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Effects Heavy Metal and Organic Contaminants During Pregnancy and Lactation on Child Health

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Introduction

This study aimed to review the scientific evidence on the influence of heavy metals and organic contaminants in foods consumed by pregnant and lactating women on child health. Heavy metal toxicity in humans is the accumulation of inorganic and organic forms of heavy metals, in toxic amounts, in cell, tissues, organs, and bodily fluids [1-3]. Symptoms and physiological outcomes are directly associated the different heavy metals, the location of the accumulation, the amount of accumulation and chronicity of the accumulation [4-5]. The poisoning caused by each heavy metal will vary depending on its inorganic or organic variant form. The most common essential heavy metals in the human body includes but are not limited to zinc, copper, chromium, iron and manganese; most of these are vital to body function in very small amounts but may become toxic if they accumulate and concentrations sufficiently [6]. The heavy metals most commonly associated with toxicity and poisoning in humans include arsenic, cadmium, lead, and mercury. Most heavy metal toxicity is associated with and the result of industrial exposure, air or water contamination, food adulteration, medicines, improperly coated food containers, tooth amalgam or the ingestion of chips or flakes of lead-based paints [7-9].

Keywords: Arsenic, Bioaccumulation, Breastfeeding, Breastmilk, Cadmium, Fish, Lead, Methyl Mercury, Mercury Toxicity, Minamata Mercury Convention, Rice, Vulnerable populations.

Since breastmilk is universally considered the best natural source of essential nutrients for all infants, any exposure of breastmilk containing toxic heavy metals could potential be harmful to the developing infant [10-11]. The World Health Organization (WHO) considers breastfeeding as the preferred source of nutrition for all infants worldwide, yet in much of the developing world breastmilk is contaminated with hazardous environmental pollutants such as heavy metals, pesticides, fungal toxins, prescribed and illegal drugs and endocrine and nervous system disrupting chemicals [12-13]. Many of these toxic substances are found in women of childbearing age and can be transferred via maternal and/or placental cord blood to the developing fetus or to the newborn or breastfeeding infant through contaminated breastmilk [14-16].

Toxic levels of these contaminants in infants are associated with low birth weight, neurobehavioral development and dysfunction, fetal growth restrictions and retardations, cognitive dysfunctions, and low APGAR and IQ scores [17-19]. These factors may be compounded by

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many sociodemographic factors such as mother's age and educational levels, smoking, alcohol, drug use and abuse, and dietary habits such as eating fish and rice containing heavy metals especially mercury and the associated methylated organic compounds it can form [19-21].

Once in the environment, inorganic mercury can be methylated to methylmercury by bacteria [22-24]. Methylmercury can bio-accumulate in many upper trophic level animals, especially humans such that they contain contains higher concentrations of methylmercury [25-28]. According to Bernhoft (2012) toxicity in human varies depending on the form, dose and rate of exposure of mercury. The target organ for inhaled mercury vapor is primarily the brain, while mercurous and mercuric salts chiefly damage the gut lining and kidney [29]. While methylmercury is widely distributed throughout human organs and tissues, methylmercury is not the only organic form that mercury can be converted to in the human body [30-32].

Mercury can readily attach to carbon-based molecules in the methyl, ethyl, phenyl of related organic molecules [33-34]. Methyl mercury reacts with sulfhydryl groups throughout the body, interfering with cellular or subcellular structure [35-36]. Dimethylmercury is a neurodegenerative toxic agent that once in the human body can be metabolized after several days to methylmercury [29,37-39]. Ethyl mercury another toxic organic form of mercury, has its origin from thimerosal-containing vaccines [40-41]. All of these toxic organic forms of mercury can bio-accumulate through the ingestion of foods such as fish, rice and grains, each containing various forms of mercury [29,42-44]. Methylmercury is lipid-friendly and can cross the cell membranes easily. The placenta cross rate of methylmercury is 10 times higher than for other mercury compounds, thereby affecting the developing fetus. Organic forms of mercury is excreted through breastmilk readily; the half-life period of methylmercury in breastfeeding women is shorter than in non-lactating women, putting breastfeeding infants at greater risk for mercury toxicity [45-47]. In the human body, both infant and adult, methylmercury is associated with impairment of the nervous and immune system, disruption of DNA repair, destruction of mitochondrial membranes, chronic fatigue syndrome, neurodegenerative diseases resulting in loss of IQ, cardiovascular and respiratory diseases, and diseases of the kidney, skin and eyes [29,34,43]. Exposure to high levels of methylmercury is known as Minamata disease [48,49]. Developing fetuses, breastfeeding infants and young children are at greatest risk to acute methylmercury exposure, where even low levels can have devastating permanent health consequences [50-51]. The effects of long-term low-dose exposure to methylmercury in this age group remains unclear [7,52].

In this manuscript we will discuss and review organic and inorganic dietary contaminants, especially heavy metals, in women of childbearing age in developing countries and the toxic health effects of these contaminants have on developing embryos, the quality of breastmilk and in the development of breastfeeding infants. We will also discuss the role of fish and rice in the bio-accumulation and bio-magnification of methylmercury in the above vulnerable populations.

Our review of the literature aimed at looking at the organic and inorganic dietary contaminants in women of childbearing age in developing countries and at the toxic health effects of these contaminants have on nascent embryos and breastfeeding infants. We specifically focused on heavy metals especially methylmercury and its passage into breast milk, negatively affecting the developing child. A literature search was done using MEDLINE database of references and abstracts on life sciences and biomedical topics, and Google Scholar with the keywords: Arsenic, bioaccumulation, breastmilk, cadmium, fish, lead, methyl mercury, mercury toxicity, Minamata Mercury Convention, rice, and vulnerable populations, used in the search. Publications were selected that observed the geographic locations with high fish and rice consumption containing organic and inorganic contaminants with focus on heavy metals especially methylmercury and the transport of methylmercury in breast milk to the developing child. Articles used were from 2006 onward, and a 1994 paper used due to its explanation of the negative effects of methylmercury on early development.

Minamata Convention on Mercury

In January 2013, the Minamata Convention on Mercury was agreed upon by 128 nations in Geneva, Switzerland to address the ongoing issue of methyl-mercury pollution [53]. It was later ratified in October of the same year in Kumamoto, Japan for implementation [54]. Then in May 2017 the documents achieved 50 ratifications allowing the legally binding mercury reduction measures to go into effect in August of that same year [54-56]. Since that time, the number of nations to ratify the legally-binding documents continue to grow, with 113 participants currently [56]. The convention was named after Minamata, Japan; considered to be the location of one of the worst mercury contamination events to date [57]. Under further investigation, this poisoning was believed to be caused by wastewater from a local chemical factory contaminating one of the city's main food sources, fish; bringing to light just one of the many sources increasing pollution on a daily basis [58]. The Convention addressed many aspects of this issue including mercury availability, and its use in products such as thermometers [59-60]. It also stressed reducing emissions from artisanal and small-scale gold mining, considered one of the largest culprits for the increased mercury emissions over the years [61]. It focused on reducing emissions from power plants and metal producing facilities as well as encouraged governments to have an action plan in place to manage the health effects of already occurring mercury exposure [59-60].

The first benefit of the Minamata Convention was bringing greater attention to the severity of the mercury issue and the necessity to remedy that issue [56,60,62]. Participating members of the Convention were tested for hair mercury levels resulting in a more motivated discussion. Mercury was found on every single person and, alarmingly, one third of participants were over the safe reference dose, set by the US National Research Council [62]. With a motivated populace the second benefit was realized, putting into place a foundational start to reducing the participating countries contributions to the mercury issue and the adverse health

outcomes it causes [54]. So far, the foundation set by the Minamata Convention has not been completely appreciated. However, early studies have shown a decrease in the atmospheric mercury and the projected global emission rates [63,64]. A third benefit of the convention was that it brought countries with the means to make change into the fight against mercury pollution, including the first country to join, the United States [59]. This issue cannot be solved globally if participating countries do not help each other in the process [65]. The convention outlined what assistance developing countries should receive, hopefully ensuring that every participant is able to meet the standards [60]. Having key countries like the United States is considered crucial in ensuring the goal of the convention is achieved [59].

While the Minamata convention's goal was unquestionably positive, there were still some inadequacies of the final documents. Leading some researchers and reporters to be left with criticisms [66-68]. The Convention did not completely eradicate mercury use, particularly in small scale gold mining and production processes. A compromise was made that prohibited new mercury mining after the treaty went into effect but allowed already existing mining to continue for up to 15 years [68]. In many of the areas where artisanal and small-scale gold mining takes place the use of mercury is essential to the people's livelihood. Banning the metal's use completely with no efficient alternative would cause a strain on those families that have little option but to mine [69-71]. Further complicating the issue, the communities that would be affected by such drastic changes are not required to be a part of the decision-making process. All of these factors could potentially cause difficulty in following through with the regulations set by the Convention [71]. Next, the Convention could not take effect until there were fifty ratifying nations, this did not occur until a little less than three years after the initial agreement, delaying potential mercury reduction progress until 2017 [55]. Another criticized aspect of the Convention was the exemption of Thimerosal vaccines from regulation. This led to some significant controversy about the disparity of where these vaccines are distributed and used, which is mainly in developing nations [72]. Finally, one of the biggest potential downfalls of the Convention is figuring out how to exactly measure its effectiveness. It is thought that some of the guidelines presented for monitoring progress of the Convention are not exactly feasible [73]. There are differing ideas on the best way to measure the global mercury levels. One of the proposed ideas is to measure through the living organisms where the heavy metal becomes trapped [73-74]. Even that has limitations however, receiving differing results depending on where and how mercury levels are tested. This makes it difficult to give an actual evaluation of the effectiveness of the Convention guidelines [74].

Since the Convention, the research on the mercury issue has greatly increased. More locations of mercury pollution are being teased out, new tools and ways to reduce emissions efficiently continue to be discovered, and the cycling process is better understood [75]. It was estimated from 2010 to 2015, the global emission rate per year slowed its ascent compared to previous projections increasing by only 1.8%. North America and Europe have reduced their mercury use and emissions [64]. However, this has been outweighed by the continued growth in emissions from developing countries, and the largest contributor to atmospheric mercury, China [64,76]. While global emission rates seem to be headed in the right direction the mercury levels found in fish and other food sources have continued to be concerning, causing some researchers to call for a change in diet to reduce exposure [77]. The continued elevated levels of mercury in this reservoir is projected to take longer to improve, highlighting the continued difficulty of effective evaluation of the Convention guidelines [63]. The Convention regulations have also started to cause a strain on the families that require mercury for their livelihood. One example is in Ghana where the ban on mercury has angered the mining population causing the country to find alternate revenue sources for those affected [65]. Even though there has been some criticism, the Minamata Convention built a foundation for reducing current and future exposure to mercury pollution. The Convention addressed the need to revise and improve as more research and feedback is given [60]. This will allow the guidelines to adjust to future issues that arise and hopefully reach the end goal of reduced mercury exposure and improved public health.

Non-Metal Organic Contaminants

The general consensus on potential risks introduced by other, non-metal environmental pollutants does not override the recommended practice for breastfeeding infants. However, according to the Centers for Disease Control, breastmilk is not routinely assessed for environmental pollutants. Gaps in knowledge leave a void with little to no known data to confirm or refute risk to infants from other potentially hazardous substances in human milk [78]. The American Association of Pediatricians' Committee on Drugs, provided a 2001 report on the transfer of drugs and other chemicals into human milk, including food and environmental contaminants. They stated the need to protect infants from potential adverse effects and protect mothers from unnecessary restrictions of needed medications [79-81].

The potential harmful effects of DDT to humans, wildlife and the environment raised great concern and regulatory action in the United States in the early 1970s, alerting public officials to the risks of exposures to organic substances. To date, there are no signs or symptoms in infants or effects on lactation due to DDT, and other commonly used organic compounds such as benzene, hexachlorides (fungicide), diedrin and aldrin (pesticides), and hepatachlorepoxide (insecticide) (AAP 2013). More recently, studies of household cleaners containing (quaternary ammonium compounds) are under study to determine exposure effects on growth and development [82]. More surveillance programs and research are needed to continually inform policy makers and the public of the safety and efficacy of an overwhelming number of substances mothers maybe exposed to, or consume, that could pose risks in infants.

Human exposures to environmental contaminants are presumed to be involuntary. Today, it is increasingly more common that concerns arise from overexposure to

prescription, illicit and over-the-counter health products. For example, a common medication used to treat severe acne, Accutane® (isotretinoin, a form of retinoic acid, a form of vitamin A), is a documented teratogen and not prescribed to pregnant women or those planning to become pregnant. Due to the toxicity of this product it can only be marketed under a restricted distribution program, iPLEDGE®, designed specifically to enroll registered prescribers, patients, pharmacies and wholesalers. Nursing mothers should not take Accutane®. It is not known if this drug is excreted in human milk [83-84]. The American Academy of Pediatrics clinical report lists drugs of abuse, once referred to as illicit street drugs, for which adverse effects are reported on the breastfeeding infant. Alcohol, amphetamines, cocaine, heroin, LSD, marijuana are among those listed. Included in the report are effects or reasons for concern and the contraindications during breastfeeding or feeding breastmilk to infant [78].

Informing breastfeeding mothers and those providing breastmilk to infants is an educational process for all involved, as seen with the unique implementation of the iPLEDGE program [83]. For most prescription drugs providers are expected to explicitly instruct patients regarding the safe use of products potentially harmful to pregnant and lactating women. Additionally, product labels clearly stating warnings as needed for pregnant and lactating mothers [84]. In some circumstances a temporary recommendation to not provide an infant with breastmilk may be warranted dependent on a mother's health condition, i.e., in the case of untreated brucellosis [85].

Other voluntary and intentional exposures to products assumed 'healthy' may actually be harmful to the mother-infant dyad, with extreme cases leading to morbidity and mortality. Misuse of essential nutrients, particularly vitamins and elements (minerals) has prompted establishing recommendations specific for various subpopulations based on age, gender and pregnancy and lactation. Intakes of single nutrients often as dietary supplements, particularly but not exclusively, the elements and the fat-soluble vitamins (Vit A, D, E, and K), can exceed safe and adequate intakes. The national recommendations are established, when scientific data are available, providing guidance on the safe and adequate daily intake levels for all age and gender groups, as well as pregnant and lactating women. If sufficient evidence was available, upper limits are also established to prevent toxicities from more acute, short-term intakes of these essential nutrients [86].

Throughout history, cultures, worldwide, have passed down the ethnic tradition of women taking herbal substances to boost milk production (*galactagogues*) during lactation. The use of herbal galactagogues varies widely and continues to gain popularity among Western cultures is the use of many herbals, i.e., fenugreek (*Trigonella foenum-gracum*), believed to aid lactation [87]. Several have provided reviews appraising the use and evidence for using galactagogues, including fenugreek and other herbs, thought to increase milk production. Lactation support organizations advocate the numerous benefits of herbal galactagogues, including psychologically empowering women struggling with real and perceived milk production insufficiency [62,63]. The research community emphasizes the lack of data to confirm safety and efficacy of galactagogues, pharmaceutical and herbal, for this purpose citing results from studies with inadequate methodologies [88-89]. Industry wide, herbal product manufacturers have yet to overcome the problem of standards of identity and consistent quantification of active ingredients. The challenges associated with the "pharmacovigilance of herbal products", particularly in breastfeeding women signify the importance of structured studies to determine herbal compound transfer in human placentas and milk [87].

Support for enhancing lactation has also been advancing with the prescription of pharmacological galactagogues. Clinical trials have indicated successful outcomes for domperidone and metoclopramide, prescribed specifically for the purpose of stimulating milk production and research is ongoing to confirm safety and efficacy [88-89].

Universally, breastfeeding remains the recommended practice for feeding infants and is endorsed by leading organizations (e.g., World Health Organization, The Center for Disease Control, The American Academy of Pediatrics, and the Academy of Nutrition and Dietetics). Risk assessment of involuntary and voluntary exposures, particularly during the vulnerable stages of development in unborn and newborn children, is needed to continually inform professionals and the public of risks on an ongoing basis [78,80,90-92].

Heavy Metal Contaminants

Arsenic, lead, and cadmium, in addition to mercury, are found in various amounts in breastmilk of women from differing countries such as Solvenia, Norway, or Lebanon [93-96]. These metals influence the cellular and humoral response of the immune system of the infant by affecting which cytokines are produced; thus, negatively influencing the ability of the immune system [93]. An increase in the production of cytokines created by lymphocyte Th1 and an inhibition of the cytokines created by Th2 in the presence of heavy metals may occur; however, the opposite may transpire depending on which particular heavy metals are present [93]. Recall lymphocyte Th1 produces interleukin 2 (IL-2), interferon gamma (INF-γ), and tumor necrosis factor-beta (TNF-β). Both Th1 and Th2 produce tumor necrosis factor-alpha (TNF-α), granulocyte-macrophage colony-stimulating factor (GM-CSF), IL-3, IL-6, and IL-10 [93]. Cadmium and lead inhibit the production of Th1 cytokines [93]. When less of cytokines (IL-2, INF-γ, TNF-β) are available, the immune system has a limited ability to sequester and prevent the spread of an infection, indirectly increasing opportunity for a parasitic organism to flourish [93].

Classified as a non-threshold carcinogen or group 1 carcinogen according to the International Agency for Research on Cancer, any arsenic exposure constitutes a risk and no tolerable intake level can be established [97-98]. Arsenic is colorless, odorless, tasteless found in rice, carrots, onions, potatoes, apples, poultry, seafood, animal feed, contaminated water and soil, or other grains like wheat or barley [93,97-99]. The inorganic forms called arsenite (III) and arsenate (V) are

both water soluble which leads to soil contamination and the accumulation of arsenic in various foods [93,98].

Rice is the most common food source of arsenic [97]. The type of rice and the soil where the rice was cultivated determine the amount of arsenic present; however brown rice does overall contain more arsenic than white rice [97-98]. Concentration of inorganic arsenic can reach 90% of the total arsenic content [97,99]. Maximum tolerable level of total arsenic for drinking water is defined as 10µg/L according to the WHO; yet, no limit for total or inorganic arsenic in any food exists for the WHO, European Union (EU), or the United States [97]. China regulates the maximum level of inorganic arsenic in rice permitted is 0.15mg/kg [97].

Once ingested, inorganic arsenic is absorbed and then methylated by S-adenosylmethionine (SAM) with the assistance of glutathione (GSH) to yield dimethylarsinous acid (DMA) and monomethylarsonous acid (MMA) which are less toxic [97]. The body usually excretes these acids in the urine [93]. Negative effects associated with exposure to arsenic during pregnancy include weak cognitive functions, lower birth weight, asthma, tachycardia, and extreme toxicity can cause fetal death [93,96-97].

Unlike arsenic, lead enters the body through the skin, digestive tract, or respiratory tract [93]. Ninety percent of lead is accumulated in the bones; but it can be stored in the liver, kidneys, hair, nails or nervous system [93]. Women with blood levels of lead below 40µg/dL can breastfeed without clinical harm to their children since a tiny fraction of lead in blood is bioavailable and human milk is low in protein, the molecular carrier of lead [100]. Thus, lead is unexpected to heavily transfer into human milk; however, this reasoning does not account for the lead released from bones during pregnancy as a result of bone turnover [93,100].

Potatoes, contaminated lead-based cooking utensils, contaminated water, and the liver and kidney of game organisms are sources of lead to consider when preparing food [93,99-101]. It is excreted through urine, feces, sweat, or human milk. Lead has no biological role in the body [102]. Because of bone resorption during pregnancy, lead can be released into the body and into human milk [93].

Depending on the lead blood level in a pediatric patient, the clinical implications vary [103]. Young children absorb lead four to five times more effectively than adults which greatly increases the risk of toxicity for children [103]. Manifestations of toxicity include developmental delays when the blood lead level is 10µg/dL, increased nerve conduction velocity seen at 20µg/dL, and decreased hemoglobin synthesis seen at 40µg/dL [103]. Exposure to lead can also affect intelligence quotient scores and the nervous system [96,103].

Cadmium has no physiological function in the human body and is considered a potent neurotoxin [96]. Cadmium enters the body mainly through inhalation but it can enter by absorption in the digestive tract [96]. It affects the liver and kidneys and is excreted through urine and feces [96]. Food sources include carrots, onions, potatoes, fish, shellfish, and grains [95-96,99].

Cadmium toxicity results in neuronal changes which manifest as reduced IQ levels, learning dysfunctions, olfactory abnormalities, psychiatric problems, attention deficits, or neurodegenerative diseases [96]. Cadmium toxicity can result in hepatoxicity; however, a combination of vitamin C, tocopherol, and flavonoid has shown to reduce the hepatotoxicity [95-96]. In infants, it is associated with pre-term birth and the development of asthma [96].

Cadmium toxicity affects the physiologic functions of zinc, iron, magnesium, calcium, plus vitamins B2, B6, and B12 [96]. For example, it decreases zinc absorption by interfering with binding of zinc to metallothionein, a protein involved with transportation of essential metals [96]. Thus, creating a deficiency of zinc [95-96]. Adequate iron, zinc, selenium, and vitamin E, have illustrated a possible protective mechanism in which absorption of cadmium is diminished [96]. Copper can also aid to reverse cadmium induced alteration of metallothionein [96,104]. In fact, supplementation with a plant-based diet demonstrated protection against cadmium toxicity given that these foods contain micronutrients necessary to combat oxidative stress and induce chelation of cadmium [94,104-105].

Fish and Rice as Sources of Mercury Contamination

Methyl mercury exposure through the consumption of fish and rice, has been documented in developing countries, where these products are a staple in the diet of many people. Rice consumption is highest in regions of China and other East Asian countries [106]. Various factors play a role in the accumulation of methylmercury, such as rice management practices and presence of environmental factors contaminating the rice fields [107-108]. Fish consumption, remains highest in regions of Asian countries, such as Japan, followed by China [109]. Environmental factors, such as the conversion of atmospheric mercury to methylmercury by microorganisms and the type of fish, with longer-lived predatory fish having the highest levels of mercury, all play a role in the levels of methylmercury [110]. The high levels of mercury from the fish and rice pose a considerable risk for pregnant mothers, in whom high levels of mercury pose risks to the future development of their child [107].

Methyl mercury, when ingested combines with glutathione, to make a methylmercury- glutathione compound that is transported throughout the body, crossing the blood brain barrier and placenta with ease [111]. The elimination of methylmercury occurs through the bile, with a fraction of the compound being reabsorbed through the process of enterohepatic circulation, which further slows the elimination of methylmercury. Pregnant women, consuming fish and rice high in methylmercury are at high risk, as the average half-life of methylmercury is 50-70 days [112]. With such a long half-life, concentrations of methylmercury remain high throughout pregnancy and into the breastfeeding, negatively affecting development.

Despite, the fact that the majority of methyl mercury is excreted, the small levels of mercury recycled via enterohepatic circulation are still significant enough to

pose a risk to the developing child [111]. Methylmercury, bound to albumin enters into breastmilk and is then directly consumed by the infant [113]. The effects of consumption of milk with high levels of methylmercury are magnified by factors such as frequency of breastfeeding and the slow elimination of methylmercury during the first year of life [114]. In addition, the efficient gastrointestinal absorption, lack of well-developed homeostasis and detoxification mechanisms present in the growing child further exacerbate the problem [115].

Critical development periods during the growth of a child, make the effects of exposure to mercury even more profound [116]. Methyl mercury is a potent neurotoxin, and high exposures of this through breastmilk, can have negative effects on development leading to mental retardation, cerebral palsy, and seizures [117]. Additional effects of early exposure can manifest as changes in the neurobehavioral function throughout life, with impacts in memory and attention, language, visual- spatial and motor skills [118].

Recent studies have shown that in certain regions of India, China, Vietnam and Thailand where gold and other heavy metals are mined and where coal is burned by power plants, soil mercury levels are high and MeHg accumulates in rich grain. In these regions, median rice MeHg concentrations were up to 10 times lower than those typically measured for fish tissue [119-120]. Daily rice-based meals (without fish) containing MeHg are common to much of the world population. Since MeHg has a strong affinity to bioaccumulate, exposure levels are comparable to a fish meal (Tuna, swordfish or any number of higher food chain fish). Detailed studies of rice containing MeHg are few [121-122]. To our knowledge, no detailed study has been done in the United States where rice exported from India, China, Vietnam and Thailand, has been examined for MeHg. Many ethnic populations eat rice one to three times/day [123]. The potential for MeHg contaminated rice exported from Asia to bioaccumulation in women in the United States, especially those women of childbearing age [124].

Conclusion

Many toxic organic and inorganic substances found throughout the food chain, end up in solid and liquid foods consumed throughout the world. So many foods we consume come from international sources where toxic materials are found in the soil and water, both fresh and marine. Often these toxic materials can bio-amplify across the various food chains and bio-accumulate in the human body. These toxic materials include drugs, pesticides, heavy metals and food additives, may accumulate and be transferred across the placenta to developing fetuses or accumulate in breastmilk and transferred to breastfeeding infants. The impact of these toxic contaminants on vulnerable infants and children worldwide is high, and may go unmeasured, unnoticed and unrecognized.

Disclosures

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References

1. Monisha Jaishankar, Tenzin Tseten, Naresh Anbalagan, Blessy B. Mathew, et al. (2014) Toxicity, mechanism and health effects of some heavy metals. Interdisciplinary toxicology 7: 60-72.
2. Varsha Mudgal, Nidhi Madaan, Anurag Mudgal, R.B. Singh, Sanjay Mishra (2010) Effect of toxic metals on human health. The Open Nutraceuticals Journal 3: 94-99.
3. Yedjou, Clement G, Anita K. Patlolla, Dwayne J. Sutton (2012) Heavy Metals Toxicity and the Environment Paul B Tchounwou. Published in final edited form as: EXS 3: 133-164.
4. Rivera-Mancía, Susana, Camilo Ríos, and Sergio Montes (2011) Manganese accumulation in the CNS and associated pathologies. Biometals 24: 811-825.
5. Sharma, Bechan, Shweta Singh, and Nikhat J. Siddiqi (2014) Biomedical implications of heavy metals induced imbalances in redox systems. BioMed research international 2014.
6. Tchounwou, Paul B, Clement G. YedjouAnita K. PatlollaDwayne J. Sutton (2012) Heavy metal toxicity and the environment. Molecular, clinical and environmental toxicology. Springer, Basel 101: 133-164.
7. Dongre, Suryabhan Shriram, and Vidhyashree Thorat (2019) To study the views of doctors on heavy metal poisoning in Mumbai. National Journal of Research in Ayurved Science 7.
8. Rather, Irfan A., Wee Yin Koh, Woon K. Paek, and Jeongheui Lim (2017) The sources of chemical contaminants in food and their health implications." Frontiers in pharmacology 8: 830.
9. Nagajyoti P C, K D Lee, T V M Sreekanth (2010) Heavy metals, occurrence and toxicity for plants: a review. Environmental chemistry letters 8: 199-216.
10. Motee, Ashmika, Rajesh Jeewon (2014) Importance of exclusive breastfeeding and complementary feeding among infants. Current Research in Nutrition and Food Science Journal 2: 56-72.
11. Yurdakök, Kadriye (2015) Lead, mercury, and cadmium in breast milk. Journal of Pediatric and Neonatal Individualized Medicine (JPNIM) 4: e040223.
12. Vahidinia A, Samiee F, Faradmal J, Rahmani A, Taravati Javad M et al. (2019) Mercury, lead, cadmium, and barium levels in human breast milk and factors affecting their concentrations in Hamadan, Iran. Biol Trace Elem Res 187: 32-40.
13. van den Berg M, Kypke K, Kotz A, Tritscher A, Lee SY, et al. (2017) WHO/UNEP global surveys of PCDDs, PCDFs, PCBs and DDTs in human milk and benefit–risk evaluation of breastfeeding. Archives of toxicology 91: 83-96.
14. Mitro, Susanna D, Tyiesha Johnson, Ami R. Zota (2015) Cumulative chemical exposures during pregnancy and early development. Current environmental health reports 2: 367-378.
15. Adlard B, Davis K, Liang CL, S Curren M, Rodríguez-Dozal S, et al. (2014) Persistent organic pollutants (POPs) and metals in primiparous women: a comparison from Canada and Mexico. Science of the Total Environment 500: 302-313.
16. Mitro, Susanna D, Robin E Dodson, Veena Singla, Gary Adamkiewicz, Angelo F. Elmi, et al (2016). Consumer product chemicals in indoor dust: a quantitative meta-analysis of US studies. Environmental science & technology 50: 10661-10672.
17. Golding, Jean, Pauline Emmett, Yasmin Iles-Caven, Colin Steer, Raghu Lingam (2014) A review of environmental contributions to childhood motor skills. Journal of child neurology 29: 1531-1547.
18. Safe, Bernadette, Annette Joosten, and Roslyn Giglia (2018) Assessing motor skills to inform a Fetal Alcohol Spectrum Disorder diagnosis

focusing on persons older than 12 years: A systematic review of the literature. Journal of Population Therapeutics and Clinical Pharmacology 25: e25-e38.

19. Tan, Jing, Annamalai Loganath, Yap Seng Chong, Jeffrey Philip Obbard (2009) Exposure to persistent organic pollutants in utero and related maternal characteristics on birth outcomes: a multivariate data analysis approach. Chemosphere 74: 428-433.

20. Miklavčič A1, Casetta A, Snoj Tratnik J, Mazej D, Krsnik M (2013) Mercury, arsenic and selenium exposure levels in relation to fish consumption in the Mediterranean area. Environmental research 120: 7-17.

21. Bellinger, David C, Martha Reed Herbert, Philip J. Landrigan, et al (2008) Scientific consensus statement on environmental agents associated with neurodevelopmental disorders. Collaborative on Health and the Environment's Learning and Developmental Disabilities Initiative (LDDI).

22. Susana, Segade, Teresa Dias, Elsa Ramalhosa (2011) Mercury methylation versus demethylation: main processes involved. Methylmercury: Formation, sources and health effects: 123-166.

23. 23. Ma Ming, Hongxia Du, Tao Sun, Siwei An, Guang Yang, et al. (2019) Characteristics of archaea and bacteria in rice rhizosphere along a mercury gradient. Science of the total environment 650: 1640-1651.

24. Krabbenhoft, David P (2004) Methylmercury contamination of aquatic ecosystems: a widespread problem with many challenges for the chemical sciences. Water and sustainable development opportunities for the chemical sciences—a workshop report to the chemical sciences roundtable. National Academies Press, Washington, DC.

25. Hosseini M1, Nabavi SM, Parsa Y (2013) Bioaccumulation of trace mercury in trophic levels of benthic, benthopelagic, pelagic fish species, and sea birds from Arvand River, Iran. Biological trace element research 156: 175-180.

26. Alvarez A, Saez JM, Davila Costa JS, Colin VL, Fuentes MS (2017) Actinobacteria: current research and perspectives for bioremediation of pesticides and heavy metals." Chemosphere 166: 41-62.

27. Harding, Gareth, John Dalziel, Peter Vass (2018) Bioaccumulation of methylmercury within the marine food web of the outer Bay of Fundy, Gulf of Maine." PloS one 13: e0197220.

28. Berlin M, R K Zalups, B A Fowler (2007) Mercury. Handbook on the toxicology of metals: 675-729.

29. Bernhoft, Robin A (2012) Mercury toxicity and treatment: a review of the literature. Journal of environmental and public health 2012.

30. Mercury and health

31. Polak-Juszczak, Lucyna (2018) Distribution of organic and inorganic mercury in the tissues and organs of fish from the southern Baltic Sea. Environmental Science and Pollution Research 25: 34181-34189.

32. Clarkson, Thomas W (1997)The toxicology of mercury. Critical reviews in clinical laboratory sciences 34: 369-403.

33. https://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/ihgem_met_g_mercuryspecies.pdf

34. https://www.who.int/news-room/fact-sheets/detail/mercury-and-health

35. Park, Jung-Duck, and Wei Zheng (2012) Human exposure and health effects of inorganic and elemental mercury. Journal of preventive medicine and public health 45: 344.

36. Mercury health

37. Byeong-Jin Ye, Byoung-Gwon Kim, Man-Joong Jeon, Se-Yeong Kim, Hawn-Cheol Kim, et al.(2016) Evaluation of mercury exposure level, clinical diagnosis and treatment for mercury intoxication." Annals of occupational and environmental medicine 28: 5.

38. https://www.epa.gov/mercury/basic-information-about-mercury

39. World Health Organization (2017). Safe management of wastes from health-care activities: a summary. No. WHO/FWC/WSH/17.05. World Health Organization.

40. Dórea JG, Bezerra VL, Fajon V, Horvat M (2011) Speciation of methyl-and ethyl-mercury in hair of breastfed infants acutely exposed to thimerosal-containing vaccines. Clinica Chimica Acta 412: 1563-1566.

41. Boischio Ana (2015) Developmental neurotoxicity: methylmercury and prenatal exposure protection in the context of the Minamata Convention. Revista Panamericana de Salud Pública 38: 243-247.

42. Li, Ping, Xinbin Feng, and Guangle Qiu (2010) Methylmercury exposure and health effects from rice and fish consumption: a review. International journal of environmental research and public health 7: 2666-2691.

43. Kevin M. Rice, Ernest M. Walker, Jr, Miaozong Wu, Chris Gillette, Eric R. Blough (2014) Environmental mercury and its toxic effects." Journal of preventive medicine and public health 47: 74.

44. https://www.canada.ca/en/environment-climate-change/services/pollutants/mercury-environment/health-concerns/food-chain.html

45. Ha, Eunhee, Niladri Basu, Stephan Bose-O'Reilly, José G. Dórea, et al. (2017) Current progress on understanding the impact of mercury on human health. Environmental research 152: 419-433.

46. Park JH, Hwang MS, Ko A, Jeong DH, Kang HS, et al. (2014) Total mercury concentrations in the general Korean population, 2008–2011. Regulatory Toxicology and Pharmacology 70: 681-686.

47. Hong, Young-Seoub, Yu-Mi Kim, Kyung-Eun Lee (2012) Methylmercury exposure and health effects. Journal of Preventive Medicine and Public Health 45: 353-363.

48. Harada, Masazumi (1995) Minamata disease: methylmercury poisoning in Japan caused by environmental pollution. Critical reviews in toxicology 25: 1-24.

49. Chang, Louis W (1997) Neurotoxic effects of mercury-a review. Environmental research 14: 329-373.

50. Jensen, Tina Kold, Philippe Grandjean, Esben Budtz Jørgensen, at al. (2005) Effects of breast feeding on neuropsychological development in a community with methylmercury exposure from seafood. Journal of Exposure Science and Environmental Epidemiology 15: 423.

51. Marques Rejane C, Luciana Abreu, José VE Bernardi, José G. Dórea (2016) Traditional living in the Amazon: extended breastfeeding, fish consumption, mercury exposure and neurodevelopment. Annals of human biology 43: 360-370.

52. Karagas Margaret R, Anna L Choi, Emily Oken, Milena Horvat, Rita Schoeny, et al. (2012) Evidence on the human health effects of low-level methylmercury exposure. Environmental health perspectives 120: 799-806.

53. Lin Y, Wang S, Steindal EH, Wang Z, Braaten HF (2017) et al. A holistic perspective is needed to ensure success of Minamata Convention on Mercury. Environ Sci Technol 51: 1070-1071.

54. http://mercuryconvention.org/Portals/11/documents/Awareness%20raising/FACT%20SHEETS/Minamata%20Convention%20on%20Mercury%20at%20a%20glance_COP1%202017.pdf

55. Selin Henrik, Susan Egan Keane, Shuxiao Wang, Noelle E. Selin, Kenneth Davis, et al. (2018) Linking science and policy to support the implementation of the Minamata Convention on Mercury. Ambio 47: 198-215.

56. http://mercuryconvention.org/Convention/History/tabid/3798/language/en-US/Default.aspx

57. Mackey Tim K, John T Contreras, Bryan A Liang (2014) The Minamata Convention on Mercury: Attempting to address the global controversy of dental amalgam use and mercury waste disposal." Science of the total environment 472: 125-129.

58. Sakamoto, Nozomi Tatsuta, Kimiko Izumo, Phuong Thanh Phan, Loi Duc Vu, et al. (2018) Health impacts and biomarkers of prenatal exposure to methylmercury: lessons from Minamata, Japan. Toxics 6: 45.

59. Yang, Tseming (2015) The minamata convention on mercury and the future of multilateral environmental agreements. Environmental Law Reporter: 1-15.

60. http://mercuryconvention.org/Portals/11/documents/Booklets/COP1%20version/Minamata-Convention-booklet-eng-full.pdf

61. Gibb Herman, Keri Grace O'Leary (2014) "Mercury exposure and health impacts among individuals in the artisanal and small-scale gold mining community: a comprehensive review." Environmental health perspectives. 122: 667-672.

62. Kessler, Rebecca (2013) "The Minamata Convention on Mercury: a first step toward protecting future generations." Environ Health Prospect 121: A304-a309

63. Wang Feiyue, Outridge PM, Feng X, Meng B, Heimbürger-Boavida LE, et al. (2019) "How closely do mercury trends in fish and other aquatic wildlife track those in the atmosphere? –Implications for evaluating the effectiveness of the Minamata Convention." The Science of the total environment 674: 58-70.

64. Streets David G, Hannah M Horowitz, Zifeng Lu, Leonard Levin, Colin P Thackray, et al. (2019) "Global and regional trends in mercury emissions and concentrations, 2010–2015." Atmospheric environment 201: 417-427.

65. Vickers, Carolyn (2018) "Removing mercury, protecting people's health." Bull World Health Organ. 96: 6-7.

66. McNutt, Marcia (2013) Mercury and health. 2013:1430-1430.

67. Malehase Tshia, Adegbenro P Daso, Jonathan O Okonkwo (2016) "Initiatives to combat mercury use in artisanal small-scale gold mining: A review on issues and challenges." Environmental reviews. 25: 218-224.

68. Selin Henrik (2014) "Global environmental law and treaty-making on hazardous substances: the Minamata Convention and mercury abatement." Global Environmental Politics 14: 1-19.

69. Esdaile Louisa J, Justin M Chalker (2018) "The Mercury Problem in Artisanal and Small-Scale Gold Mining." Chemistry–A European Journal. 24: 6905-6916.

70. Ferring, David, Heidi Hausermann, Emmanuel Effah (2016) "Site specific: Heterogeneity of small-scale gold mining in Ghana." The Extractive Industries and Society. 3: 171-184.

71. Spiegel Samuel, Susan Keane, Steve Metcalf, Marcello Veiga, Annalee Yassi (2014) "The Minamata convention on mercury: Time to seek solutions with artisanal mining communities." Environmental health perspectives 122: A203-A204.

72. Sykes Lisa K, Geier DA, King PG, Kern JK, Haley BE, et al. (2014) "Thimerosal as discrimination: vaccine disparity in the UN Minamata Convention on mercury." Indian J Med Ethics 11: 206-218.

73. Gustin Mae Sexauer, Evers DC, Bank MS, Hammerschmidt CR, Pierce A, et al. (2016) "Importance of integration and implementation of emerging and future mercury research into the Minamata Convention." 50: 2767-2770.

74. Fino A, N Pirrone (2018) How Science Supports Policy in the Implementation of the Minamata Convention. Conference Proceeding of the CNR-Institute of Atmospheric Pollution Research: 103-107.

75. Hsu-Kim Heileen, Chris S Eckley, Noelle E. Selin (2018) "Modern science of a legacy problem: mercury biogeochemical research after the Minamata Convention." Environmental Science: Processes & Impacts. 20: 582-583.

76. Zhang L, Wang S, Wang L, Wu Y, Duan L, et al. (2015) "Updated emission inventories for speciated atmospheric mercury from anthropogenic sources in China." Environmental Science & Technology. 49: 3185-3194.

77. Sundseth Kyrre, Jozef M Pacyna, Elisabeth G Pacyna, Nicola Pirrone, Rebecca J Thorne (2017) "Global sources and pathways of mercury in the context of human health." International journal of environmental research and public health. 14: 105.

78. https://www.cdc.gov/breastfeeding/breastfeeding-special-circumstances/diet-and-micronutrients/index.html

79. American Academy of Pediatrics Committee on Drugs. The transfer of drugs and other chemicals into human milk. Pediatrics. 108(3), Sep 2001

80. Sachs, Hari Cheryl and Committee on Drugs, American Academy of Pediatrics, The transfer of drugs and therapeutics into human breast milk; An update on selected topics. Pediatrics, 132(3), Sep 2013

81. Accessed Sep 18, 2019

82. Melin Vanessa E, Haritha Potineni, Patricia Hunt, Jodi Griswold, Bill Siems, et al. (2014) Exposure to common quaternary ammonium disinfectants decreases fertility in mice. Reprod Toxicol. 50: 163-170.

83. https://www.accessdata.fda.gov/drugsatfda_docs/label/2008/018662s059lbl.pdf

84. Rosa Franz W (1983) Teratogenicity of isotretinoin. The Lancet. 2: 513.

85. Tuon FF , RB Gondolfo, N Cerchiari (2017) Human-to-human transmission of Brucella - a systematic review. Trop Med Int Health. 22: 539-546.

86. Dietary Reference Intakes (DRIs): Recommended Dietary Allowances and Adequate Intakes, Elements, Food and Nutrition Board, Institute of Medicine, National Academies.

87. Sim Tin Fei, H Laetitia Hattingh, Jillian Sherriff, Lisa BG Tee (2015) The use, perceived effectiveness and safety of herbal galactagogues during breastfeeding: a qualitative study. Int J Environ Res Public Health. 12: 11050-11071.

88. Grzeskowiak Luke E, Mary E Wlodek, Donna T Geddes (2019) What evidence do we have for pharmaceutical galactagogues in the treatment of lactation insufficiency? - A narrative review. Nutrients. 11: 974.

89. Bazzano AN, R Hofer, S Thibeau, V Gillispie, M Jacobs, KP Theall (2016) A review of herbal and pharmaceutical galactagogues for breast-feeding. Ochsner J. Winter; 16: 511-524.

90. https://www.who.int/en/news-room/fact-sheets/detail/infant-and-young-child-feeding. Accessed Sep 19, 2019.

91. Rachelle Lessen, Katherine Kavanagh (2015) Practice Paper of the Academy of Nutrition and Dietetics: Promoting and supporting breastfeeding. J Acad Nutr Diet. 115: 444-449.

92. James DC, Lessen R: American Dietetic Association (2009) Position of the American Dietetic Association: Promoting and supporting breastfeeding. J Am Diet Assoc. 109: 1926-1942.

93. Pajewska-Szmyt, Martyna, Sinkiewicz-Darol E, Gadzała-Kopciuch R (2019) "The impact of environmental pollution on the quality of mother's milk." Environmental Science and Pollution Research. 26: 7405-7427.

94. Tratnik Janja, Falnoga I, Mazej D, Kocman D, Fajon V, et al. (2019) "Results of the first national human biomonitoring in Slovenia: Trace elements in men and lactating women, predictors of exposure and reference values." International Journal of Hygiene and Environmental Health. 222: 563-582.

95. Vollset Marie, Iszatt N, Enger Ø, Gjengedal ELF, Eggesbø M (2019) "Concentration of mercury, cadmium, and lead in breast milk from Norwegian mothers: Association with dietary habits, amalgam and other factors." Science of the Total Environment 677: 466-473.

96. Batool Zehra, Agha F, Tabassum S, Batool TS, Siddiqui RA (2019) "Prevention of cadmium-induced neurotoxicity in rats by essential nutrients present in nuts." Acta Neurobiol Exp. 79: 169-183.

97. Hojsak Iva, Braegger C, Bronsky J, Campoy C, Colomb V, et al. (2015) "Arsenic in Rice: A Cause for Concern." JPGN. 60: 142-145.

98. Rogers Shannon H, Rardin LR, Lawlor K, Chen CY, Borsuk ME. (2019) "Communicating Arsenic's Risks." Int. J. Environ. Res. Public Health, 16: 34-36.

99. Stasinos Sotiris, Nasopoulou C, Tsikrika C, Zabetakis I (2014) "The Bioacculumation and Physiological Effects of Heavy Metals in Carrots, Onions, and Potatoes and Dietary Implications for Cr and Ni: A Review." Journal of Food Science. 79: R765-R780.

100. Barrett Julia (2014) "Lead Transfer during Breastfeeding." Environmental Health Perspectives. 122: 26.

101. Rolston, David DK. (2011) "Uncommon Sources and Some Unusual Manifestations of Lead Poisoning in a Tropical Developing Country."

Tropical Medicine and Health. 39: 127-132.

102. Astolfi Maria Luisa, Protano C, Schiavi E, Marconi E, Capobianco D, et al. (2019) "A propholatic multi-strain probiotic treatment to reduce the absorption of toxic elements: In-vitro study and biomonitoring of breast milk and infant stools." Environmental International 130: 1-13.

103. Mayans Laura. "Lead Poisoning in Children." American Family Physician. 100: 24-29.

104. El-Boshy Mohamed E, Engy F Risha, Fatma M Abdelhamid, Mohammad S Mubarak, Taibi Ben Hadda (2015) "Protective effects of selenium against cadmium induced hematological disturbances, immunosuppressive, oxidative stress and hepatorenal damage in rats." Journal of Trace Elements in Medicine and Biology. 29: 104-110.

105. Rahimzadeh, Mehrdad Rafati, Mehravar Rafati Rahimzadeh, Sohrab Kazemi, Ali-akbar Moghadamnia (2017) "Cadmium toxicity and treatment: An update." Caspian journal of internal medicine. 8: 135.

106. Kearney J (2010) Food consumption trends and drivers. Philos Trans R Soc Lond B Biol Sci. 365: 2793-2807.

107. Rothenberg SE, Windham-Myers L, Creswell JE (2014) Rice methylmercury exposure and mitigation: a comprehensive review. Environ Res. 133: 407-423.

108. Qui G, Feng X, Li P, Wang S, Li G, et al. (2008) Methylmercury Accumulation in Rice (Oryza sativa L.) Grown at Abandoned Mercury Mines in Guizhou, China. Journal of Agricultural and Food Chemistry. 56: 2465-2468.

109. Guillen J, Natale F, Carvalho N, John Casey, Johann Hofherr, et al. (2019) Global seafood consumption footprint. Ambio. 48: 111-122.

110. Silbernagel SM, Carpenter DO, Gilbert SG, Gochfeld M, Groth E, et al. (2011) Recognizing and preventing overexposure to methylmercury from fish and seafood consumption: information for physicians. J Toxicol. 2011: 983072.

111. Hong YS, Kim YM, Lee KE (2012) Methylmercury exposure and health effects. J Prev Med Public Health. 45: 353-363.

112. Rand MD, Caito SW (2019) Variation in the biological half-life of methylmercury in humans: methods, measurements and meaning. Biochim. Biophys. Acta Gen. Subj. 1863: 129301.

113. Björnberg KA, Vahter M, Berglund B, Niklasson B, Blennow M, et al. (2005) Transport of methylmercury and inorganic mercury to the fetus and breast-fed infant. Environ Health Perspect. 113: 1381-1385.

114. Grandjean P, Jørgensen PJ, Weihe P (1994) Human milk as a source of methylmercury exposure in infants. Environ Health Perspect. 102: 74-77.

115. Ruggieri F, Majorani C, Domanico F, Alimonti A (2017) Mercury in Children: Current State on Exposure through Human Biomonitoring Studies. Int J Environ Res Public Health. 14: 519.

116. Bose-O'Reilly S, McCarty KM, Steckling N, Lettmeier B (2010) Mercury exposure and children's health. Curr Probl Pediatr Adolesc Health Care. 40: 186-215.

117. Spurgeon A (2006) Prenatal Methylmercury Exposure and Developmental Outcomes: Review of the Evidence and Discussion of Future Directions. Environmental Health Perspectives. 114: 307-312.

118. Ruggieri F, Majorani C, Domanico F, Alimonti A (2017) Mercury in Children: Current State on Exposure through Human Biomonitoring Studies. Int J Environ Res Public Health. 4: 519.

119. Clemens, Stephan, Jian Feng Ma (2016) "Toxic heavy metal and metalloid accumulation in crop plants and foods." Annual review of plant biology 67: 489-512.

120. Ha, Eunhee, Niladri Basu, Stephan Bose-O'Reilly, José G. Dórea, Emeir McSorley, Mineshi Sakamoto, and Hing Man Chan (2017) "Current progress on understanding the impact of mercury on human health." Environmental research 152: 419-433.

121. Zhang, Hua, Xinbin Feng, Hing Man Chan, Thorjørn Larssen (2014) "New insights into traditional health risk assessments of mercury exposure: implications of selenium." Environmental science & technology. 48: 1206-1212.

122. Meng Bo, Xinbin Feng, Guangle Qiu, Christopher WN Anderson, Jianxu Wang, et al. (2014) "Localization and speciation of mercury in brown rice with implications for Pan-Asian public health." Environmental science & technology. 48: 7974-7981.

123. Ma, Guansheng (2015) "Food, eating behavior, and culture in Chinese society." Journal of Ethnic Foods. 2: 195-199.

124. Bell L, D Evers, S Johns, K Regan, J DiGangi, et al. (2017) Mercury in Women of Child-bearing Age in 25 Countries. Göteborg: IPEN and Biodiversity Research Institute.

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