Health Prob Civil. 2024, Volume 18, Issue 1
ISSN 2353-6942, eISSN 2354-0265

HEAVY METALS IN HUMAN MILK: LITERATURE REVIEW

METALE CIĘŻKIE W POKARMIE KOBIECYM: PRZEGLĄD PIŚMIENNICTWA

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Authors' contribution
Wkład autorów:
A. Study design/planning
zaplanowanie badań
B. Data collection/entry
zebranie danych
C. Data analysis/statistics
dane – analiza i statystyki
D. Data interpretation
interpretacja danych
E. Preparation of manuscript
przygotowanie artykułu
F. Literature analysis/search
wyszukiwanie i analiza literatury
G. Funds collection
zebranie funduszy

Summary

The escalating global environmental pollution leads to the increased exposure to heavy metals, including chromium, mercury, copper, and lead. These substances ubiquitous in our environment and food, can induce severe health issues, including intellectual disabilities, kidney damage, and certain types of cancer. The article presents a current literature review concerning breast milk and its potential contamination with heavy metals. Research reveals varied levels of heavy metal contamination in human milk, contingent on geographical location and lifestyle factors. Some studies have detected a higher concentration of heavy metals in urban areas compared to suburban ones, while others have reported an increased level in the milk of women who smoke cigarettes. Moreover, the concentration of heavy metals in human milk often exceeded permissible limits set by the World Health Organization. Given the increasing exposure to heavy metals, it is imperative to monitor their concentration in food and conduct further studies to understand the risk factors for exposure.

Keywords: heavy metals, human milk, breastfeeding, mercury, lead

Streszczenie

Narastające globalne zanieczyszczenie środowiska prowadzi do zwiększonej ekspozycji na metale ciężkie, w tym chrom, rtęć, miedź i ołów. Substancje te, powszechne w naszym otoczeniu i żywności, mogą powodować poważne problemy zdrowotne, w tym niepełnosprawność intelektualną, uszkodzenie nerek i niektóre rodzaje nowotworów. W artykule został przedstawiony aktualny przegląd piśmiennictwa dotyczący pokarmu kobiecego i potencjalnego skażenia go metalami ciężkimi. Stwierdzono zróżnicowane poziomy zanieczyszczenia mleka kobiecego metalami ciężkimi w zależności od lokalizacji geograficznej i czynników stylu życia. Niektóre badania wykazały wyższe stężenie metali ciężkich w obszarach miejskich w porównaniu z przedmieściami, podczas gdy w innych stwierdzono zwiększony ich poziom w mleku kobiet palących papierosy. Co więcej, stężenie metali ciężkich w mleku kobiecym często przekraczało dopuszczalne limity ustalone przez Światową Organizację Zdrowia. Ze względu na rosnącą ekspozycję na metale ciężkie, niezbędne jest monitorowanie ich stężenia w żywności i przeprowadzanie dalszych badań, aby zrozumieć czynniki ryzyka ekspozycji.

Słowa kluczowe: metale ciężkie, pokarm kobiecy, karmienie naturalne, rtęć, ołów

Tables: 0
Figures: 0
References: 36
Submitted: 2023 Sep 16
Accepted: 2023 Nov 4
Published Online: 2023 Nov 27

Młodawska M, Młodawski J, Świercz A, Świercz G. Heavy metals in human milk: literature review. Health Prob Civil. 2024; 18(1): 55-61. https://doi.org/10.5114/hpc.2023.132629

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Introduction

The increasing urbanization and environmental pollution expose us to numerous potentially harmful substances, such as heavy metals. Among the most harmful are chromium, mercury, cadmium, and lead. The content of these elements in soil, air, water, or food can impact human health. Continuous exposure to heavy metals has been associated with the risk of developing intellectual disabilities, kidney damage, certain cancers, and even death in cases of extreme body exposure [1]. Exposure to heavy metals may vary depending on the living area (urban vs. suburban settlements). Exposure to heavy metals is also known through consumption of predatory fish, hence they are not recommended in diets during pregnancy and breastfeeding. Due to the high content of mercury, the Food and Drug Administration and the Environmental Protection Agency recommend avoiding the consumption of certain fish during pregnancy and breastfeeding, such as tuna, shark, or king mackerel [2]. To ensure food safety, regulatory bodies and health organizations establish guidelines and limits for permissible levels of heavy metals in food products.

Breast milk is the optimal and recommended method of feeding according to numerous scientific societies. It is a source of nutrients, unique immunological substances, and biologically active substances, having a positive short- and long-term impact on the child [3]. However, like the milk of other mammals, it can be a potential source of heavy metals for the developing child's body.

Aim of the work

In this paper, a current literature review is presented regarding breast milk and the presence of heavy metals in it.

Literature review results

Most infants benefit from breast milk as their primary source of nutrition. It is advisable to exclusively breastfeed for the initial six months of a baby's life, followed by continued breastfeeding while introducing complementary solid foods for at least the first year and beyond. These guidelines receive strong support from various medical and professional organizations, including the American Academy of Pediatrics [4], American Academy of Family Physicians [5], American College of Obstetricians and Gynecologists [6], and the World Health Organization [7], due to the many advantages it offers to both mothers and children, both in the short and long term. The World Health Organization specifically recommends breastfeeding until a child reaches their second birthday.

Human milk is a complex and biologically active liquid that not only provides the essential macro- and micro-nutrients required for a child's growth but also contains living cells, growth factors, and immunological components [3]. Moreover, many of these factors remain biologically active on the child's mucous membrane surface, thanks to their insensitivity to the action of digestive enzymes in the gastrointestinal tract. Extensive research has highlighted the most well-documented advantages of breastfeeding, which encompass its favorable influence on the maturation of both the digestive and immune systems, as well as its effectiveness in preventing infections. These advantages are particularly pronounced in low- and middle-income nations, where the absence of breastfeeding is linked to elevated mortality rates [8]. In contrast to formula milk, breastfeeding appears to offer sustained protection against acute illnesses like otitis media and pneumonia, even after the discontinuation of breastfeeding during the early years of a child's life [9]. Beyond its immediate benefits, breastfeeding is also linked to long-term advantages, such as reducing the risk of several chronic diseases. However, information on the long-term effects of breastfeeding primarily derives from cohort observational studies and may be limited due to potential confounding variables. There exists moderate-

quality evidence supporting its role in preventing conditions such as type 1 diabetes, inflammatory bowel disease (IBD) [10], and wheezing [11] in young children. While breastfeeding benefits may indeed exist, they are not as extensively documented in the context of conditions like leukemia, atopic asthma [12], eczema, food allergies [13], obesity [14], and neurodevelopmental outcomes [15]. Recent data suggests, among other findings, that children who are breastfed tend to exhibit improved cognitive functions and achieve better results in intelligence tests when compared to those who are formula-fed.Początek formularzaDół formularza

Heavy metals, such as iron (Fe), zinc (Zn), and copper (Cu), serve various biochemical functions, are cofactors of many enzymes, and therefore are considered essential for the human body. They become toxic only when they exceed recommended concentrations. Other elements, such as cadmium (Cd), lead (Pb), and mercury (Hg), serve no biological function in the human body and can cause toxic effects at very low concentrations [16]. Due to their long half-life, ability to accumulate in the human body, and low biodegradability, heavy metals are a specific type of pollutants, posing a real threat to human and animal health [17]. Not only exceeding critical values but also prolonged exposure to low concentrations of heavy metals is a potential hazard to the human body [18]. Accumulation of these elements, e.g., in the liver, heart, kidneys, or brain, disrupts the functioning of these organs and can have serious consequences. Toxic effects of heavy metals include neurotoxic effects, including memory disorders, language disorders [19], carcinogenic effects, kidney function disorders, cardiovascular system disorders, and endocrine disorders [20]. Heavy metals occur naturally in the earth's crust, but intensified industrial processes have increased human exposure to their actions. They can infiltrate the human body in various ways, for example, through the air, by consuming contaminated food or drinking water [21]. The scientific studies deal with the content of heavy metals in mammalian milk. However, the degree of milk contamination is not constant and varies depending on the exposure route, environmental conditions, animal feeding, lactation stage, and animal breed [22]. The presence of heavy metals has been demonstrated in cow's milk from various regions worldwide [23,24].

A comprehensive meta-analysis from 2021 covering 60 studies examined the content of heavy metals in raw cow's milk worldwide in the last decade (2010-2020) [22]. The concentrations of some elements in raw cow's milk collected globally were higher than the maximum limit recommended by the US Food and Nutrition Board. The contamination of cow's milk was generally higher in developing countries and lower in developed countries, reflecting less stringent veterinary regulations in developing countries. Thus, it seems that monitoring heavy metal concentrations and continuous food safety control is necessary [22].

In the case of breastfeeding women, heavy metals can pass from the mother's body into the milk. The degree of heavy metal contamination in human milk can vary depending on factors such as geographical location, the mother's exposure to environmental factors (including tobacco smoke), and dietary habits. Monitoring and limiting environmental pollution, as well as maintaining a healthy lifestyle and making proper dietary choices, are important strategies for minimizing exposure to heavy metals during breastfeeding. In one study, researchers examined the levels of heavy metals in the breast milk of women who had recently given birth, comparing those residing in urban and suburban areas within Rivers State, Nigeria [25]. The study involved 59 postpartum patients in each group, all of whom were within the 0 to 10-day period of the puerperium. The findings from this investigation revealed that there were no significant differences ($p>0.05$) in the concentrations of the specified heavy metals between the two groups. This research work effectively illustrated that the composition of heavy metals in the breast milk of postpartum women remains consistent irrespective of whether they live in urban or suburban areas. This suggests a similarity in environmental conditions between the two groups. Nevertheless, despite the lack of statistical significance (which could result from low study power and Type II error), the concentration of individual heavy metals in human milk was higher among women residing in urban areas vs. suburban: the concentration of lead was 0.15±0.1 mg/l vs 0.07±0.04

mg/l, and cadmium was 0.1±0.03 mg/l vs 0.0±0.0 mg/l. In another study, the concentration of mercury, lead, and cadmium in the milk of mothers living in Madrid, Spain (n=100) was analyzed and attempted to correlate it with sociodemographic factors, lifestyle, diet, and environmental exposure, including exposure to tobacco smoke. The study showed, among other things, a higher level of cadmium in the milk of women who smoked cigarettes; a lower level of cadmium in the milk of women who were exclusively breastfeeding compared to those who fed their children in a mixed manner (their milk and artificial formula); a higher level of lead in the milk of women exposed to the car exhaust fumes, and those consuming larger amounts of potatoes (*p* trend = 0.02); a lower level of mercury in the milk of women >30 years old, breastfeeding exclusively with their milk, breastfeeding their children longer from previous pregnancies. As with the previous example, the limited size of the group was likely the cause of the lack of statistical significance in some relationships. Nevertheless, this study emphasizes the need to promote healthy eating habits, not smoking during pregnancy and breastfeeding, and monitoring the presence of heavy metals in human milk, which may reflect environmental pollution [26]. Lead and cadmium pollution has also been demonstrated in the milk of mothers living in Iran (n=100) [27], as well as in many other countries, including Saudi Arabia [28], Brazil [29], Austria [30], Bangladesh [31], and Japan [32,33]. The concentrations of heavy metals in human milk in many studies exceeded the concentration allowed by the WHO [34]. In the milk of women living in Austria, the average cadmium content was one of the lowest in Europe (0.086±0.085 μg/l, 95% CI: 0.07-0.10; n=124) [30]. In this Austrian study, a higher level of cadmium in breast milk was associated with smoking and frequent cereal consumption, while a lower level was linked to supplementation of vitamins and trace elements, but only in non-smoking women [30]. The cadmium level in breast milk showed a statistically significant positive correlation with the maternal urine concentration [33].

Increased content of heavy metals, exceeding the permissible limit values, has also been documented in samples of modified milk for infants, as well as powdered milk, indicating the need for a rigorous monitoring program to reduce food contamination and limit the potential risk to human health [35].

Available data suggests that the level of lead found in mother's milk can reach up to 3 percent of the mother's own blood lead level (BLL) and is directly related to the concentration of lead in the mother's bloodstream [36]. It is generally not recommended to routinely measure the lead content in mother's milk, except in cases where mothers have been notably exposed to lead. The monitoring of blood lead concentration in newborns and infants should proceed in accordance with recommendations for control tests for newborns and infants up to the 6th month of life. Based on estimates of blood concentration increases in newborns after consumption of mother's milk, all mothers with venous BLL <40 μg/dl should be encouraged to breastfeed. It is uncertain whether the risk of breastfeeding for mothers with a blood lead concentration ≥40 μg/dl, living in a country with limited resources, outweighs the benefits. The decision to continue breastfeeding in such cases should be based on an analysis of the impact of increased lead concentration in breast milk on the elevated lead levels observed in infants, as determined through screening studies of both the mother and infant [36].

Conclusions

In light of increasing human exposure to heavy metals in the environment, it seems thoughtful to monitor their concentration in food, particularly in food intended for infants and young children, who, due to rapid growth, are particularly vulnerable to their adverse effects. It also seems reasonable to further understand the risk factors for heavy metal exposure by conducting new clinical studies. This would allow for the updating of recommendations for pregnant women and breastfeeding mothers to limit the exposure of the developing fetus and subsequently the infant to heavy metals.

Disclosures and acknowledgements

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article. The project was financed under the program of the Minister of Science and Higher Education under the name "Regional Initiative of Excellence in 2019-2023" project number: 024/RID/2018/19, financing amount: 11,999,000.00 PLN. The publication fee was financed by the project of the Jan Kochanowski University in Kielce, no. SUB.RN 22.071. Artificial intelligence (AI) was not used in the creation of the manuscript.

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