

Mercury

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Abstract

This page draws on the ATSDR 2024 Toxicological Profile for Mercury (ATSDR 2024), the EPA IRIS chemical assessments for mercuric chloride and methylmercury (EPA IRIS Hg, EPA IRIS MeHg), the JECFA 61st meeting methylmercury monograph (JECFA 61st), the EFSA CONTAM 2012 Scientific Opinion on Mercury and Methylmercury in Food (EFSA Hg 2012), the Minamata Convention on Mercury (Minamata Convention 2013), the Farina-Rocha-Aschner 2011 mechanistic review (Farina et al. 2011), and the joint FDA/EPA fish consumption advice (FDA/EPA Fish Advice).

Chapter-level cross-metal toxicology context for elemental mercury vapor, inorganic mercury, methylmercury, global cycling, neurotoxicity, renal toxicity, and treatment is connected from Ufelle & Barchowsky 2021.

1 | Overview

Mercury occurs in three toxicologically distinct forms relevant to food and environmental health: elemental mercury (Hg⁰, the metallic liquid form, primarily an inhalation hazard from dental amalgam, occupational exposure, and broken thermometers/lamps); inorganic mercury salts (mercuric chloride and others, primarily a renal hazard via oral exposure); and organic mercury compounds, dominantly methylmercury (MeHg), which forms in aquatic systems through microbial methylation and bioaccumulates up marine and freshwater food chains (ATSDR 2024). Methylmercury is the species relevant to dietary risk through fish and seafood consumption and is the species addressed in the FDA/EPA fish consumption advice for pregnant women and children.

The dominant dietary exposure route for methylmercury is fish and seafood, particularly long-lived predatory fish (swordfish, shark, king mackerel, tilefish, bigeye tuna) which biomagnify methylmercury to concentrations substantially above the surrounding water and lower-trophic-level prey (FDA/EPA Fish Advice, EFSA 2012). Inorganic mercury exposure through diet is less common; dental amalgam release contributes elemental mercury vapor to occupational and dental-patient inhalation exposure (ATSDR 2024). The Minamata Convention on Mercury (2013, with 2024 revisions) is the international treaty regulating anthropogenic mercury emissions

worldwide, named for the 1950s–1960s methylmercury poisoning event in Minamata Bay, Japan, that established the developmental and adult neurotoxicity of methylmercury at high exposure (Minamata Convention).

The methylmercury reference values across EPA IRIS (oral RfD 0.1 µg/kg/day) (EPA IRIS MeHg), EFSA (TWI 1.3 µg Hg/kg b.w./week, daily-equivalent ~0.19) (EFSA 2012), and JECFA (PTWI 1.6, daily-equivalent ~0.23) (JECFA 61st) converge to within a factor of 2.3, all anchored on the same Faroe Islands and Seychelles cohort developmental-neurotoxicity endpoint. This is the most harmonized of the heavy-metal regulatory landscapes covered by the wiki; it stands in stark contrast to lead (no harmonized PTWI), arsenic (PTWI withdrawn), and cadmium (3-way EFSA/JECFA/ATSDR divergence).

2 | At a glance

Three facts that matter most for consumer decision-making about mercury exposure.

First, the species of mercury matters as much as the amount. Methylmercury in fish is the species relevant to dietary risk, especially for pregnant women and children (ATSDR 2024). Inorganic mercury exposure through diet is uncommon. Elemental mercury vapor from dental amalgam is a separate exposure with its own (largely settled) health profile, addressed by dental practice rather than food choice (ATSDR 2024).

Second, fish choice within the seafood category matters more than total seafood consumption. Long-lived predatory fish (swordfish, shark, king mackerel, tilefish, bigeye tuna, marlin, orange roughy) carry methylmercury concentrations roughly 10x to 50x higher than lower-trophic-level fish (salmon, sardines, anchovies, tilapia, shrimp, catfish) (FDA/EPA Fish Advice). The FDA/EPA fish consumption advice categorizes seafood into "Best Choices" (2–3 servings/week recommended), "Good Choices" (1 serving/week), and "Choices to Avoid" specifically to operationalize this difference for pregnant women and children. Light canned tuna is a "Good Choice" (1 serving/week); albacore (white) tuna is in the higher-mercury range and a frequent--consumption decision point; bigeye tuna is in the "Choices to Avoid" category (FDA/EPA Fish Advice).

Third, the developmental window is the most consequential exposure period. Methylmercury crosses the placenta and concentrates in the developing fetal brain (Farina et al. 2011). The major regulatory dietary reference values (EFSA TWI 1.3 µg Hg/kg b.w./week, JECFA PTWI 1.6, EPA IRIS RfD 0.1 µg/kg/day) are all anchored on developmental neurotoxicity (EFSA 2012, JECFA 61st, EPA IRIS MeHg). Pregnant and breastfeeding women, women who might become pregnant, and children should follow the FDA/EPA fish consumption advice categories rather than averaging across "fish" as a single category.

3 | Toxicology

Methylmercury crosses the blood-brain barrier and the placenta, binds cysteine residues on glutathione and other thiols, accumulates in the developing brain, and induces oxidative stress, glutamate excitotoxicity, and disruption of cellular calcium homeostasis (Farina, Rocha, and Aschner 2011). The developmental neurotoxicity endpoint anchored on Faroe Islands and Seychelles cohort studies of children exposed in utero through maternal seafood consumption is the basis for every modern dietary methylmercury reference value. Adult methylmercury neurotoxicity is documented at higher exposures in occupational and contamination settings (Minamata Bay being the canonical historical example, where industrial methylmercury discharge produced thousands of cases of "Minamata disease" with characteristic ataxia, dysarthria, sensory disturbance, and visual field constriction).

The Faroe Islands cohort (Grandjean et al.) and the Seychelles Child Development Study Nutrition Cohort produced the dominant epidemiological evidence base for current methylmercury reference values (JECFA

61st, EFSA 2012). The Faroe cohort showed dose-response associations between maternal hair methylmercury concentrations and offspring neurodevelopmental outcomes (memory, attention, visuospatial processing, language) (JECFA 61st); the Seychelles cohort produced more complex findings interpreted as showing that the protective effects of n-3 long-chain polyunsaturated fatty acids in fish may partially counteract methylmercury developmental neurotoxicity (EFSA 2012). EFSA's 2012 lowering of the EU TWI from 1.6 to 1.3 µg Hg/kg b.w./week incorporated the n-3 fatty acid protective adjustment derived from the Seychelles cohort literature (EFSA 2012).

Inorganic mercury (mercuric chloride and other salts) is primarily nephrotoxic via oral exposure, with autoimmune kidney effects as the EPA IRIS critical endpoint anchoring the 0.3 µg/kg/day oral RfD (EPA IRIS HgCl₂). Elemental mercury (Hg⁰) is primarily neurotoxic via inhalation, with tremor, mood lability ("erethism," historically called "mad hatter syndrome" from the 19th-century felt hat industry's mercury exposure), and cognitive effects documented in occupational cohort studies (ATSDR 2024). The ATSDR 2024 profile covers all three species with separate MRLs.

4 | Typical exposure routes

Dietary methylmercury through fish and seafood is the dominant route for the general population (EFSA 2012). Marine surface waters globally have elevated mercury concentrations relative to pre-industrial baselines because of anthropogenic mercury emissions (coal combustion, artisanal small-scale gold mining, historical chloralkali industry); the Minamata Convention's purpose is upstream emissions reduction (Minamata Convention).

Elemental mercury inhalation exposure is occupational (dental practice, fluorescent lamp manufacture, chloralkali legacy operations, gold processing) and dental-amalgam-related (a small chronic vapor exposure from dental fillings, considered acceptably low by major regulatory bodies but a contested area in some patient-advocacy literature) (ATSDR 2024).

Fetal exposure to methylmercury occurs through transplacental transfer during pregnancy (Farina et al. 2011).

5 | Food sources

MATRIX	METHYLMERCURY CONCERN
Swordfish, shark, king mackerel, tilefish, marlin, orange roughy, bigeye tuna	"Choices to Avoid" per FDA/EPA; concentrations typically 0.5 to 1.5 ppm (FDA/EPA Fish Advice)
Albacore (white) tuna, yellowfin tuna, halibut, mahi-mahi, snapper	"Good Choices" per FDA/EPA; 1 serving/week recommended; 0.1 to 0.5 ppm (FDA/EPA Fish Advice)
Salmon, sardines, anchovies, tilapia, shrimp, catfish, pollock, trout, herring	"Best Choices" per FDA/EPA; 2-3 servings/week recommended; <0.1 ppm (FDA/EPA Fish Advice)
Light canned tuna	"Good Choices" (1 serving/week); typically 0.1 to 0.3 ppm (FDA/EPA Fish Advice)
Crab, oysters, scallops	"Best Choices" (FDA/EPA Fish Advice)

The FDA/EPA fish consumption advice (joint guidance, 2017 update) provides serving-frequency recommendations for pregnant women, women who might become pregnant, breastfeeding women, and children ages 1 to 11. The advice emphasizes that fish is a meaningful source of n-3 fatty acids and other nutrients

important to fetal and child development, and that consumption within the "Best Choices" or "Good Choices" categories at recommended frequencies provides nutritional benefit while keeping methylmercury exposure within reference values.

What this means for food choice

For pregnant women, breastfeeding women, and women who might become pregnant: follow the FDA/EPA fish consumption advice categories. Eat 2 to 3 servings per week from the "Best Choices" list (salmon, sardines, anchovies, tilapia, shrimp, catfish, pollock, trout, herring, oysters, scallops). One serving per week from the "Good Choices" list is acceptable (light canned tuna, halibut, mahi-mahi, snapper, bluefish). Avoid the "Choices to Avoid" list entirely (swordfish, shark, king mackerel, tilefish from the Gulf of Mexico, bigeye tuna, marlin, orange roughy). Albacore tuna and yellowfin tuna are higher-mercury than light canned tuna; substituting light canned tuna or salmon for albacore is a high-leverage swap.

For children ages 1 to 11: the same category guidance applies, with serving sizes scaled to age. The FDA/EPA chart provides age-specific serving sizes; for children under 6, a serving is typically 1 ounce (cooked).

For consumers concerned about dental amalgam mercury vapor: this exposure is small in absolute terms, considered acceptably low by major regulatory bodies, and is a separate decision from food choice (ATSDR 2024). The Minamata Convention initially promoted phase-down of dental amalgam but did not require complete phase-out; jurisdictions vary in dental amalgam policy (Minamata Convention).

6 | Regulatory limits

JURISDICTION / BODY	TYPE	VALUE	PAGE
EPA IRIS (US)	Methylmercury oral RfD	0.1 µg/kg/day	epa-iris-methylmercury--rfd
EPA IRIS (US)	Mercuric chloride oral RfD	0.3 µg/kg/day	epa-iris-mercury-rfd
EFSA (EU)	Methylmercury TWI	1.3 µg Hg/kg b.w./week (daily ≈ 0.19 µg/kg/day)	efsa-methylmercury-twi
EFSA (EU)	Inorganic mercury TWI	4 µg Hg/kg b.w./week	efsa-mercury-twi
JECFA (international)	Methylmercury PTWI	1.6 µg/kg b.w./week (daily ≈ 0.23 µg/kg/day)	jecfa-methylmercury--ptwi
FDA / EPA (US)	Fish consumption advice	Three-tier seafood categorization for pregnant women and children	FDA/EPA Fish Advice
ATSDR (US)	Mercury MRLs	Multiple by species and route	ATSDR 2024
International	Minamata Convention	Treaty regulating anthropogenic Hg emissions worldwide	Minamata Convention 2013

What the reference values mean in practice

Mercury is the most regulatory-harmonized of the heavy metals on this wiki. The methylmercury reference values across EPA IRIS, EFSA, and JECFA agree to within a factor of 2.3 when expressed on a daily per-kg basis (EPA IRIS MeHg, EFSA 2012, JECFA 61st). For a 70-kilogram adult, the daily-equivalent reference values are: EPA IRIS RfD 7 µg MeHg/day (0.1 µg/kg/day × 70 kg); EFSA TWI 13.3 µg/day (1.3 ÷ 7 × 70); JECFA PTWI 16 µg/day (1.6 ÷ 7 × 70). For a 25-kilogram child, the corresponding values are 2.5, 4.8, and 5.7 µg MeHg/day respectively.

For a consumer estimating exposure: the methylmercury concentration in light canned tuna is approximately 0.1 to 0.3 ppm (FDA/EPA Fish Advice). A 100-gram serving (one can) delivers approximately 10 to 30 µg MeHg. For a 70 kg adult, one can of light canned tuna per week is at or below the EFSA TWI; two cans per week would exceed EFSA but remain below JECFA. For a 25 kg child, one 100-gram serving would be at or above all three reference values. The FDA/EPA "Good Choices" recommendation of 1 serving per week (with serving sizes scaled by age) operationalizes these numbers for the standard at-risk populations (FDA/EPA Fish Advice).

7 | Testing

Biomonitoring for methylmercury exposure typically measures hair mercury (integrating exposure over the hair growth period, weeks to months) or whole-blood mercury (recent integrated exposure) (JECFA 61st, EFSA 2012). Maternal hair mercury was the dominant biomarker in the Faroe Islands cohort underlying the EFSA TWI (EFSA 2012).

8 | Microbiome effects

Pending dedicated microbiome ingests. Methylmercury is itself the product of microbial methylation of inorganic mercury, primarily by sulfate-reducing bacteria in anaerobic aquatic sediments. The same microbial process operates at much lower rates in the human gut, with potential implications for inorganic mercury exposure assessment but not for the dominant dietary methylmercury pathway. The wikibiome-crosswalk anchor is tentatively mercury-gut-axis.

9 | Historical context: Minamata disease and the Convention

Minamata disease was the methylmercury poisoning event that established the developmental and adult neurotoxicity of methylmercury at high exposure. The Minamata Bay site in Japan was the location of industrial methylmercury discharge that caused thousands of cases of developmental and adult neurological disease beginning in the 1950s (Minamata Convention).

The Minamata Convention on Mercury, named for this event, was adopted October 10, 2013 under the United Nations Environment Programme and entered into force August 16, 2017 (Minamata Convention). It addresses the supply, use, trade, emissions, and waste of mercury and mercury compounds across multiple sectors: artisanal and small-scale gold mining (the largest single anthropogenic mercury release source globally), coal combustion, mercury-added products (fluorescent lamps, batteries, switches, cosmetics, certain dental amalgams), industrial processes, and contaminated sites (Minamata Convention). The treaty is the international policy framework underlying mercury-related dietary risk: by reducing global anthropogenic mercury emissions, it operates upstream of the methylmercury bioaccumulation in fish and seafood that drives EFSA, JECFA, FDA/EPA, and ATSDR dietary mercury reference values.

10 | Vulnerable populations

POPULATION	BASIS
Pregnant women	Transplacental transfer; developmental neurotoxicity of methylmercury in offspring; FDA/EPA fish advice targets this population (Farina et al. 2011, FDA/EPA Fish Advice)
Women who might become pregnant	Mercury body burden persists for months; pre-pregnancy exposure matters (FDA/EPA Fish Advice)
Children ages 1 to 11	Developmental neurotoxicity persists post-birth; smaller body size amplifies per-kg exposure (FDA/EPA Fish Advice)
Frequent consumers of high-mercury fish (sport fishers, subsistence fishers, certain cuisines)	Long-lived predatory fish concentrations 10-50x lower-trophic-level fish (FDA/EPA Fish Advice)
Occupational mercury exposure	Dental work, mining, fluorescent lamp manufacture, chloralkali (legacy), gold processing (ATSDR 2024, Minamata Convention)

If you are in one of these groups

For pregnant women and women planning pregnancy: follow the FDA/EPA fish consumption advice. Eat 2 to 3 servings per week from "Best Choices" (salmon, sardines, anchovies, tilapia, shrimp, light canned tuna, catfish, pollock, trout). Avoid the "Choices to Avoid" list entirely. For women planning pregnancy, the body burden built up before conception matters; if you are a frequent albacore tuna or sushi consumer, switching to "Best Choices" species in the months before pregnancy reduces fetal exposure during the first trimester (the most developmentally sensitive window for methylmercury).

For breastfeeding women: continue the FDA/EPA category guidance; breast milk methylmercury reflects maternal blood methylmercury, which reflects maternal recent and accumulated dietary intake. The benefits of breastfeeding (immune, developmental, bonding) are widely considered to outweigh the methylmercury transfer risk for women following the FDA/EPA category guidance.

For parents of children ages 1 to 11: serving sizes scale with age. The FDA/EPA chart provides age-specific guidance. Tilapia, salmon, sardines, light canned tuna, and shrimp are appropriate frequent choices; albacore tuna, swordfish, and similar high-mercury species should be limited or avoided.

For sport fishers and subsistence fishers: state-level water-body-specific advisories are the operative guidance. State environment and fish-and-game departments publish advisories based on local fish-tissue mercury testing. Lake trout, walleye, bass, pike, and other large predatory freshwater species from contaminated water bodies can carry methylmercury concentrations far above commercial-seafood averages. Eating fewer servings, choosing smaller specimens of the same species (smaller fish carry less methylmercury than larger fish of the same species), and rotating across multiple water bodies all reduce cumulative exposure.

11 | App-layer integration

Machine-readable takeaways from this synthesis for the Heavy Metal Index consumer app pipeline.

The methylmercury reference value scale is harmonized: EPA IRIS RfD 0.1 µg/kg/day, EFSA TWI 1.3 µg/kg/week (daily ≈ 0.19), JECFA PTWI 1.6 µg/kg/week (daily ≈ 0.23). The app can present a single "percent of EPA RfD"

or "percent of EFSA TWI" benchmark for methylmercury without the multi-value-divergence framing that other metals require. Default reference: EPA RfD 0.1 µg/kg/day (the most conservative).

Critical app handling: methylmercury and inorganic mercury are different toxicants with different reference values. Total-mercury measurements in fish are dominated by methylmercury (90+ percent typically) and can be treated as approximately equal to methylmercury for fish/seafood inputs; total-mercury measurements in non-fish matrices may be dominated by inorganic mercury and must be flagged.

Pediatric multipliers for methylmercury are mostly through body-weight scaling rather than per-kg amplification; a 25 kg child following the same per-kg reference as a 70 kg adult has a daily MeHg cap of 2.5 µg vs the adult's 7 µg.

Structured outputs:

- Methylmercury concentration ranges by fish category (default app values for inferring fish exposure):
- "Best Choices" species: <0.1 ppm
- "Good Choices" species: 0.1 to 0.5 ppm
- "Choices to Avoid" species: 0.5 to 1.5+ ppm
- Maternal hair MeHg associated with first-percentile-affected developmental endpoint: approximately 6.4 µg/g (Faroe-Seychelles BMDL) (JECFA 61st).
- Pregnancy risk weighting: amplify reference-value benchmarking for pregnant users by treating maternal blood/hair MeHg as the operative biomarker for fetal exposure.

Consumer-facing risk communication should treat methylmercury as the default "fish mercury" concept and explicitly inform users that the FDA/EPA category guidance (Best Choices / Good Choices / Choices to Avoid) operationalizes the regulatory reference values into shopping-and-cooking decisions.

12 | Open questions

Two load-bearing open questions for mercury, surfaced by the current ingest:

First, the n-3 fatty acid protective adjustment that EFSA 2012 incorporated into its TWI lowering remains a contested methodological choice. The Faroe Islands cohort showed methylmercury developmental neurotoxicity associations; the Seychelles cohort showed weaker or null associations and was interpreted by some authors as evidence that fish nutrients (n-3 LCPUFAs, selenium, choline) protect against methylmercury developmental effects at typical seafood-consumption levels. EFSA's TWI lowering from 1.6 to 1.3 µg Hg/kg b.w./week incorporates this protective adjustment; JECFA does not, retaining the 1.6 PTWI. The wiki records both values without resolving which adjustment is more defensible; subsequent meta-analytic literature is needed to settle this.

Second, the EPA IRIS methylmercury reassessment (currently in step 1 at IRIS) may produce an updated oral RfD when finalized, with potential implications for the 0.1 µg/kg/day value that has been operative since 2001. The wiki should track the IRIS reassessment progress and update the methylmercury page when a new value is finalized.

Which type of mercury in food should I actually worry about?

Methylmercury (MeHg) is the form relevant to dietary risk, and it comes primarily from fish and seafood, especially long-lived predatory fish (ATSDR 2024). Inorganic mercury exposure through diet is uncommon, and elemental mercury vapor from dental amalgam is a separate exposure handled through dental practice rather than food choice (ATSDR 2024).

Which fish are highest in mercury and which are safest to eat?

Long-lived predatory fish such as swordfish, shark, king mackerel, tilefish, bigeye tuna, marlin, and orange roughy carry methylmercury roughly 10x to 50x higher than lower-trophic-level fish and are in the FDA/EPA "Choices to Avoid" category (FDA/EPA Fish Advice). Lower-mercury "Best Choices" like salmon, sardines, anchovies, tilapia, shrimp, and catfish (under 0.1 ppm) are recommended at 2 to 3 servings per week, while light canned tuna is a "Good Choice" at 1 serving per week (FDA/EPA Fish Advice).

Why are pregnant women and children singled out for mercury advice?

Methylmercury crosses the placenta and concentrates in the developing fetal brain, and the developmental window is the most consequential exposure period (Farina et al. 2011). The major dietary reference values from EFSA, JECFA, and EPA IRIS are all anchored on developmental neurotoxicity, so pregnant and breastfeeding women, women who might become pregnant, and children should follow the FDA/EPA fish categories rather than averaging across "fish" as one group (EFSA 2012, JECFA 61st, FDA/EPA Fish Advice).

What are the official regulatory limits for methylmercury?

The main dietary reference values are the EPA IRIS oral RfD of 0.1 µg/kg/day, the EFSA tolerable weekly intake (TWI) of 1.3 µg Hg/kg body weight per week (daily equivalent about 0.19), and the JECFA provisional tolerable weekly intake (PTWI) of 1.6 µg/kg body weight per week (daily equivalent about 0.23) (EPA IRIS MeHg, EFSA 2012, JECFA 61st). These values agree to within a factor of 2.3, making mercury the most regulatory-harmonized of the heavy metals on this wiki, and all are anchored on the same Faroe Islands and Seychelles cohort developmental-neurotoxicity endpoint (EFSA 2012).

How is mercury exposure measured in people?

Biomonitoring for methylmercury exposure typically measures hair mercury, which integrates exposure over weeks to months, or whole-blood mercury, which reflects recent integrated exposure (JECFA 61st, EFSA 2012). Maternal hair mercury was the dominant biomarker in the Faroe Islands cohort that underlies the EFSA TWI (EFSA 2012).

How much light canned tuna can I safely eat?

Light canned tuna contains roughly 0.1 to 0.3 ppm methylmercury, so a 100-gram serving delivers about 10 to 30 µg (FDA/EPA Fish Advice). For a 70-kg adult, one can per week is at or below the EFSA TWI, but for a 25-kg child a single serving would be at or above all three reference values, which is why the FDA/EPA "Good Choices" guidance of 1 serving per week with age-scaled serving sizes exists (FDA/EPA Fish Advice).

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