

Breastmilk Is an Infant Metal Pathway No Food Standard Reaches

Karen Pendergrass · ORCID 0000-0002-2348-7259 · Heavy Metal Certified · August 2026

Cite as: Heavy Metal Certified. "Breastmilk Is an Infant Metal Pathway No Food Standard Reaches". <https://heavymetalcertified.com/articles/breastmilk-heavy-metal-exposure-pathway>. CC BY 4.0.

Abstract

Human breastmilk carries measurable concentrations of lead, cadmium, arsenic and mercury — and, in specific settings, aluminum and chromium — and the load passed to a breastfed infant is set by the mother's cumulative body burden and current diet rather than by anything intrinsic to the milk. That makes breastmilk a genuine infant heavy-metal exposure pathway, mechanistically distinct from infant formula, where the metal load enters through the ingredient supply chain and process water and can in principle be sourced, screened and limited. The certification consequence is a boundary line: a product certification reaches manufactured foods like formula, but breastmilk is not a product — it is not sold, not sampled by food-monitoring programs, and cannot be specified or reformulated. It is characterized only by the biomonitoring literature, and the lever that moves it is maternal exposure reduction, not a product limit. The full anchor-source evidence base lives on the Heavy Metal Index, the independent literature reference this analysis cites one way.

Two Pathways, One Infant

Human breastmilk is not a metal-free baseline against which infant formula is judged. The most current and comprehensive U.S. systematic review treats human milk and infant formula as two separate matrices, each with its own per-analyte concentration distribution, and finds that on a per-serving basis human-milk arsenic, cadmium, lead and mercury are generally lower than reconstituted formula [1]. Lower is not zero, and the comparison does not collapse the two pathways into one manageable category.

The load a breastfed infant actually receives is set by the mother's cumulative body burden and current diet rather than by anything intrinsic to the milk. In a cohort of 209 lactating Korean mothers, cadmium was detected in 99 percent of samples, mercury in 97 percent, total arsenic in 89 percent and lead in 79 percent [2]. Where formula's metal load originates in the ingredient supply chain and the process water — and can in principle be sourced, screened and limited — breastmilk's originates in the individual mother's exposure biography, which cannot be specified or reformulated.

What Maternal Body Burden and Diet Write Into the Milk

The mechanism is direct: breastmilk is a route by which a mother's stored and current metal burden is partitioned into a fluid the infant consumes. Environmental and dietary exposure drives maternal accumulation — lead in bone, cadmium in the kidney, lipophilic organometals in adipose tissue — and lactation then mobilizes those stores, so that bone resorption can transfer lead to the infant even when the mother's current dietary intake is low [3]. This is why maternal age, parity and historic exposure all matter, and why the leaded-gasoline era remains relevant to a nursing infant decades later.

Current diet supplies the other half. In the Korean cohort, breastmilk lead rose with legume and seaweed consumption, cadmium with vegetable and seaweed consumption, mercury with sugar intake, and arsenic with meat and seafood intake, each identified by regression against maternal food groups [2]. Across the

wider review literature, cadmium ran 37 to roughly 300 percent higher in mothers who smoked, mercury about 42 percent higher in regular marine-fish consumers and roughly threefold higher with dental amalgam, and lead higher under iron-deficiency anemia through the shared divalent-metal transporter [3].

Timing matters too. Lead, aluminum and total arsenic peak in colostrum and fall by 75 to 90 percent over the first two months as milk protein content declines, whereas cadmium is the exception — actively transported in competition with zinc and calcium, it stays stable or rises to a peak at four to six months of lactation [3].

The Health Signal Is Real at Ordinary Concentrations

These are not concentrations too low to matter. In a prospective São Paulo cohort of 185 mother-infant pairs, infants exposed to lead through breastmilk showed significantly lower language-development trajectories at 10 to 16 months than unexposed infants, scoring a mean Bayley language composite of 97.47 against 102.96 [4]. The exposed infants' mean breastmilk lead, 8.67 micrograms per litre, was lower than in most prior studies — the deficit appeared at the lower end of the reported range, consistent with the position that no safe threshold exists for lead neurodevelopmental toxicity.

A Chinese cohort near one of the country's largest e-waste recycling districts adds a second outcome and a second metal. There, maternal-milk cadmium was inversely associated with birth weight in female infants even at concentrations within WHO permissible milk limits, and 34.3 percent of mothers had breastmilk chromium above the WHO permissible range — an industrial signature written into the milk by where the mother lives, not by any product she bought [5]. The infant is a uniquely vulnerable recipient: immature hepatic and renal clearance, higher intake per unit body weight, and gastrointestinal lead absorption several times that of an adult [3].

The Surveillance Blind Spot

Food-safety surveillance is built around commercial matrices that can be sampled at market — cereals, produce, dairy, fish, packaged foods, and manufactured infant formula. Breastmilk is none of these. It is not sold, not sampled by the FDA Total Diet Study or equivalent national programs, and never entered into packaged-food occurrence databases [6]. For the exclusively breastfed infant, who may take breastmilk as the sole dietary intake for the first six months, the single most-consumed matrix is the one matrix no food-monitoring stream measures.

The only characterization of this pathway comes from the biomonitoring literature, which measures the milk directly in research cohorts of lactating mothers. That literature is dispersed across environmental-health and toxicology journals rather than aggregated in a food database, it attaches to maternal cohorts and exposure settings rather than to a labelled product, and its units, detection limits and speciation practices vary enough that direct pooling is difficult [3]. Two geographically independent reviews nonetheless converge on the same framing — human milk as a biomonitor of maternal exposure [7]. The pathway is real and measured; it is simply measured in a literature that food surveillance does not read.

What this means for certification

The boundary this finding draws is clean. A product certification reaches manufactured foods, because those foods have a supply chain that can be sourced, a formulation that can be specified, and finished units that can be sampled and held to a limit. Infant formula is exactly such a product: its metal load is a supply-chain-and-testing problem, and a certification standard can set a ceiling on it. That is what the infant formula and ready-to-feed standards do — adopting, for each analyte, the strictest maximum level set by a credible government regulator, and for the four Tier-1 toxics (lead, cadmium, inorganic arsenic

and methylmercury) the stricter of that government limit and the cleaner end of the occurrence evidence; nickel, tin, aluminium and hexavalent chromium are treated as Tier-2 and adopt the government limit directly.

Breastmilk cannot be certified this way, and the finding explains why. It is not a product: it is not sold, has no specifiable formulation, and its lead and cadmium load is a function of the individual mother's exposure biography rather than of any recipe. A certification can therefore state plainly what it does and does not cover — it governs the formula on the shelf, not the milk at the breast — without implying the uncovered pathway is negligible. The lever that actually moves breastmilk contamination is maternal exposure reduction, a public-health instrument rather than a product limit: breastmilk lead fell roughly 90 percent in Hungary and Sweden across the decades following leaded-gasoline phase-out, on the timescale of environmental regulation, not product reformulation [3]. Reading the two pathways as one certifiable category would misdirect the intervention: certification covers the formula, and maternal-diet and environmental policy cover the milk.

Frequently asked questions

Does breast milk contain heavy metals?

Yes. Across multiple independent cohorts, human breastmilk carries measurable lead, cadmium, arsenic and mercury, plus aluminum and chromium in some settings. In a study of 209 Korean mothers, cadmium was detected in 99 percent of samples, mercury in 97 percent, total arsenic in 89 percent and lead in 79 percent. The amount reaching the infant depends on the mother's body burden and diet, not on anything intrinsic to the milk.

Is breast milk or infant formula higher in heavy metals?

The most current U.S. systematic review finds that, per serving, human-milk concentrations of arsenic, cadmium, lead and mercury are generally lower than reconstituted infant formula. But lower is not zero, and the two are separate pathways: formula's metals come from its supply chain and can be limited, while breastmilk's come from the mother's own exposure history and cannot be specified or reformulated. Reviewed evidence also consistently finds that under typical conditions the benefits of breastfeeding outweigh the measured metal risks.

What raises heavy metals in breast milk?

Maternal body burden and current diet. Stored lead in bone, cadmium in the kidney, and lipophilic metals in fat are mobilized during lactation, while current intake matters too — breastmilk lead and cadmium track seaweed intake and arsenic tracks seafood. Cadmium also runs markedly higher in mothers who smoke, mercury is higher with frequent marine-fish consumption and dental amalgam, and lead is higher under iron-deficiency anemia.

Can a food certification cover breast milk?

No. A product certification reaches manufactured foods like infant formula, which have a supply chain to source, a formulation to specify and finished units to test against a limit. Breastmilk is not a product — it is not sold, has no formulation, and no food-monitoring program samples it — so it sits outside any product standard. The tool that moves breastmilk contamination is maternal exposure reduction, a public-health lever rather than a certifiable product specification.

References

- [1] Arsenic, cadmium, lead and mercury in human milk and infant formula across the U.S. market: a systematic review. Thorig et al., 2025. Systematic review treating human milk and infant formula as two separate matrices; finds persisting human-milk concentrations of arsenic, cadmium, lead and mercury generally lower than reconstituted formula.
- [2] Maternal dietary intake and heavy-metal concentrations in Korean breast milk. Moon et al., 2025. Cohort of 209 lactating Korean mothers; cadmium detected in 99% of samples, mercury 97%, total arsenic 89%, lead 79%; total arsenic was the largest hazard-quotient contributor and tracked maternal seafood intake.
- [3] Human milk as a biomonitor of maternal toxic-metal exposure: sources and transfer mechanisms. Katrynska et al., 2026. Review of 112 primary studies framing human milk as a biomonitor of maternal exposure; documents bone, kidney and adipose accumulation, lactation-stage dynamics, and maternal determinants including smoking, marine-fish intake and dental amalgam.
- [4] Breastmilk lead and infant language development in a São Paulo cohort. Napolini et al., 2024. Prospective cohort of 185 mother-infant pairs; infants exposed to lead through breastmilk showed significantly lower language-development trajectories at 10 to 16 months, at concentrations lower than most prior studies.
- [5] Prenatal heavy-metal exposure and birth outcomes in a Chinese e-waste region. Chen et al., 2023. Cohort of 102 mothers in a Taizhou e-waste district; 34.3% had breastmilk chromium above the WHO permissible range, and maternal-milk cadmium was inversely associated with female birth weight within WHO permissible milk limits.
- [6] FDA Total Diet Study and Closer to Zero infant-food action plan. U.S. Food and Drug Administration. National food-monitoring and infant-food programs that sample commercial matrices, including manufactured infant formula, but not human breastmilk.
- [7] Environmental and maternal determinants of heavy-metal content in breast milk: a systematic review. Aisyiah et al., 2025. PROSPERO-registered review of 9 primary studies across seven countries; independently reaches the biomonitor framing and links breastmilk metal concentrations to seafood, canned-food and water intake, smoking and industrial residence.
- [8] Heavy Metal Index — breastmilk as a heavy-metal exposure pathway (synthesis with full anchor-source records). The independent literature synthesis this analysis reframes, carrying every anchor source and its per-record page. · heavymetalindex.com

Cite this analysis

