF 2022
Carrot, baby, raw (FDA)	42	29.26	100%	1.86	2%	21.88	100%	ND	0%	5.20	93%	--	NT	FDA 2017,2020
Carrot, fresh, peeled, boiled (FDA)	14	28.11	100%	2.68	21%	22.36	100%	--	NT	3.07	57%	--	NT	FDA 2017
Carrot, raw (HBBF)	12	38.13	100%	3.24	100%	28.68	100%	ND	0%	5.78	100%	11.80	100%	HBBF 2022
Cauliflower, fresh/frozen, boiled (FDA)	42	15.11	100%	ND	0%	11.23	100%	ND	0%	1.57	5%	--	NT	FDA 2017,2020
Celery, raw (FDA)	42	40.65	100%	ND	0%	36.62	100%	ND	0%	1.88	12%	--	NT	FDA 2017,2020
Cereal, corn flakes (FDA)	17	8.69	100%	3.26	41%	1.99	100%	ND	0%	3.35	6%	--	NT	FDA 2017,2020
Cereal, cream of wheat, farina, cooked (FDA)	17	14.35	94%	4.09	41%	6.69	94%	ND	0%	3.49	47%	--	NT	FDA 2017,2020
Cereal, crisped rice (FDA)	17	186.15	100%	2.29	24%	14.12	100%	1.98	94%	167.76	100%	93.10	100%	FDA 2017,2020
Cereal, granola (FDA)	3	34.83	100%	ND	0%	16.00	100%	ND	0%	16.33	100%	--	NT	FDA 2020
Cereal, oat ring (FDA)	17	46.43	100%	5.81	94%	15.47	100%	ND	0%	25.06	100%	--	NT	FDA 2017,2020
Cereal, shredded wheat (FDA)	14	60.11	100%	1.61	7%	52.71	100%	--	NT	5.79	86%	--	NT	FDA 2017
Cereal, whole wheat, cooked (FDA)	3	8.50	100%	3.43	33%	3.07	100%	ND	0%	ND	0%	--	NT	FDA 2020
Cheese, various (FDA)	46	5.87	39%	2.09	17%	1.01	24%	ND	0%	2.73	28%	--	NT	FDA 2017
Chicken and broth/gravy - baby food (FDA)	14	4.64	64%	1.61	7%	0.93	57%	ND	0%	1.61	7%	--	NT	FDA 2017
Chicken breast, oven-roasted, skin removed (FDA)	42	5.40	38%	1.95	2%	0.72	19%	ND	0%	2.24	29%	--	NT	FDA 2017,2020
Chicken noodle dinner - baby food (FDA)	22	22.47	100%	3.52	41%	11.13	100%	ND	0%	7.63	100%	--	NT	FDA 2017,2020
Chicken thigh, oven-roasted, skin removed (FDA)	42	4.89	31%	ND	0%	0.59	10%	0.51	2%	1.97	19%	--	NT	FDA 2017,2020
Chicken with rice - baby food (FDA)	14	24.50	100%	3.00	43%	9.29	100%	--	NT	12.21	100%	--	NT	FDA 2017
Chickpeas (garbanzo) beans, canned, drained solids (FDA)	1	8.70	100%	ND	0%	1.30	100%	ND	0%	4.90	100%	--	NT	FDA 2020
Collards, fresh/frozen, boiled (FDA)	42	34.58	100%	3.52	36%	27.47	100%	0.74	36%	2.85	40%	--	NT	FDA 2017,2020
Corn, canned (FDA)	17	5.94	82%	1.79	6%	1.34	71%	ND	0%	2.71	35%	--	NT	FDA 2017,2020
Corn, fresh/frozen, boiled (FDA)	42	6.28	95%	ND	0%	2.59	93%	ND	0%	1.54	2%	--	NT	FDA 2017,2020
Corn/hominy grits, enriched, cooked (FDA)	14	3.75	21%	ND	0%	0.75	21%	--	NT	ND	0%	--	NT	FDA 2017
Cottage cheese, creamed, reduced fat (FDA)	14	4.57	36%	1.75	7%	0.68	7%	--	NT	2.14	29%	--	NT	FDA 2017
Cream of wheat - dry (HBBF)	1	78.07	100%	21.80	100%	36.70	100%	ND	0%	19.50	100%	--	NT	HBBF 2019
Cucumber, peeled, raw (FDA)	42	16.08	95%	ND	0%	1.36	62%	ND	0%	12.56	90%	--	NT	FDA 2017,2020
Drink - not 100% fruit - baby food (HBBF)	5	4.12	80%	0.95	80%	0.77	40%	ND	0%	2.33	60%	--	NT	HBBF 2019
Eggs, hard-boiled (FDA)	42	4.45	2%	ND	0%	ND	0%	ND	0%	1.63	2%	--	NT	FDA 2017,2020
Fruit and veggie mix - baby food (HBBF)	10	10.94	100%	1.94	100%	6.06	90%	0.10	20%	2.85	70%	--	NT	HBBF 2019
Fruit cocktail, canned in light syrup, solids and liquids (FDA)	17	7.56	94%	5.44	94%	0.53	6%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Fruit veggie mix with grain/meat/dairy - baby food (HBBF)	6	22.98	100%	9.33	100%	5.01	83%	0.13	33%	8.50	83%	26.00	100%	HBBF 2019

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Granola bar, with raisins (FDA)	14	52.46	100%	4.04	64%	16.43	100%	--	NT	32.00	100%	--	NT	FDA 2017
Grape juice - baby food (FDA)	22	15.90	100%	3.33	64%	ND	0%	ND	0%	11.89	100%	--	NT	FDA 2017,2020
Grape juice - baby food (HBBF)	6	17.19	100%	5.98	100%	ND	0%	ND	0%	10.95	100%	9.02	100%	HBBF 2019,2022
Grape juice (FDA)	3	13.97	100%	4.97	100%	1.47	100%	ND	0%	7.03	100%	7.30	100%	FDA 2020
Grape juice (FDA)	122	--	NT	8.73	89%	--	NT	--	NT	--	NT	--	NT	FDA 2022
Grape juice (HBBF)	5	17.03	100%	7.06	100%	0.20	40%	ND	0%	9.62	100%	--	NT	HBBF 2022
Grape juice, frozen concentrate, reconstituted (FDA)	14	10.79	93%	4.79	86%	0.83	71%	--	NT	5.18	93%	--	NT	FDA 2017
Grapefruit juice, bottled/cartoned (FDA)	16	1.43	13%	ND	0%	ND	0%	ND	0%	0.63	13%	--	NT	FDA 2017,2020
Grapes (red/green), raw (FDA)	15	8.07	53%	3.23	40%	0.70	13%	ND	0%	4.10	53%	--	NT	FDA 2017
Green beans - baby food (FDA)	22	4.46	45%	1.80	5%	0.98	45%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Green beans - baby food (HBBF)	13	3.84	100%	1.71	100%	0.95	77%	ND	0%	0.82	31%	--	NT	HBBF 2019,2022
Green beans - homemade baby food (HBBF)	11	7.38	100%	5.17	100%	0.44	27%	ND	0%	1.41	27%	--	NT	HBBF 2022
Green beans, canned (FDA)	17	4.12	18%	ND	0%	0.62	12%	ND	0%	1.82	6%	--	NT	FDA 2017,2020
Green beans, fresh/frozen, boiled (FDA)	42	4.72	40%	1.87	2%	0.93	38%	ND	0%	1.59	5%	--	NT	FDA 2017,2020
Green beans, raw/frozen (HBBF)	11	8.90	100%	6.38	100%	0.54	27%	ND	0%	1.55	27%	--	NT	HBBF 2022
Infant formula, milk-based, iron fortified, RTF (FDA)	14	1.59	14%	0.79	14%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2017
Infant formula, milk-based, powdered, prepared with water (FDA)	1	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2020
Infant formula, soy-based, powdered (FDA)	2	14.30	100%	ND	0%	6.15	100%	ND	0%	5.65	100%	--	NT	FDA 2020
Infant formula, soy-based, powdered, prepared with water (FDA)	1	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2020
Infant formula, soy-based, RTF (FDA)	14	1.54	29%	ND	0%	0.39	29%	ND	0%	ND	0%	--	NT	FDA 2017
Infant formula, various types (HBBF)	13	7.85	100%	2.88	100%	1.47	62%	0.11	8%	3.40	62%	--	NT	HBBF 2019
Juice, fruit blend (100% juice), canned/bottled (FDA)	17	6.68	94%	2.01	65%	ND	0%	ND	0%	4.36	94%	--	NT	FDA 2017,2020
Kale, fresh, pan-cooked (FDA)	6	41.27	100%	3.15	33%	30.22	100%	0.97	67%	6.93	100%	--	NT	FDA 2020
Lentils, dry, cooked (FDA)	1	5.50	100%	ND	0%	1.50	100%	ND	0%	ND	0%	--	NT	FDA 2020
Lettuce, iceberg, raw (FDA)	42	43.97	100%	ND	0%	40.32	100%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Lettuce, leaf, raw (FDA)	42	68.22	100%	3.97	36%	60.76	100%	ND	0%	3.15	38%	--	NT	FDA 2017,2020
Lima beans, immature, frozen, boiled (FDA)	14	4.64	86%	ND	0%	1.64	86%	--	NT	ND	0%	--	NT	FDA 2017
Macaroni and cheese - baby food (FDA)	5	13.00	100%	3.80	100%	6.00	100%	--	NT	3.20	60%	--	NT	FDA 2017
Macaroni and cheese with vegetables - baby food (FDA)	14	15.68	100%	5.26	71%	4.49	100%	ND	0%	5.65	93%	--	NT	FDA 2017,2020
Macaroni and cheese, prepared from boxed mix (FDA)	17	16.41	100%	1.91	6%	12.26	100%	ND	0%	2.15	35%	--	NT	FDA 2017,2020
Mandarin orange (HBBF)	1	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	HBBF-EDF 2022
Mango - baby food (FDA)	5	10.92	100%	ND	0%	4.82	100%	ND	0%	3.60	100%	--	NT	FDA 2020
Mango, glass jar - baby food (FDA)	5	10.60	100%	ND	0%	2.82	100%	ND	0%	5.28	100%	--	NT	FDA 2020

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Mango, raw/frozen (FDA)	6	8.25	83%	ND	0%	2.58	83%	ND	0%	3.17	50%	--	NT	FDA 2020
Meal - meat, vegetable, grain - baby food (HBBF)	10	26.26	100%	5.04	100%	12.14	100%	0.10	20%	8.98	70%	13.00	100%	HBBF 2019
Meat - single meats, various - baby food (HBBF)	6	3.51	83%	1.48	83%	0.59	17%	0.10	17%	1.34	17%	--	NT	HBBF 2019
Milk (FDA)	127	2.04	4%	0.73	2%	ND	0%	ND	0%	0.57	2%	--	NT	FDA 2017,2020
Mixed vegetables, frozen, boiled (FDA)	17	10.16	100%	2.21	18%	6.36	100%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Multi-grain cereal - dry, As only, baby food (HBBF)	18	NT	100%	ND	0%	ND	0%	--	NT	34.88	89%	20.44	100%	HBBF 2017
Multi-grain cereal - dry, baby food (FDA)	7	67.60	100%	5.96	100%	29.00	100%	ND	0%	32.14	100%	26.40	100%	FDA 2017,2020
Multi-grain cereal - dry, baby food (HBBF)	2	46.22	100%	3.10	100%	19.30	100%	0.22	50%	23.60	100%	31.00	100%	HBBF 2019
Multi-grain cereal - dry, prepared with water, baby food (FDA)	15	15.57	100%	2.07	13%	7.10	100%	0.50	50%	6.33	100%	--	NT	FDA 2017,2020
Non-rice-based cracker - butter style (FDA)	17	31.92	100%	2.37	6%	24.88	100%	ND	0%	4.58	71%	--	NT	FDA 2017,2020
Non-rice-based cracker - graham cracker (FDA)	17	38.35	100%	5.09	47%	29.76	100%	ND	0%	3.41	53%	--	NT	FDA 2017,2020
Non-rice-based cracker - saltine (FDA)	17	31.51	100%	1.86	12%	27.18	100%	ND	0%	2.38	41%	--	NT	FDA 2017,2020
Oat ring cereal (HBBF)	10	49.20	100%	5.41	100%	18.01	100%	ND	0%	24.90	100%	21.75	100%	HBBF 2022
Oat ring cereal, honey (FDA)	3	40.93	100%	6.43	100%	13.00	100%	ND	0%	21.00	100%	--	NT	FDA 2017,2020
Oatmeal - dry (HBBF)	10	35.33	100%	2.28	50%	18.19	100%	ND	0%	14.03	100%	22.50	100%	HBBF 2022
Oatmeal cereal - dry, As only, baby food (HBBF)	18	NT	100%	ND	0%	ND	0%	--	NT	26.14	78%	12.39	100%	HBBF 2017
Oatmeal cereal - dry, baby food (FDA)	7	42.50	100%	ND	0%	12.29	100%	ND	0%	27.71	100%	--	NT	FDA 2020
Oatmeal cereal - dry, baby food (HBBF)	15	35.11	100%	5.02	93%	12.16	100%	ND	0%	17.33	100%	23.33	100%	HBBF 2019,2022
Oatmeal cereal - dry, prepared with water, baby food (FDA)	15	8.17	100%	ND	0%	3.14	100%	ND	0%	3.47	87%	--	NT	FDA 2017,2020
Oatmeal cereal with fruit - dry, baby food (HBBF)	4	0.00	100%	ND	0%	ND	0%	--	NT	30.33	75%	13.25	100%	HBBF 2019
Oatmeal cereal with fruit - prepared with water, baby food (FDA)	14	8.86	100%	ND	0%	3.36	100%	--	NT	3.96	93%	--	NT	FDA 2017
Oatmeal, plain, cooked (FDA)	17	6.84	100%	ND	0%	2.15	100%	ND	0%	2.59	29%	--	NT	FDA 2017,2020
Orange, raw (FDA)	42	4.68	12%	ND	0%	0.52	2%	ND	0%	2.01	12%	--	NT	FDA 2017,2020
Other juice - baby food (HBBF)	3	4.87	67%	1.38	67%	0.37	33%	ND	0%	3.05	67%	--	NT	HBBF 2019
Peach - baby food (FDA)	36	9.43	100%	2.00	6%	2.39	100%	ND	0%	4.74	94%	--	NT	FDA 2017,2020
Peach - baby food (HBBF)	2	10.18	100%	1.65	100%	1.18	50%	0.11	50%	7.25	100%	--	NT	HBBF 2019
Peach - canned in light/medium syrup (FDA)	28	9.30	100%	6.96	100%	0.57	14%	0.00	--	NT	11%	--	NT	FDA 2017
Peach, raw/frozen (FDA)	42	7.40	81%	ND	0%	0.90	31%	ND	0%	4.34	67%	--	NT	FDA 2017,2020
Peanut butter, creamy (FDA)	17	66.02	100%	5.76	65%	52.29	100%	ND	0%	7.88	100%	--	NT	FDA 2017,2020
Peanuts, dry roasted, salted (FDA)	17	53.41	100%	2.18	6%	44.59	100%	ND	0%	6.55	88%	--	NT	FDA 2017,2020
Pear - baby food (FDA)	22	7.51	100%	ND	0%	1.71	100%	ND	0%	3.62	77%	--	NT	FDA 2017,2020
Pear - baby food (HBBF)	13	5.83	100%	1.26	100%	1.05	77%	0.35	8%	3.17	77%	--	NT	HBBF 2019,2022
Pear - homemade baby food (HBBF)	10	5.31	100%	0.60	40%	0.95	70%	ND	0%	3.38	70%	7.54	100%	HBBF 2022

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Pear fruit - canned (HBBF)	64	10.40	100%	7.22	100%	1.01	25%	ND	0%	1.39	19%	--	NT	HBBF-EDF 2022
Pear fruit - plastic container (HBBF)	6	5.93	83%	2.13	83%	1.38	33%	ND	0%	1.57	17%	--	NT	HBBF-EDF 2022
Pear juice - baby food (FDA)	22	6.73	100%	1.58	36%	0.91	64%	ND	0%	4.06	100%	--	NT	FDA 2017,2020
Pear juice - baby food (HBBF)	4	4.62	100%	0.68	100%	0.83	100%	ND	0%	2.95	100%	--	NT	HBBF 2022
Pear juice (FDA)	77	--	NT	1.04	56%	--	NT	--	NT	--	NT	--	NT	FDA 2022
Pear juice (HBBF)	3	4.40	100%	0.70	100%	0.32	67%	ND	0%	3.20	100%	--	NT	HBBF 2022
Pear, raw, peeled (HBBF)	10	5.77	100%	0.64	40%	0.99	70%	ND	0%	3.75	70%	8.19	100%	HBBF 2022
Pear, with peel, raw (FDA)	42	7.68	83%	1.88	2%	1.05	45%	ND	0%	4.41	71%	--	NT	FDA 2017,2020
Pears and pineapple - baby food (FDA)	14	5.79	93%	ND	0%	1.18	64%	--	NT	3.11	64%	--	NT	FDA 2017
Peas - baby food (FDA)	14	4.04	21%	1.82	7%	0.71	14%	--	NT	ND	0%	--	NT	FDA 2017
Peas - baby food (HBBF)	13	4.69	100%	1.89	92%	0.65	54%	ND	0%	1.80	23%	--	NT	HBBF 2019,2022
Peas - homemade baby food (HBBF)	10	3.62	100%	1.77	100%	1.07	70%	ND	0%	0.54	40%	--	NT	HBBF 2022
Peas, green, fresh/frozen, boiled (FDA)	17	5.34	76%	ND	0%	2.16	76%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Peas, raw/frozen (HBBF)	10	5.95	100%	2.88	100%	1.76	70%	ND	0%	0.89	40%	--	NT	HBBF 2022
Pepper, bell, green, raw (FDA)	42	12.93	100%	ND	0%	9.24	100%	ND	0%	1.54	2%	--	NT	FDA 2017,2020
Pineapple juice, canned/bottled (FDA)	7	6.10	86%	5.00	86%	ND	0%	ND	0%	0.59	14%	--	NT	FDA 2017,2020
Pineapple, canned in juice (FDA)	14	9.46	93%	6.75	93%	0.64	14%	--	NT	2.07	14%	--	NT	FDA 2017
Pineapple, raw/frozen (FDA)	28	5.64	14%	ND	0%	1.55	11%	ND	0%	1.60	4%	--	NT	FDA 2017,2020
Potato, peeled, boiled (FDA)	42	29.85	100%	1.86	2%	25.90	100%	ND	0%	1.75	10%	--	NT	FDA 2017,2020
Potato, with peel, baked (FDA)	42	48.64	100%	3.43	31%	40.62	100%	ND	0%	4.26	69%	--	NT	FDA 2017,2020
Prune - baby food (HBBF)	3	8.14	100%	3.53	100%	ND	0%	0.17	67%	4.18	67%	--	NT	HBBF 2019
Puffs - baby food (FDA)	8	62.69	100%	5.13	25%	15.25	100%	0.56	13%	41.75	100%	30.70	100%	FDA 2020
Puffs - baby food (HBBF)	18	176.86	100%	9.09	100%	25.89	100%	1.24	39%	140.64	89%	80.39	100%	HBBF 2019,2022
Quinoa cereal - dry, As only, baby food (HBBF)	5	NT	80%	ND	0%	ND	0%	--	NT	12.90	80%	5.70	80%	HBBF 2017
Quinoa cereal with fruit - dry, As only, baby food (HBBF)	4	NT	100%	ND	0%	ND	0%	--	NT	27.00	100%	15.00	100%	HBBF 2017
Quinoa, cooked (FDA)	3	21.00	100%	5.00	33%	11.17	100%	ND	0%	4.33	33%	--	NT	FDA 2020
Raisins (FDA)	17	34.39	100%	12.01	100%	0.82	53%	1.15	82%	20.41	100%	--	NT	FDA 2017,2020
Rice - brown, cooked (FDA)	28	77.25	100%	ND	0%	7.98	100%	0.75	32%	66.54	100%	--	NT	FDA 2017,2020
Rice - white, dry (HBBF)	8	159.31	100%	1.39	63%	26.38	100%	2.26	50%	129.29	100%	97.07	100%	HBBF 2022
Rice cakes (HBBF)	10	236.21	100%	1.87	90%	11.70	100%	2.75	80%	219.90	100%	138.00	100%	HBBF 2022
Rice cereal - dry, As only, baby food (HBBF)	20	NT	100%	ND	0%	ND	0%	--	NT	134.15	65%	73.45	100%	HBBF 2017
Rice cereal - dry, baby food (FDA)	9	125.03	100%	3.17	44%	10.87	100%	2.00	100%	109.00	100%	72.80	100%	FDA 2020
Rice cereal - dry, baby food (HBBF)	13	122.85	100%	5.91	100%	11.15	100%	1.58	62%	104.21	100%	75.47	100%	HBBF 2017,2019,2022
Rice cereal - dry, prepared with water, baby food (FDA)	27	29.90	100%	1.80	4%	2.59	100%	0.56	11%	24.96	100%	17.30	100%	FDA 2017,2020
Rice-based teething biscuits and rusks (HBBF)	19	87.35	100%	7.44	100%	9.31	100%	1.58	74%	69.03	100%	51.90	100%	HBBF 2019,2022
Rice, white, enriched, cooked (FDA)	41	56.28	100%	ND	0%	6.43	100%	0.63	15%	47.39	100%	41.60	100%	FDA 2017,2020

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Seeds, sunflower, shelled, salted, roasted (FDA)	17	386.25	100%	ND	0%	379.35	100%	0.77	33%	4.68	76%	--	NT	FDA 2017,2020
Snacks, various - snack/fruit bars, cookies, yogurt - baby food (HBBF)	12	39.13	100%	10.10	100%	10.84	75%	0.22	58%	17.98	83%	39.00	100%	HBBF 2019
Spinach, fresh/frozen, boiled (FDA)	15	144.87	100%	6.03	67%	134.80	100%	0.60	20%	3.43	53%	--	NT	FDA 2017
Spinach, raw (FDA)	27	235.51	100%	6.81	78%	222.22	100%	0.56	11%	5.92	100%	--	NT	FDA 2020
Squash - baby food (FDA)	22	4.35	55%	1.82	9%	0.85	50%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Squash - baby food acorn (HBBF)	2	7.38	100%	3.90	100%	0.65	100%	ND	0%	2.43	50%	--	NT	HBBF 2022
Squash - baby food butternut (HBBF)	10	3.52	90%	1.42	80%	0.74	60%	ND	0%	1.03	10%	--	NT	HBBF 2019,2022
Squash - baby food pumpkin (HBBF)	1	7.77	100%	4.00	100%	1.10	100%	ND	0%	2.60	100%	--	NT	HBBF 2022
Squash - homemade baby food (HBBF)	9	5.38	89%	1.81	89%	0.74	44%	ND	0%	2.50	44%	10.60	100%	HBBF 2022
Squash, acorn, raw (HBBF)	2	15.40	100%	5.55	100%	2.50	50%	ND	0%	6.93	50%	10.60	100%	HBBF 2022
Squash, acorn/Hubbard, fresh/frozen, boiled (FDA)	15	10.87	93%	2.43	27%	4.60	87%	ND	0%	3.80	60%	--	NT	FDA 2017
Squash, raw, butternut (HBBF)	7	3.69	86%	1.16	86%	0.59	43%	ND	0%	1.51	43%	--	NT	HBBF 2022
Squash, summer, fresh/frozen, boiled (FDA)	15	5.17	73%	1.70	13%	1.93	73%	ND	0%	ND	0%	--	NT	FDA 2017
Squash, winter, fresh/frozen, boiled (FDA)	27	7.67	100%	ND	0%	2.16	93%	ND	0%	3.01	30%	--	NT	FDA 2020
Strawberry, raw/frozen (FDA)	42	16.53	100%	2.06	5%	10.50	100%	ND	0%	3.64	57%	--	NT	FDA 2017,2020
Sweet potato - baby food (FDA)	22	22.85	100%	16.32	100%	3.80	100%	ND	0%	2.54	36%	--	NT	FDA 2017,2020
Sweet potato - baby food (HBBF)	28	18.47	100%	10.66	100%	2.68	96%	ND	0%	4.92	96%	29.00	100%	HBBF 2019,2022
Sweet potato - canned (FDA)	14	20.57	100%	13.00	100%	3.64	100%	--	NT	3.93	71%	--	NT	FDA 2017
Sweet potato - homemade baby food (HBBF)	11	23.24	100%	14.86	100%	4.54	91%	ND	0%	3.51	55%	--	NT	HBBF 2022
Sweet potato - raw, peel removed (HBBF)	11	30.80	100%	20.10	100%	5.65	91%	ND	0%	4.63	55%	--	NT	HBBF 2022
Teething biscuit - organic rice* (HBBF)	1	465.28	100%	1.70	100%	5.40	100%	3.18	100%	455.00	100%	47.00	100%	HBBF 2022
Teething biscuits - grain not specified in FDA tests (FDA)	22	72.50	100%	18.36	95%	27.00	100%	ND	0%	26.95	100%	23.20	100%	FDA 2017,2020
Teething biscuits and crackers - non-rice-based (HBBF)	3	28.08	100%	3.40	100%	19.27	100%	ND	0%	5.08	67%	--	NT	HBBF 2019
Tofu, firm, plain, drained solids (FDA)	1	16.00	100%	ND	0%	12.00	100%	ND	0%	ND	0%	--	NT	FDA 2020
Tortilla, corn (FDA)	28	6.91	89%	ND	0%	1.60	89%	ND	0%	2.82	36%	--	NT	FDA 2017,2020
Tortilla, flour (FDA)	41	32.38	100%	2.51	12%	24.49	100%	0.61	4%	4.98	95%	--	NT	FDA 2017,2020
Turkey and broth/gravy - baby food (FDA)	22	4.11	14%	ND	0%	ND	0%	ND	0%	1.75	14%	--	NT	FDA 2017,2020
Turkey and rice - baby food (FDA)	22	17.57	100%	7.49	86%	3.48	100%	ND	0%	6.42	100%	--	NT	FDA 2017,2020
Turkey breast, oven-roasted (FDA)	42	7.42	55%	1.98	2%	0.55	10%	ND	0%	4.40	52%	--	NT	FDA 2017,2020
Turkey, ground, pan-cooked (FDA)	28	9.68	68%	ND	0%	1.10	57%	ND	0%	6.10	50%	--	NT	FDA 2017,2020
Vegetables and beef - baby food (FDA)	17	19.72	100%	2.97	29%	7.46	100%	0.53	6%	8.76	100%	--	NT	FDA 2017,2020
Vegetables and chicken - baby food (FDA)	17	18.79	100%	2.74	18%	7.63	100%	ND	0%	8.34	94%	--	NT	FDA 2017,2020
Vegetables and turkey - baby food (FDA)	21	18.04	100%	4.42	43%	6.63	100%	ND	0%	6.82	95%	--	NT	FDA 2017,2020
Veggie burger (FDA)	3	27.03	100%	4.13	67%	17.00	100%	ND	0%	5.40	100%	--	NT	FDA 2020
Veggie mixed - baby food (FDA)	22	18.45	100%	4.24	64%	11.79	100%	0.55	9%	1.87	18%	--	NT	FDA 2017,2020

APPENDIX C: Summary of Test Results for Heavy Metals from Six HBBF and FDA studies (continued)

Food	Total samples tested	Total metals (average, ppb)	Percent detect (any metal)	Lead (average, ppb)	Lead - percent detected	Cadmium (average, ppb)	Cadmium - percent detected	Mercury (average, ppb)	Mercury - percent detected	Arsenic, total (average, ppb)	Arsenic, total - percent detected	Arsenic, inorganic (average, ppb)	Arsenic, inorganic - percent detected	Study
Veggie mixed - baby food (HBBF)	3	16.60	100%	8.67	100%	4.57	100%	ND	0%	3.30	67%	--	NT	HBBF 2019
Walnuts, shelled (FDA)	23	9.22	96%	2.13	4%	0.57	13%	ND	0%	6.02	96%	--	NT	FDA 2017,2020
Water, baby, bottled - baby food (FDA)	8	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Watermelon, raw/frozen (FDA)	42	5.19	55%	1.86	2%	0.86	43%	ND	0%	2.14	21%	--	NT	FDA 2017,2020
Wheat cereal - dry, As only, baby food (HBBF)	8	NT	88%	ND	0%	ND	0%	--	NT	30.71	88%	16.56	88%	HBBF 2017
Wheat cereal - dry, baby food (HBBF)	1	96.97	100%	5.50	100%	50.80	100%	ND	0%	40.60	100%	39.00	100%	HBBF 2019
Yogurt, lowfat, fruit-flavored (FDA)	17	5.12	18%	3.03	18%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2017,2020
Yogurt, peach pear - baby food (FDA)	3	ND	0%	ND	0%	ND	0%	ND	0%	ND	0%	--	NT	FDA 2017,2020

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HBBF-EDF 2022 (Healthy Babies Bright Futures and Environmental Defense Fund). 2022. Lead in canned fruit. www.healthybabyfood.org (see Resources).

APPENDIX D:

The details – Food by food, HBBF's analysis and recommendations

Fruits

Choose fresh and frozen fruit over canned and dried. FDA found lead 30 times more often in canned fruit than in fresh and frozen fruit.

For this reduction in heavy metal concentration	serve this	instead of this
30X less likely to contain lead*	Fresh and frozen fruit	Canned fruit
Lower lead means lower total heavy metals. For example:		
36% ↓	Fresh pears and baby food brand pears	Canned pears

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Our tests – Are baby food brands or homemade purees better?
Both are recommended, with relatively low levels of heavy metals.

Top tips: Limit dried fruit (high metals) and canned fruit (higher lead). Eat cantaloupe, but not every day (moderate metal levels).

We tested baby food brands and fresh fruit for apples, pears, and bananas. Levels in store-bought baby food, homemade purees, and fresh fruit are all low and lie within a 3-ppb range for each fruit.

Not all forms of fruit have low levels. Higher amounts are found in dried and canned fruits. Levels in raisins, for example, are more than four times the amounts found in grapes. Add to that dried fruits' reputation as a choking hazard for babies and a concentrated source of fruit sugars in their diet, and fresh fruits and purees emerge as a clearly better choice.

Canned fruit is also not the best option. FDA found lead 30 times more often in canned fruit than in fresh and frozen fruit, according to an analysis of the most recent results from the agency's national food testing program (2014-2017). Only 1 of 31 fresh or frozen samples of fruit (pears, pineapple, and peaches) had detectable lead (a fresh pear) compared to 41 of 42 for the canned versions (EDF 2020). Available tests found 4 times more lead in canned pears than in fresh and baby-food pears, on average.

Cantaloupe is loaded with nutrients but has higher heavy metal levels than other fresh fruits, nearly 4 times the average amount in other popular fruits consumed by babies (including apples, bananas, pears, peaches) according to available tests. Arsenic and cadmium drive the higher levels. We recommend keeping this nutritious food on the menu but serving it less than daily in rotation with other fruits. FDA has not tested other melons (except for watermelon, which is low in metals), but it would be prudent for parents to offer them in the same way, in rotation with other fruits.

Vegetables

Peas, green beans, and butternut squash are reliably low in heavy metals, in baby food and fresh/frozen forms. For other vegetables, follow the tips below.

For this reduction in heavy metal concentration...	serve this...	instead of this.
43% ↓	Variety of vegetables	Carrot, potato, or sweet potato every day
14% ↓ arsenic	Peeled carrot	Unpeeled carrot
7-17% ↓ lead, cadmium	Peeled sweet potato	Unpeeled sweet potato

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Our tests – Are baby food brands or homemade vegetable purees win? Both are recommended.

Top tips: To remove surface metals, wash all produce under cold running water for 20 seconds, scrubbing those with tough skins using a vegetable brush or your hands (CR 2020).

- Carrots potatoes, and sweet potatoes: Eat each one less than daily; rotate with other vegetables. For fresh produce, vary each type – choose different brands or varieties or from different stores from week to week to avoid accidentally eating a high-metals source often.
- Peel carrots, sweet potatoes, and potatoes to remove heavy metals concentrated in the peel.
- Serve baby food squash or homemade puree made from butternut squash.
- Serve spinach but not as a daily staple, to limit cadmium exposure. Choose baby spinach for less cadmium.

HBBF tested baby-food brands and homemade purees, including five types of vegetables – green beans, peas, squash, carrots, and sweet potatoes. We analyzed FDA's tests for those and many additional vegetables, including potatoes, summer squash, and three types of greens. We also reviewed 27 peer-reviewed studies to assess if cooking, washing, and peeling help lower heavy metal levels. And finally, we conducted our own simple kitchen experiments to estimate the benefits of peeling carrots and sweet potatoes.

For four vegetables we tested – peas, green beans, carrots, and sweet potatoes – we recommend both baby food brands and homemade purees. For squash we recommend butternut squash for both baby food brands and homemade purees.

All but 2 vegetable samples we tested (a jar of baby food squash and one fresh squash) contained one or more heavy metals, and most samples contained arsenic, lead, and cadmium in combination. Mercury was detected in only a few samples. Relative amounts of metals varied from one vegetable type to another. We discuss our findings below.

Vegetables – impacts of cooking and peeling. Studies show that cooking can reduce heavy metal concentrations in food. But the reductions come at a price – these actions remove nutrients as well. When cooking strips water-soluble metals from vegetables, it also leaches out water-soluble nutrients like vitamin C and the B vitamins. Longer cooking times with greater water contact, as in boiling, remove more of these compounds than methods like microwaving and steaming (Lee 2019).

Among studies showing cooking's impact to heavy metal levels are tests demonstrating a 39% and 15% decline in arsenic in potatoes and string beans, respectively, after boiling (Perello 2008) and a 54% reduction in lead in sweet potato noodles after boiling (Lee 2019).

Tests considered in this study included boiled and fresh samples; heavy metal levels reflected the expected difference. FDA tests considered in this study (FDA 2017, 2020) show similar heavy metal levels between the two types of cooked foods tested for some vegetables, baby food brands (made of cooked vegetables) and family-style boiled vegetables (Appendix C). In our tests, baby food brands are somewhat lower in heavy metals than the fresh purees we tested. Our fresh purees are not boiled, but are instead consistent with a cooking method like steaming or microwaving that preserves more of the heavy metal content (Moisture was adjusted in these purees to mirror the water content of baby foods, but samples were not cooked to leach out metals; see Appendix F.) The raw, fresh vegetables we tested had higher metal levels than our homemade purees or baby food brands.

Like cooking, peeling can also lower the average concentration of some metals in vegetables like carrots, potatoes, and sweet potatoes, according to studies conducted largely outside the U.S. (Appendix E). It carries a cost as well, removing nutrients that are concentrated in peel, including, for example, half of a carrot's phytonutrients (Tufts University 2018).

Our recommendations for parents: Baby food brands, homemade purees, and fresh or frozen vegetables are all recommended. Peas, green beans, and butternut squash are reliably low in heavy metals, in baby food and fresh/frozen forms. We advise that parents choose butternut squash over other squash varieties for both baby food and fresh produce, and baby spinach over regular spinach, for lower metal amounts. Metal levels in carrots, potatoes, and sweet potatoes are relatively high compared to other vegetables; we recommend keeping these nutritious foods in the diet but serving each one less than daily. Because of high spikes in some of the carrots and sweet potatoes tested, we suggest varying the type that you purchase if possible, choosing a different variety or from a different store from week to week, to avoid serving a high-metals source often. Also because of high spikes, we recommend peeling until U.S.-based research is available to reassess.

For vegetables, the answer to heavy metal contamination isn't as simple as "eat this, not that" or "prepare it this way." Vegetables with the highest heavy metal levels are among the most nutritious, including carrots and sweet potatoes. Avoiding them is not the best option. At-home actions like peeling and cooking remove nutrients along with the metals. Parents should not need to consider whether nutrient loss from boiling or peeling is an acceptable price for heavy metal reduction. FDA, food companies, and growers should instead lower the levels upstream of supermarkets.

Food companies and growers can test, set standards, optimize soil chemistry, and choose varieties that take up less metals (e.g., Schaefer 2020, USDA 2022). Until these solutions are ingrained along the supply chain, parents can take the simple steps below, supported by available data, to reduce babies' exposures to heavy metals in higher metals vegetables like carrots and sweet potatoes.

Peas. In our tests heavy metals were low in all types of peas sampled, with a difference of less than 2 ppb between baby food brands and homemade purees on average. Both are recommended for babies. We tested baby-food samples and bags of frozen peas. Our results were similar to those of FDA's national market basket testing, which included baby food and boiled fresh or frozen samples (Appendix C).

Green beans. Both baby food brands and homemade purees are recommended. We tested baby-food green beans and bags of frozen green beans; FDA tested baby food, canned, and boiled fresh or frozen samples. Metal levels are also relatively low in all types of green beans tested. Baby food brands and cooked (boiled and canned) samples show similar, low amounts of metals (Appendix C). Raw green beans and our homemade purees (simulating a cooking method like steaming with limited water contact) have somewhat higher amounts. But metal levels in all samples are well below amounts in vegetables like potatoes, sweet potatoes, and carrots.

Carrots. Both baby food brands and homemade purees are recommended. Preparation makes a marginal difference in heavy metal content of carrots, based on limited available studies conducted mostly outside the US. Peeling removes an estimated 14% of the total mass of arsenic from the vegetable (arsenic is concentrated in the peel). But arsenic comprises only a fraction of carrots' total metal content, 14% in our tests of fresh carrots, on average. Peeling is unlikely to significantly reduce either lead or cadmium, the dominant metal in carrots. These metals do not appear to be concentrated in peel to the same extent, and at least one study finds lead concentrated in the flesh, not the peel (see Appendix E and Dartmouth 2022).

Removing the peel shaves off nutrients that are concentrated there. It removes about half of a carrot's phytonutrients and some vitamin C and niacin (a B vitamin) as well. It has little impact on minerals concentrated in the core of the carrot, though, including calcium, potassium, magnesium, and phosphorus (Tufts University 2018). On balance, we consider it prudent to peel carrots before eating, pending rigorous study of carrots sold in the U.S.

For parents purchasing fresh carrots, we recommend varying the type, choosing different brands or varieties or from different stores from week to week to avoid accidentally eating a high-metals source often. HBBF's tests show a 15-fold difference in cadmium between the highest and lowest levels measured in fresh carrots (90.6 versus 6.0 ppb), suggesting that some sources or varieties have far more cadmium than others. Recent U.S.-based research found that metal levels vary by carrot type, with a 10-fold difference in arsenic and 31-fold difference in cadmium found among 726 carrot varieties tested (USDA 2022).

Sweet potato. Both baby food brands and homemade purees are recommended. Average total heavy metal levels are within a 3-ppb margin for baby food brands and cooked (canned) sweet potatoes. Levels are higher for homemade purees that assume a cooking method like microwaving that would preserve heavy metals, but still within 5 ppb of amounts in baby food brands.

Scrubbing under tap water is recommended to clean off surface soils that can contain metal contamination. Peeling may help to some extent, according to the study we identified on this issue. Conducted in a contaminated region of China, it indicated that peeling could remove an estimated 6 to 9% of the total amount of lead and cadmium in a sweet potato (Appendix F). Peeling carries a nutritional cost, as the peel has nearly 10 times the antioxidant power of the flesh (Padda 2008).

Nearly all peeling studies we identified were conducted outside the U.S. with vegetables grown in unusually contaminated soil. U.S.-based teams at major agricultural research centers have only recently launched research to identify low-metal varieties and to understand the impact of peeling on vegetables available in the U.S. (USDA 2022, Villordon 2022). The studies hold promise to inform growers, baby food companies, and consumers on preferred varieties and preparation methods specific to the U.S. market.

Of the 11 whole sweet potatoes we tested, 4 had notably high heavy metal concentrations, 19 times higher than the 7 remaining samples, on average (50.5 ppb versus 2.7 ppb). Variety and state or country of origin were not always available at retail, giving us no way to assess possible causes for the difference. Because of the variation in concentration, we recommend that shoppers vary the type they purchase, choosing different brands or varieties or from different stores from week to week to avoid accidentally eating a high-metal source often. Because of both the variation and the lack of peeling data for U.S. varieties, we recommend peeling before eating.

Nutritionists recommend that sweet potatoes be boiled instead of baked or fried, to retain beta-carotene (a form of vitamin A) and make it more absorbable. They advise that to maximize nutrients, cooking time should be limited (e.g., boil with a tight lid for 20 minutes) and with the skin on to minimize leaching of both vitamin C and up to 92% of beta-carotene (Harvard 2022). The impact to heavy metal content for this method of cooking is not available in the studies HBBF reviewed.

Researchers have noted a lack of basic knowledge regarding heavy metals and sweet potatoes. They have little baseline data on metal levels in the vegetable and soil, and do not yet understand either genetic influences or the factors that drive the uptake of metals (USDA 2022). Studies are underway to fill these data gaps and get lower-metal sweet potatoes in stores in future years.

Potatoes. We did not test potatoes, but FDA's tests found 38% lower heavy metal levels in peeled, boiled potatoes versus unpeeled, baked potatoes, on average (Appendix C). Both boiling and peeling would remove metals and could lie behind the difference. Studies we reviewed found arsenic, lead, and cadmium more concentrated in the peel than the flesh (Appendix E), with cadmium dominating. Concentrated metals could be removed by peeling the potatoes to at least a depth of 1 mm (Norton 2015), approximately the depth for a standard kitchen peeler (Appendix F). As for carrots and sweet potatoes, we recommend peeling and varying the type of potato purchased, buying different varieties or from different stores from week to week.

Squash. Metal levels in squash are low in the baby food brands tested by both HBBF and FDA. Baby food brands usually contain butternut squash, according to HBBF's review of ingredient labels (Appendix C). Tests show low levels in fresh butternut squashes as well. But tests indicate higher levels in winter squash, including acorn and Hubbard varieties. FDA found heavy metal levels nearly 2.5 times higher in boiled Hubbard and acorn squash than in baby food squash. HBBF tested only a small number of fresh squash samples, but the total heavy metal level in acorn squash averaged 4 times higher than amounts in butternut squash. Because of the differences these data show, we recommend butternut squash for babies, either baby food brands or homemade puree.

Spinach – Spinach is known for its nutritional benefits, but it also has high cadmium levels, more than any other food tested by HBBF and topped only by sunflower seeds' cadmium amount from the far longer list of FDA-tested foods. Much of the spinach in the U.S. is grown in California's Salinas Valley, parts of which have naturally high soil cadmium levels and produce greens that are particularly high in cadmium (Chaney 2012). The state requires that spinach with cadmium above a health-based threshold be labeled to warn consumers that it contains the metal, which California has determined can cause developmental toxicity (OEHHA 2021). Concerns about cadmium may be mitigated by its low absorption rate; see Section 2 of the main report and the discussion below regarding high cadmium in protein sources.

Scientists from UC Davis are breeding lines of spinach that uptake less cadmium (Melotto 2020), and a USDA team has found a 2-fold difference in cadmium uptake among 90 varieties that are currently available to growers (USDA 2022). But until that work leads to cleaner spinach in stores, we recommend limiting this nutritious food, keeping it on the menu but not in the daily staple role of other greens. We recommend baby spinach over full-size spinach, based on research showing that younger spinach has lower cadmium for all cultivars tested (USDA 2022).

Drinks

Juices are an avoidable source of heavy metals.

For this reduction in heavy metal concentration...	serve this..	instead of this
>90% ↓	Filtered tap water	Grape juice*
76% ↓	Tap water	Grape juice*
52% ↓		Pear juice*
39% ↓		Apple juice

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Our tests – Are baby food brands or family brand juices better?

Levels for baby-food juices and family brands are similar for the 3 juices we tested (apple, pear, and grape), within 1 ppb.

Top tip: No juice for children under age 1. Juices are high in calories and sugar and lack the fiber and nutrients found in whole fruit. Tap water (for older babies) and whole fruit are better choices. Test your tap water for lead and filter it if lead is detected, especially during pregnancy or if using it to make infant formula (leadkit.hbbf.org).

Apple, pear, and grape juices contain traces of lead and arsenic. Grape juice has notably high levels of both, and pear juice also contains cadmium. Levels in juice 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. We recommend testing your tap water for lead and filtering if needed (HBBF 2022). Another alternative is whole or pureed fruits (like applesauce), which offer less sugar and more fiber and nutrients than juice. If juice is served, stick to 100% fruit juice and avoid grape juice; it has more than twice the heavy metal levels of pear juice and three times the levels in apple juice, on average. The American Academy of Pediatrics (AAP) found that "Fruit juice offers no nutritional benefit to children

under age 1 and should not be included in their diet." AAP warns parents of juice's high caloric and sugar content, recommends no fruit juice before age 1, and advises that if offered to toddlers, it be included as part of a meal, not sipped over time, to reduce tooth decay risk (AAP 2017a,b).

Meat, Beans, Eggs, Nuts, Seeds, and their Butters

Sunflower seeds have more cadmium than any other food we assessed. Peanut butter has more lead and arsenic than baby food brand meats.

For this reduction in heavy metal concentration...	serve this...	instead of this.
69% ↓ lead and inorganic arsenic	Baby food brand meats*	Peanut butter

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Are baby food brands or homemade and family brands better? It's a tie, according to FDA's national market basket tests, summarized in Appendix C.

Top tip: Serve a variety of lean meats, baby-food brand meats, and eggs. Serve peanut butter less often than daily. Eat sunflower seed butter (and seeds) rarely. FDA has tested only one sample of tofu (low levels). Veggie burgers have moderate levels according to FDA tests, but the ingredients are not specified. Bean-based burgers would be expected to have lower metal levels than veggie burgers that contain significant amounts of sweet potatoes or other vegetables with moderate metal levels.

Eggs, beans, and baby food brand meats tested by HBBF and FDA are low in heavy metals. Two nut- and seed-based foods tested, on the other hand (peanut butter and sunflower seeds), are surprisingly high in cadmium, giving them a much higher total heavy metals level than other protein sources. Peanut butter is also relatively high in lead and arsenic.

Sunflower seeds have 96 times more cadmium than a key protein source for babies, baby food brand meats. Peanuts and peanut butter are also near the top of the list for high cadmium, with levels topped only by rice and greens. FDA has not tested sunflower seed butter, but like the seeds, it is expected to be high in cadmium, judging from the fact that peanut butter's high cadmium level is similar to that of peanuts. In fact, sunflowers accumulate heavy metals to such an extent that they are used to clean up highly contaminated soil (e.g., CBC 2014).

However, far less cadmium may absorb into the body after a meal – between 3 and 44% (Schaefer 2020, Vesey 2010) - compared to metals like arsenic and lead, which are almost completely absorbed. Available research indicates gender-based differences in absorption, with an average absorption rate of about 5% for men and 10% for women. Evidence of cadmium's toxicity to the developing brain is compelling but more limited than the extensive body of studies available for lead and arsenic. And studies are not available to indicate how much cadmium absorbs into an infant's body after a meal, or when infants are deficient in nutrients known to block cadmium absorption. Until research gaps are filled, we recommend caution when it comes to serving these foods.

Unlike peanuts, peanut butter, and sunflower seeds, meats are relatively low in heavy metals. Meats mixed with grains and vegetables have higher amounts. For all these foods, follow the general recommendation to serve a variety, since offering the same food daily for a long time can accidentally concentrate a particular contaminant in the diet.

Grilled and charred meats raise red flags in a baby's diet not for their metal content but for contaminants that cause similar types of harm. They contain toxins called PAHs that, like metals, can harm the developing brain and nervous system. PAHs are formed when meat fat burns and when meat is charred. To cut exposures choose lean meat, trim fat before cooking, marinate before grilling, and partially pre-cook in the microwave if possible. Using a drip pan and foil when grilling to capture drips and reduce flare-ups keeps the flavor with fewer toxins. Keeping the grill clean – scraping the charred buildup off before cooking – helps as well. Boiling, stewing, and microwaving are alternate ways to cook that also cut PAH exposure.

Cereal and Grains

Rice can be grown in ways that cut arsenic in half, but our tests show that this shift still hasn't been made. Rice-based foods still have more inorganic arsenic than any other food we have tested.

Rice, ranked from high to low for inorganic arsenic level
1 - Avoid: Brown rice (highest)
2 - Avoid: White rice grown in Arkansas, Louisiana, Texas, or simply "U.S."[1]
3 - Better: Basmati rice from California, India, Pakistan. Sushi rice from U.S.[1]
4 - Best choice for rice: White rice cooked in extra water poured off before eating, using rice listed in #3 above (lowest)
5 - Better still: Eat a variety of grains. Try amaranth, quinoa, buckwheat, millet, and polenta (all gluten-free), or bulgur, barley, and farro (these contain gluten).

[1] CR 2014

For this reduction in heavy metal concentration...	serve this...	instead of this
46% ↓	Infant rice cereal	White rice (with no extra cooking water used)
Better still:		
75% ↓	Oatmeal (baby food or family brand)	Infant rice cereal
62% ↓	Multi-grain infant cereal	Infant rice cereal

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Our tests – Did baby food brands or family-style foods win?

For oatmeal it's a tie – average levels are within 1 ppb. Infant rice cereal had lower metal levels than rice (the ingredient in homemade infant rice cereal), but the gap would close if rice were cooked in extra water.

Top tip: Rice and quinoa rise to the top as grains with relatively high heavy metal levels. For babies, serve oatmeal and multi-grain cereals instead. For the family, serve a variety of grains. If you're serving rice, choose from the lower-metals sources listed here, and cook it in extra water poured off before eating to remove some of the arsenic.

Infant rice cereal and rice

Rice and rice-based foods' high total heavy metals level is dominated by inorganic arsenic, the most toxic form of arsenic. These foods have more of it than any other food tested by HBBF and FDA.

Rice, in contrast with other grains, readily absorbs and concentrates arsenic from soil and water. It concentrates about 10 times more arsenic than other grains used in infant cereals (Davis 2017). Rice is also often grown where arsenic is abundant in soil, magnifying the problem. And it is usually cultivated in flooded fields; under these conditions, arsenic is prevalent in the form (trivalent) that is most toxic to humans and most easily accumulated by rice.

Infant rice cereal is the top source of inorganic arsenic in infant's diets. An HBBF study of infant cereals found that leading brands of infant rice cereal have 6 times more arsenic, on average, than non-rice and multi-grain varieties, including oatmeal and multi-grain (HBBF 2017). The situation is improving:

- FDA finally finalized their action level of 100 ppb for inorganic arsenic in infant rice cereal, four years after its issuance in draft and following sustained pressure from HBBF, Consumer Reports, and other public health organizations (FDA 2020b). The level is guidance, not mandatory, but the agency can choose to use it to deem a cereal adulterated, to limit an import, or encourage a company-led recall.
- Infant brown rice cereal is no longer offered by major baby food companies. Gerber exited first; our shoppers last found their product in stores in 2016. Earth's Best and Happy Family have also discontinued it. We found their brown rice cereals on store shelves in 2019 but not 2021. Smaller companies

that include Biokinetics and Healthy Times have followed suit. We last purchased their brown rice cereals for testing in 2019, but it is no longer available. Brown rice cereal has an average inorganic arsenic level 40% higher than that of white rice cereal; its absence from store shelves is a welcome change.

- Beech-Nut completely exited the rice cereal market in 2021 after the state of Alaska's testing found inorganic arsenic levels above FDA's 100 ppb action level (FDA 2021c). Beech-Nut had offered a white rice cereal for infants that was widely available in stores.
- Three states have taken infant rice cereal off the list of approved foods for the Women, Infants and Children (WIC) supplemental food program, led by Oregon in February 2019 and followed by Hawaii and Alaska. WIC serves nearly half of all infants in the U.S., so these state-wide changes are a major boon for babies' health (Bettin 2020, Hawaii WIC 2019, Alaska WIC 2020). The U.S. House Committee on Oversight and Reform has urged USDA to remove infant rice cereal from the WIC program, an action that would encompass all U.S. states and territories (Krishnamoorthi 2021).

As a result of these actions and sustained attention to the problem of arsenic in rice, infant rice cereal's share of the infant cereal market dropped sharply, from 37% in 2008 to 24% in 2018 (USDA 2022).

Parents can still purchase infant brown rice cereal, even though U.S. brands have stopped selling it. Some products are available online, including Slurrp Farms cereal from India. Given the prevalence of high inorganic arsenic in infant brown rice cereals we have tested – with an average just over 100 ppb – we recommend that parents steer clear of these online sources and choose iron-fortified oatmeal or multi-grain cereals instead.

Available data show that certified organic rice and organic infant rice cereal have higher levels of arsenic than conventionally grown, non-organic rice and rice-based foods. However, the specific, highly toxic form of arsenic (inorganic arsenic) is no higher in organic than in conventionally grown rice (USDA 2022). The accumulation of arsenic happens in organically grown rice because the fields are flooded for long periods of time to control weeds, and the soils tend to be richer in organic matter; both conditions increase arsenic uptake in the plant.

FDA research and other published studies show that cooking rice in extra water can remove 40 to 60% of the inorganic arsenic. Similar to how pasta is cooked, 1 part rice is cooked in 6 to 10 parts water that is drained off after cooking. This comes with a downside – it strips off 50-70% of the vitamins and minerals added to white rice to make it nutritious, including folate, iron, and niacin and thiamine (B vitamins). Rinsing rice is not helpful – it removes minimal arsenic and washes off added nutrients (FDA 2022b).

HBBF has called on FDA to reduce the action level to protect babies' neurological development. In setting the current limit 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). Rapid action by FDA to set a protective level would protect children from high levels of arsenic in rice.

Snacks

Baby-food puffs have 18 times more heavy metals than other baby-friendly snacks, on average.

For this reduction in heavy metal concentration...	serve this...	instead of this
59% ↓	Oat-ring cereal	Puffs (rice-based)
Better still:		
95% ↓	Apples, applesauce (unsweetened), bananas, beans, cheese, grapes (cut lengthwise), hard-boiled eggs, peaches, and yogurt	Puffs (rice-based)

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Our tests – Are baby food or family food brands better?

Our tests pitted puffs from the baby-food aisle against oat-ring cereal. The cereal had far lower heavy metal levels.

Top tip: Avoid rice-based baby food puffs, which are contaminated with significant levels of inorganic arsenic. While oat-ring cereal is a better choice, it still contains significant amounts of arsenic, lead, and cadmium. We recommend baby-friendly snacks that are low in heavy metals, including applesauce, bananas, hard-boiled eggs, yogurt, and other foods on our preferred snack list on page 9.

Teething foods - Rice cakes, teething biscuits, and rusks

Rice cakes stand out as a food to avoid for children and adults alike, with higher amounts of inorganic arsenic, the most toxic form of arsenic, than any other food we tested.

For this reduction in heavy metal concentration...	serve this...	instead of this
60% ↓	Rice-based teething biscuits and rice rusks from the baby food aisle	Rice cakes
Better still:		
95% ↓	Frozen banana	Rice-based teething biscuits and rusks
75% ↓	Peeled, chilled cucumber*	
36% ↓	Non-rice teethers and crackers	

Source: HBBF analysis of 288 tests conducted for this study and additional results from FDA 2017, 2020 and 2022; HBBF 2017, 2019; and HBBF-EDF 2022. Reductions shown correspond to total heavy metals (the sum of lead, cadmium, mercury, and inorganic arsenic) except as otherwise noted. See Appendix C for test results.

Our tests – Are baby food brands or family-style brands better?

Baby food biscuits and rusks have far lower metal levels than rice cakes.

Top tip: Skip rice-based foods, including rice cakes and baby food biscuits and rusks. To soothe teething opt for a frozen banana or peeled, chilled cucumber.

Averaging 138 ppb, inorganic arsenic in rice cakes exceeded amounts in all other high-arsenic foods we tested, including rice-based teethers, puffs, and white rice (with 52, 80, and 97 ppb inorganic arsenic on average, respectively). It also topped the 100-ppb cap FDA imposed for infant rice cereal.

Rice cakes are a popular snack sometimes served to older babies who can handle the crunchy texture, including as a teething food for babies who have learned to chew with their back gums. But arsenic levels in rice cakes are so high that this food should be avoided altogether, for teething or snacking. In our tests we found far lower metal levels in rice-based teething biscuits and risk rusks from the baby food aisle, which offer a 60% reduction in total heavy metals compared to rice cakes. Non-rice teethers and crackers had even lower levels; choices include graham, saltine, and butter-style crackers.

But even these alternatives contain significant amounts of arsenic, lead, and cadmium – and they lack nutrients and can contribute to tooth decay as well. Doctors and dentists recommend other solutions for baby teething pain (Colgate 2020, AAP 2014). Options include a frozen banana or a peeled and chilled cucumber, both of which have far lower metal levels. Parents can also offer a clean, cold wet washcloth or spoon. Healthcare professionals advise parents to stay with their baby regardless of the food or object, to watch for any choking.

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APPENDIX E:

Studies of food preparation methods to reduce heavy metals

Washing, cooking, and peeling can influence heavy metals concentrations in food. Representative published studies reviewed by HBBF in developing the recommendations in this report are listed below.

Action	Food(s)	Metals(s)	Study finding	Action details	Location and conditions	Retail samples or Non-retail	Reference
Carrots							
Cooking	Carrot	Lead and cadmium	The traditional cooking method reduced lead content by 6-47% and cadmium content by 35-44%.		Poland - Samples from Warsaw market and fields in upper Silesia	Retail and field crops	Wieczorek 1997
Peeling	Carrot	Arsenic	Arsenic levels in carrot peel are 1.8 - 3.3 times higher in peel than flesh. Peeling would reduce levels in the carrot but the low weight of the peel would lead to only a small decrease.Values for carrot peel were 0.88, 0.72, 2.71, and 5.32 mg kg−1 for 4 types of soil, compared to values of 0.30, 0.40, 1.72, and 1.61 mg kg−1 for peeled carrot roots grown on the same soils. The higher levels of As in the peel compared to the peeled root may be from direct contact between the root and the lead arsenate contaminated soils, even though the carrots were washed thoroughly before peeling. Alternatively, the cells of the peel layer may accumulate As to higher levels than do other carrot cells. Nevertheless, peeling carrot roots before eating should not have a substantial effect on the intake of total As due to the low weight of the carrot peel with respect to the total weight of the carrot (Munoz et al., 2002).	Roots were scrubbed using a vegetable brush, washed in sodium lauryl sulfate, rinsed multiple times with de-ionized water to minimize the presence of soil particles in the carrot peel layer before peeling.	US - Soil from four orchards with a history of lead-arsenate pesticide use, used to grow three common carrot cultivars in the laboratory.	Non-retail (laboratory grown)	Codling 2014
Peeling	Carrot	Lead	Peeling is not effective in reducing Pb in carrots. Pb was consistently higher for peeled carrot roots than for peel. This result was unexpected because researchers initially assumed that soil contamination of the peel was responsible for Pb in root vegetables such as carrots. The high levels of Pb within peeled carrot roots might be explained by the presence of xylem vessels that adsorb Pb on their surfaces. Additionally, the formation of lead phosphates within the xylem may trap Pb in storage roots.	Roots were scrubbed using a vegetable brush, washed in sodium lauryl sulfate, rinsed multiple times with de-ionized water to minimize the presence of soil particles in the carrot peel layer before peeling.	US - Soil from four orchards with a history of lead-arsenate pesticide use, used to grow three common carrot cultivars in the laboratory.	Non-retail (laboratory grown)	Codling 2014
Peeling	Carrot	Arsenic	Peeling would help lower arsenic levels in carrots. As concentration in carrot peel was 2 to 7 times higher than that of peeled carrot roots.	The roots were rinsed thoroughly to remove all visible soil particles in order to prevent soil contamination. The carrots were separated into peel and core, and the samples were shredded and freeze-dried.	Denmark - Carrots were grown in seven experimental plots containing mixtures of arsenic-contaminated (from former wood preservation site) and uncontaminated soil	Non-retail (field experiment)	Hegelson 1998
Peeling	Carrot	Arsenic	Arsenic is concentrated in peel, but peeling carrot roots before eating should not have a substantial effect on the intake of total metals due to the low weight of the carrot peel compared to the total weight of the carrot. Total and inorganic arsenic concentrations in peel are 3 and 2 times, respectively, those of the interior of the carrot.	Samples were cleaned by shaking them to remove soil and then cleaning with deionized water (method not described) prior to peeling.	Chile - area with volcanic soils naturally high in arsenic	Field samples	Munoz 2002

Action	Food(s)	Metals(s)	Study finding	Action details	Location and conditions	Retail samples or Non-retail	Reference
Peeling	Carrot	Lead and cadmium	Cadmium and lead levels in peeled carrots were approximately 90% of concentrations found in unpeeled carrots (n=32), but the differences were not statistically significant.		UK - Locally produced fruit and vegetables from retail outlets in SW and NE Britain, and field crops and soil from SW. Samples were washed in kitchen skin with tap water. Peeled and unpeeled potatoes and root vegetables were prepared. Samples were prepared as commonly consumed.	Retail and field crops	Norton 2015
Peeling	Carrot	Arsenic	Peel constituted 16.5% of total weight of medium carrot. Assuming twice the arsenic contration in peel vs flesh gives 14% reduction in arsenic exposure for peeled vs unpeeled carrot.	Scrubbed and washed in tap water, dried, and peeled with standard kitchen peeler. Weight measured in grams using kitchen scale.	Carrot purchased at retail in Maryland, sourced from Israel.	Retail	Appendix D of this study
Peeling	Carrot	Lead, arsenic, cadmium	In composite samples from Chile and Spain, carrot peel contained significantly more Cd, As, and Pb than the flesh - 1.6, 3.1, and 1.8 times, respectively.	Samples were peeled with plastic knife. Washing for sample preparation was not discussed.	Market samples from Northern Chile (Chiu region, contaminated by copper mining) and Madrid, Spain	Retail	Pizarro 2016
Peeling	Carrot	Lead and cadmium	Peeling eliminates up to 25% lead and about 19% cadmium. Peel contains 2 to 3 times more lead and cadmium than the interior of the carrot.		Poland - Samples from Warsaw market and fields in upper Silesia. Upper Silesia is industrial area known for metal contamination.	Retail and field crops	Wieczorek 1997
Soaking	Carrot	Lead and cadmium	Soaking carrot for 24 h resulted in 40% decrease in lead and 67% decrease in cadmium.	Soaking for 24 hours	Poland - Samples from Warsaw market and fields in upper Silesia	Retail and field crops	Wieczorek 1997
Washing and Peeling (not effective)	Carrot	Lead	Cleaning methods did not significantly affect lead concentrations in carrots. Peeling also did not statistically change lead concentrations in carrots. Researchers speculate that cleaning methods were not effective in reducing lead levels because lead is concentrated in carrots' core. Concentrations in peel versus flesh are not provided.	Two cleaning methods were compared: Laboratory cleaning - rinsing with tap water, deionized water, sodium laurel sulfate solution, then deionized water again, to remove all adhering soil dust particles from produce surface; Kitchen-style cleaning-only tap water, removing all visible soil particles. Peeling was accomplished by removing a very thin outer layer of the carrots.	MIssouri - Urban community garden with lead-contaminated soil	Non-retail (community garden)	Attanayake 2014
Potato							
Peeling	Potato	Arsenic	Arsenic is concentrated in peel. Peeling could help reduce exposures. Total and inorganic arsenic concentrations in peel are 3 and 2 times, respectively, those of the interior of the potato.	Samples were cleaned by shaking them to remove soil and then cleaning with deionized water (method not described) prior to peeling.	Chile - area with volcanic soils naturally high in arsenic	Field samples	Munoz 2002
Peeling	Potato	Cadmium	Cadmium is concentrated in the peel, with median amount 2.3 times greater and average 7.5 times greater, among 25 samples of 9 potato varieties grown in 5 areas.	Peel was removed from potato. Samples were rinsed in distilled water.	Brazil - Mato Grosso and Minas Gerais States	Field experiment	Corguinha 2012
Peeling	Potato	Cadmium	Cd concentration in potato peel was double that in peeled tubers and decreased with increasing soil pH.		UK - Sewage sludge-treated agricultural soils		Stasinos 2014, citing Smith 1994
Peeling	Potato	Cadmium	Cd concentration in potato peel was higher than in peeled tubers.		Czech Republic - agricultural research field with application of cattle slurry and mineral-based fertilizers	Non-retail (field experiment)	Stasinos 2014, citing Šrek et al. 2012

Action	Food(s)	Metals(s)	Study finding	Action details	Location and conditions	Retail samples or Non-retail	Reference
Peeling	Potato	Lead and cadmium	Cadmium and lead are concentrated in the peel, with levels 2.9 and >20, respectively, compared to flesh. Concentrated lead in peel may be influenced by the source area's extensive mining history and high background lead levels in soil. All tested samples exhibited higher lead concentrations, and most exhibited increased concentrations of cadmium in the potato skin compared to the flesh. In 20 potato samples average levels in peel and flesh were 23.7 vs 8.3 ppb for cadmium and 163 vs <8 ppb for lead.	Samples were washed in tap water at a kitchen sink, diced in a food processor and frozen prior to further homogenization. Both peeled and unpeeled samples were prepared.	UK - Locally produced fruit and vegetables from retail outlets in SW and NE Britain, and field crops and soil from SW. SW area, the source of potatoes measured for lead in peel, is an area with extensive mining history and high soil lead levels. Samples were washed in kitchen skin with tap water. Peeled and unpeeled potatoes and root vegetables were prepared. Samples were prepared as commonly consumed.	Retail and field crops	Norton 2015, 2022
Soaking	Potato	Lead and cadmium	Soaking the in vinegar after washing and peeling removed more Pb and Cd than washing and peeling alone. Reductions increased following soaking, for Pb from 84% (post washing and peeling) to 92% after soaking, and for Cd from 63% to 81%. Researchers speculate that vinegar chelates metals from the sample.	Washing with tap water and soaking in vinegar solution (5%) for 5 min	Egypt - Sample source not described.	Not available	Abdel-Rahman 2018
Washing	Potato	Cadmium	Over 50% of Cd found in intact tubers was probably due to contamination of the tuber surface with soil particles. Fine soil particles enriched in metals strongly adhered to tuber surface and were not removed even by careful washing.	Plant samples were washed in deionized water, transferred to paper bags, and dried in an air-forced oven at 60°C for 48 h.	Poland - Soil contaminated by smelter flue-dust	Non-retail (field experiment)	Dudka et al. 1996
Washing and Peeling	Potato	Lead and cadmium	Washing reduced heavy metals in potatoes by 46% for Pb and 38% for Cd. With subsequent peeling, reductions increased to 84% for Pb and 63% for Cd.	Washing with tap water	Egypt - Sample source not described.	Not available	Abdel-Rahman 2018
Sweet potato							
Cultivar	Sweet potato	Lead, cadmium	Distinct differences were observed among Cd and Pb accumulations in the fourteen sweet potato cultivars. After peeling, non-purple sweet potatoes had 26% less lead than purple sweet potatoes, on average. Cadmium levels were also lower on average, but not significantly.	14 cultivars were tested for lead and cadmium - 6 starch sweet potatoes (for starch used to make noodles), 5 non-purple edible cultivars, and 3 purple cultivars.	China - Cd and Pb contaminated areas in eastern Hunan Province.		Huang 2020
Peeling	Sweet potato	Lead, cadmium	Cadmium and lead were consistently higher in the peel than the flesh - 2.2 and 2.9 times higher for non-purple sweet potatoes, respectively, and 2.2 and 2.0 times higher for purple sweet potatoes.	Sweet potatoes were peeled, details not provided. Prior to peeling sweet potatoes were washed thoroughly - rinsed in water to remove soil, soaked in acid for 15 minutes to remove absorbed ions, rinsed in deionized water.	China - Cd and Pb contaminated areas in eastern Hunan Province.		Huang 2020
Peeling	Sweet potato	Heavy metals	Peel constituted 10.5% and 6.5% of the total weight of a small and large sweet potato, respectively. Assuming 2.0-2.9 the cadmium and lead contration in peel vs flesh gives 9.1% and 6.5% reduction in heavy metal exposure for peeled vs unpeeled sweet potatoes, for the small and large potatoes tested, respectively.	Scrubbed and washed in tap water, dried, and peeled with standard kitchen peeler. Weight measured in grams using kitchen scale.	Sweet potatoes purchased at retail, Maryland.	Retail	Appendix D of this study
Greens							
Washing	Spinach	Lead, mercury, arsenic	Heavy metal residues in spinach declined significantly for all washing methods studied. Mercury reductions ranged from 7 to 23%, lead from 7 to 28%, and arsenic 6 to 22%. More reduction was for lead, followed by mercury and arsenic, respectively. "Out of all the washing treatments, it was observed that the minimum reduction of mercury residues 7% was recorded when tap was applied to spinach. The spinach treated with 10% citric acid yielded the maximum reduction of mercury which was 23% followed by lemon extract 22%, sodium carbonate 17%, reddish extract 15% and hydrogen peroxide 12%."	Washing solutions included tap water, reddish, sodium carbonate, hydrogen peroxide, lemon, citric acid			Amir 2018

Action	Food(s)	Metals(s)	Study finding	Action details	Location and conditions	Retail samples or Non-retail	Reference
Washing	Spinach		Washing with the basic medium was better to remove pesticides and some of exogenous toxic heavy metals from the surfaces of spinach leaves and to preserve the essential elements of the plant				Moussaif 2021
Washing	Spinach	Lead, cadmium	Washing of vegetables with clean water reduced average lead and cadium contamination by 85 and 89 percent, respectively.	Thorough washing with tap water	India - peri-urban sites in New Delhi		Singh 2006
Washing	Cabbage	Lead, cadmium	Washing reduced lead and cadmium concentrations by 16 and 37 percent, respectively.	Rinsing and agitating under tap water for one minute.	Ghana: Imported produce purchased in supermarkets		Dzimado 2016
Washing	Swiss chard	Lead	Swiss chard cleaned with the kitchen cleaning method contained 2.6 to 4.6 times greater Pb concentrations than that cleaned with the lab cleaning method.	Laboratory cleaning - rinsing with tap water, deionized water, sodium laurel sulfate solution, then deionized water again, to remove all adhering soil dust particles from produce surface. Kitchen-style cleaning- only tap water, removing all visible soil particles. A portion of the lab-carrots were also peeled.	MIssouri - Urban community garden with lead-contaminated soil	Non-retail (community garden)	Attanayake 2014
Other fruits and vegetables							
Peeling	Beet	Arsenic	Arsenic is concentrated in peel. Peeling could help reduce exposures. Total and inorganic arsenic concentrations in peel are each 5 times those of the interior of the beetroot.	Samples were cleaned by shaking them to remove soil and then cleaning with deionized water (method not described) prior to peeling.	Chile - area with volcanic soils naturally high in arsenic	Field samples	Munoz 2002
Peeling	Beet	Lead, arsenic, cadmium	In composite samples, beet peel contained significantly more As than the flesh (5.2 times); peel and flesh had similar levels of Cd and Pb.	Samples were peeled with plastic knife.			Pizarro 2016
Washing	Apples, grapes, broccoli	Lead, cadmium	Washing reduced lead and cadmium concentrations by these percentages, respectively: 19 and 28% for apples, 12 and 26% for grapes, and 19 and 41% for broccoli.	Rinsing and agitating under tap water for one minute.	Ghana: Imported produce purchased in supermarkets	Retail	Dzimado 2016
Washing	Okra	Lead, cadmium	Washing of vegetables with clean water reduced average lead and cadium contamination by 87 and 90 percent, respectively.	Thorough washing with tap water	India - peri-urban sites in New Delhi		Singh 2006
Washing	Vegetables	Lead, cadmium and other metals	Researchers tested for Cd, Hg, As, Cr and Pb in vegetables before and after washing by household chemicals. Washing by 10% acetic acid was more effective for heavy metals removal than tap water, 5% acetic acid, 5% sodium chloride and 10% sodium chloride.				Sattar 2013, cited in Abdel-Rahman 2018
Washing	Tomato	Lead	Kitchen-cleaned tomatoes had 3.0 times greater Pb concentrations than lab-cleaned tomatoes.		MIssouri - Urban community garden with lead-contaminated soil	Non-retail (community garden)	Attanayake 2014
Washing and soaking	Tomato	Lead and cadmium	Washing reduced heavy metals in tomatoes by 60% for Pb and 100% for Cd (below detection limit). With subsequent soaking in vinegar solution, reduction increased to 84% for Pb.	Washing with tap water and soaking in vinegar solution (5%) for 5 min	Egypt - Sample source not described.	Not available	Abdel-Rahman 2018
Washing and soaking	Cucumber	Lead and cadmium	Washing reduced heavy metals in cucumber by 79% for Pb and 100% for Cd (below detection limit). Subsequent soaking in vinegar solution did not lead to significant additional reductions (to 81% for Pb). Researchers speculate that lead is tightly bound to cucumber (to functional groups on cucumbers' natural biopolymers).	Washing with tap water and soaking in vinegar solution (5%) for 5 min	Egypt - Sample source not described.	Not available	Abdel-Rahman 2018

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APPENDIX F:

Calculation methods

Method to estimate impact of peeling vegetables on heavy metals concentrations

HBBF purchased produce at retail in Maryland - one carrot and two sweet potatoes. We scrubbed each vegetable vigorously under tap water to remove any surface soil, and then allowed the vegetables to air dry. We then weighed each whole vegetable on a kitchen scale to the nearest gram. We fully peeled each using a standard kitchen peeler and weighed the resulting peel. We calculated the percent reduction in heavy metal concentration for the peeled vegetable versus the original unpeeled vegetable using the relative weights of peel and flesh and assuming a ratio of 2 - 2.9 for heavy metal content in peel versus flesh consistent with data in Munoz (2002), Pizarro (2016), and Huang (2020) for arsenic in carrots and lead and cadmium in sweet potatoes (see Appendix E).

Vegetable*	Total weight of vegetable with peel (g)	Peel weight (g)	Heavy metal ratio - ratio of concentration in peel vs flesh	Percent reduction in heavy metal concentration after peeling**
Carrot, medium size	79	13	2	14.1%
Sweet potato, small	172	18	2.0 - 2.9	9.5 - 16.6%
Sweet potato, large	528	39	2.0 - 2.9	6.9 - 12.3%

* Varieties were not specified at retail. The carrot was grown in Israel; source was not listed for the sweet potatoes.

** The reduction compares the concentration in the original whole vegetable to the concentration in the peeled vegetable.

Method to estimate depth of peel for a standard kitchen peeler

Concentrated metals in some root vegetables could be removed by peeling to at least a depth of 1 millimeter (mm) (Norton 2015). HBBF approximated the number of peelings this would require in a simple kitchen experiment. We purchased carrots (product of USA) and potatoes (New Red Potatoes packed in Massachusetts) at retail. We peeled each with a standard home swivel peeler, then stacked 12 peel lengths of each vegetable, lightly compressed them manually, and measured. This yielded a single peel depth of 0.8 mm for carrot and 1 mm for potato.

Method to compare heavy metal levels in baby food purees and homemade purees

This study includes comparisons of heavy metal content in baby food purees and homemade purees for banana, apple, pear, sweet potato, carrot, squash, green beans and peas. Brooks Applied Labs (Brooks) tested the ingredients of homemade purees – homogenized raw produce – rather than prepared purees. They prepared the produce per typical home preparation (peeling, removing seeds, coring) as described in Appendix B, and then analyzed samples for total solids and four metals - arsenic, lead, cadmium, and mercury. Brooks measured the same parameters in the commercial baby food samples.

HBBF adjusted the measured concentrations in raw produce to reflect puree preparation at home, which can include the addition of water to achieve a smoother blend. For each pair of foods our shoppers purchased, a commercial baby food and the comparable produce, we estimated the metals concentration in homemade puree by multiplying the metals concentration in raw produce by the ratio of total solids (by weight) in commercial baby food to total solids in the produce. This had the effect of diluting the raw produce to achieve the same moisture content as the commercial baby food, simulating the addition of water at home and allowing us to compare commercial and homemade purees on a moisture-equal basis. The method mirrors what is expected when parents use a cooking method like steaming or microwaving that preserves much of the heavy metal content. Cooking methods like boiling, with its more intense water use and contact, would give lower concentrations that those estimated by the method above (Lee 2019).

Method to estimate inorganic arsenic levels from analytical results for total arsenic

Nearly all food tests included in this study were tested for total arsenic. But the most toxic form of arsenic, inorganic arsenic, was analyzed in fewer samples, 24% of HBBF's food samples (HBBF 2017, 2019 and current study), and is available for only 1% of FDA's samples (FDA 2017). It was necessary to implement a strategy of scaling the total arsenic in other samples to account for the fact that a portion of the arsenic was not inorganic arsenic. This strategy facilitated HBBF's use of the average total heavy metal concentration (the sum of inorganic arsenic, lead, cadmium, and mercury) that informs consumption recommendations in this study. The method employed in Abt (2019) was used. As in the Abt (2019) study, HBBF assumed in general that 70% 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). Most of the exceptions to the application of this rule came from information about the arsenic makeup of foods specified in Cubadda (2017). Using this information, HBBF 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
- 90% of total arsenic is inorganic in vegetables.

In addition, HBBF assumed the following inorganic arsenic compositions based on independent testing from 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.

HBBF 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).

Method to establish consumption recommendations for foods to eat freely, limit, and avoid

To develop the recommendations for foods to eat freely, limit and avoid (see page 9), HBBF:

- Synthesized data from seven studies measuring heavy metal levels in commercial baby food and other foods babies and toddlers eat (HBBF 2017, 2019, HBBF-EDF 2022, current study; FDA 2017, 2020, 2022).

- Assumed a concentration equal to 1/2 the detection limit for metals not detected consistent with Xue (2010).
- To represent heavy metal levels in homemade purees (as shown in Appendix C), adjusted metal concentrations to reflect the impact of pureeing food at home. The adjustment equalizes the moisture content of each pair of foods, mimicking the addition of water to achieve a smoother blend for homemade purees; see above for calculation details.
- For foods for which total arsenic but not speciated (including inorganic) arsenic was analyzed, estimated the inorganic arsenic level using the method described above. (Inorganic arsenic was tested in one-quarter of HBBF samples, generally for samples that showed high levels of total arsenic, and is available for only 1 percent of FDA tests.)
- Calculated the total heavy metal level for each food type as the average of the sum of inorganic arsenic, lead, cadmium, and mercury for each sample.
- Developed consumption recommendations for food groups, reflecting sequentially better foods (with sequentially lower average total heavy metal concentrations) within each group, across four consumption categories: Avoid, Serve Rarely, Limit, and Serve. Levels are not consistent across food groups for these four categories, but are instead designed to reflect within each food group sequentially lower metal levels with each step from Avoid to Serve. This design is based on the fact that every lower-metal choice a parent makes will incrementally lower a baby's exposure, whether the choices are within lower-metals groups like fruit or a higher-metals group such as grains.
- Relied on results from studies with more sensitive detection limits and higher rates of detection, for foods for which detection limits (and detection rates) varied widely among studies.
- Labeled in our recommended food list the foods that fall in the Limit category but that are nutritious, with a designation that they should be part of a baby's diet but served in rotation with other foods, not as a daily staple.
- Selected foods for the Avoid category as those with the highest metal levels that can be avoided with no nutritional downside for babies.

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APPENDIX G:

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 10 years revealing IQ loss, attention deficits, and other learning and behavioral impacts among children who are exposed through food and other sources (HBBF 2019). Three of the metals, arsenic, lead, and cadmium, are also 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. Although many foods are contaminated with arsenic, rice-based foods have the highest levels; the grain naturally accumulates arsenic from contaminated soil and irrigation water. Arsenic's most toxic form, inorganic arsenic, is the dominant form in baby food.

Inorganic arsenic is rapidly absorbed into the body, with up to 90% entering the bloodstream after a meal (FDA 2016, NRC 2001). It 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.

The other form of arsenic common in baby food, an organic form called DMA, is considered less toxic than inorganic arsenic, there is little information on its safety early in life, when the body and brain are developing. Like inorganic arsenic, it is easily absorbed from food into the body (at least 75-85%). It is easily transferred from mother to fetus across the placenta, and it crosses the blood-brain barrier in infants (EFSA 2009, Abt 2017). There are no epidemiological studies of effects in people, even though exposures are widespread. The few available studies in laboratory animals have found it to be toxic only at levels well above amounts typical in children's diets (Abt 2017, FDA 2016). In its review of arsenic in rice, FDA noted that "little information exists on early-life toxicity" of organic forms of arsenic (FDA 2016). Further study is needed to verify that this contaminant is safe in the amounts typically found in a baby's diet.

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.

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 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-lead-your-home-english

Evidence of lead's toxicity spans decades. Among published 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.

Lead is readily absorbed into the body, especially if a lead-contaminated food is eaten on an empty stomach outside of a balanced meal. Children absorb about 50% of ingested lead after a meal, about 2.5 times more than adults. They absorb up to 100% on an empty stomach (ATSDR 2022a). People who skip meals and eat in a fasting state absorb lead more quickly and in greater amounts (Liu 2011). 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 2019).

Lead is toxic at all stages of life. Recent studies have focused on cardiovascular damage in adults exposed to low amounts of lead. Impacts include high blood pressure and heart attacks for an estimated 412,000 deaths each year attributable to lead (Lanphear 2018).

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 the limited published studies available show that 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). In a 2019 review researchers found convincing evidence that exposures during pregnancy impact children's neurodevelopment, including impaired language development, performance ability, and general cognitive development for children exposed in utero (Liu 2019b).

There are questions about how much of the cadmium present in food absorbs into the body following a meal. Typically, estimates have ranged from as little as 3% for people with a nutrient-rich diet and as much as 9% for people who are deficient in iron (Schaefer 2020, ATSDR 2022b, citing older data). Research shows gender-based differences, with absorption averaging about 5% for men and 10% for women (Schaefer 2022). And some studies have found higher absorption rates, especially among those with a subsistence rice diet, including 40% among women in their 30's-50's, and 44% among women under 30 (Vesey 2010). More cadmium can be absorbed when iron, zinc, and calcium are low in the body or low in the food itself, as they are in white rice. Laboratory studies suggest that even marginal deficiencies in the body's nutrients can increase cadmium absorption by a factor of 10 (Reeves 2008). Studies are not available to indicate how much cadmium absorbs into an infant's body after a meal, or how much more would be absorbed by an infant deficient in nutrients known to block

cadmium, though laboratory experiments suggest that cadmium absorption may be higher in infancy (Eklund 2003, CDC 2015).

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). 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).

Mercury was detected in 8 percent of the 288 foods tested in this study, at levels 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 2021). Some 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).

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